Q. **Reference: Schedule 1, Page 11, footnote 26.**

Advise when the 2025 Inspection Report will be finalized and confirm a copy will be provided to the Board as soon as available.

A. The 2025 Inspection Report was finalized on May 4, 2026, and is provided as PUB-NLH-003, Attachment 1. The 2025 inspection identified 14 indications in 13 cans, 8 of these cans had been previously refurbished, and noted repeated failure of previously repaired welds.[1,2] The consultant continued to recommend replacement of the 17-ft. section within the next 5 years. Please refer to Newfoundland and Labrador Hydro's response to PUB-NLH-005 of this proceeding for further discussion on the advancement of life extension work for Penstock 3.

[1] Of the 17 indications found, 7 did not require weld repair, 4 were able to be removed during the inspection, and 3 were deemed acceptable by Hydro's third-party inspector, Kleinschmidt Associates ("Kleinschmidt"). As a result of this planned life extension work and the implementation of operating restrictions on Units 5 and 6, Kleinschmidt determined that the remaining 7 indications posed no material concern at that time, and the penstock could safely be returned to service.
[2] As part of the 2018 weld repairs, 7 of the previously repaired cans were repaired, and the 8th was previously repaired in both 2018 and 2023.

PENSTOCK 3 INSPECTION AND EVALUATION

BAY D'ESPOIR HYDROELECTRIC DEVELOPMENT
PENSTOCKS 1-3 INSPECTION PROJECT

Prepared for:
Newfoundland and Labrador Hydro

Prepared by:
Kleinschmidt Associates

Kleinschmidt CANADA

May 2026

EXECUTIVE SUMMARY

Newfoundland and Labrador Hydro (NLH) contracted with Kleinschmidt Associates Canada Inc. (Kleinschmidt) in January 2023 to inspect and evaluate the condition of Penstocks 1, 2, and 3 at the Bay d'Espoir Hydroelectric Development.

In 2016, cracking was identified in Penstock 1 and Kleinschmidt assisted NLH with the inspection and weld repair design. Penstock 1 was repaired the same year as the inspection. Kleinschmidt inspected Penstock 2 later in 2016 and discovered similar weld deterioration of Penstock 2, which was repaired in 2017. Subsequent to the previous inspections of Penstock 1 and 2, deteriorated welds were repaired in Penstock 3 after inspection in 2018.

As indicated in the record drawings, Penstock 3 was installed in 1968, a year after the Penstock 1 and 2, using similar plate materials, thicknesses, and weld procedures. Due to the three penstocks being of similar age and design and because of the identified weld deterioration and corrosion, NLH initiated a penstock inspection program requiring an inspection of each penstock every year until the penstocks are fully refurbished or replaced. The main focus of the Penstock 3 inspection was to assess the integrity of the welds and complete steel thickness measurements to evaluate metal loss and corrosion to determine if the penstock condition is acceptable to operate through another calendar year.

An inspection of Penstock 3 was conducted by Kleinschmidt in November 2025, which consisted of a visual walk-over of the penstock exterior, and a detailed evaluation of the condition of the interior of the penstock. The interior inspection included a visual condition assessment by Kleinschmidt's Structural Engineer, which consisted of cleaning and visually inspecting the steel shell and the longitudinal and circumferential welds. Non-destructive weld tests and ultrasonic thickness measurements of the penstock steel shell were also performed during the inspection.

The 2025 inspection identified weld indications in thirteen (13) cans, with fourteen (14) indications observed in total, including two indications within a single can, as listed in Section 3.2. Seven of those indications are recommended to be repaired and were within the 17-foot diameter section and were previously repaired welds. The remaining seven indications found were addressed at the time of the inspection.

The inspection revealed minimal loss of material thickness of the penstock shell. The plate thickness was comparable to the record drawings, and the interior of the shell displayed a layer of rust with moderate corrosion and pitting common for a 50-year-old penstock. Definitions for qualitative terminology such as fair and good are in Table 3-1 in Section 3.

The sinkhole discovered in 2019 downstream of the surge tank on the left side of the penstock has been filled in previous years and appears to have stabilized. The area should continue to be monitored for further erosion.

The structural evaluation showed stress ratios for a combined static and dynamic internal pressures peak at 1.43 (Can 221). This indicates that the penstock joints in this area does not meet present day design criteria for new penstock design. When the hoop stress is compared to the plate yield stress the minimum factor of safety is 1.05, which is not acceptable for late 1960 steel pipe. The calculated stress at the joints assumes a 0.7 joint efficiency factor. A higher joint efficiency factor could be used for the analysis, as discussed in Section 4, if RT weld testing is performed to verify the integrity of the welds. A higher joint efficiency would result in favorable factors of safety; however, considering the known weld deterioration, a higher joint efficiency is not justified at this time.

The base plate material away from the joints has stress ratios that varies significantly ranging from 0.3 to 1.0. Only one of the measured cans had a ratio equal to 1.0.

This approximately 50-year-old penstock has shown minimal loss of thickness from the original plate thicknesses. Kleinschmidt anticipates that the penstock plating has an additional 50 years of useful service life. However, because of the condition of the existing welds, the 17-ft section of penstock will need to be replaced, the remaining penstock welds refurbished, and the interior re-coated before the steel deteriorates further.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS

ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
CH	Chainage (in metres)
cms	Cubic Metres per Second
ETS	EasternTechnical Services Ltd.
Fu	Ultimate Tensile Stress
Fy	Yield Stress
GWh	Gigawatt Hours
kPa	Kilo-Pascals
Kleinschmidt	Kleinschmidt Associates
MW	Megawatts
NLH	Newfoundland and Labrador Hydro
SPRAT	Society of Professional Rope Access Technicians
STA	Station (in feet)
TRR	Technical Rope and Rescue
UT	Ultrasonic Thickness

1.0 INTRODUCTION

The focus of the Penstock 3 inspection in 2025 was to assess the integrity of the welds and to complete steel plate thickness measurements to evaluate the current condition of the steel. The 2025 inspection concentrated on welds that have never been inspected from the headgate downstream to the last bend near the powerhouse and welds not inspected during the previous year.

The November 2025 inspection of Penstock 3 consisted of weld inspections and steel plate thickness measurements completed by Technical Rope and Rescue (TRR) and Eastern Technical Services (ETS). Kleinschmidt engineers Chris Vella, P.Eng. and Youssef Abdeldayem, E.I.T. travelled to the Bay d'Espoir Hydro Site to complete an interior and exterior condition assessment of the penstock and assist with the weld inspection.

This report presents our evaluation of the capacity of the penstock in its current condition, provides recommendations for inspection procedures in the future, and estimates the remaining service life.

2.0 PROJECT DESCRIPTION

NLH owns and operates the Bay d'Espoir Hydroelectric Development in Bay d'Espoir, Newfoundland and Labrador. The Project went into service in 1967 and is supplied by Long Pond. The tailrace feeds a canal leading to the tidal waters of Bay d'Espoir and the Atlantic Ocean. The plant has a hydraulic head of approximately 577 ft (176 metres [m]) and seven generating units with a total capacity of 604 megawatts (MW). The hydro development is comprised of four intake structures, feeding four penstocks into two powerhouses. Penstocks Nos. 1, 2, and 3 have surge towers approximately 1700 ft (518 m) upstream of the powerhouse. The first phase of the initial project construction included installation of two intake structures and a four-unit powerhouse with Penstocks 1 and 2 connecting the two intakes to the powerhouse. The second phase of the project consisted of installing Penstock 3 with a third intake and two additional units in the powerhouse. A separate intake structure and powerhouse for Unit 7, connected by Penstock 4 was built in 1978. Penstock 3 supplies Units 5 and 6. The rated flow across all seven units is 397 cubic metres per second (m^3/s) (14,020 cubic feet per second [cfs]).

Penstock 3 is a 1,200-m-long buried steel penstock, tapering from 5.2 m in diameter (at the intake) to 4.1 m in diameter at the powerhouse bifurcation. At the flattest point, the penstock has a 0.0% slope and reaches a maximum slope of approximately 36.5% (20 °) at its steepest section. There are at least three areas to access the interior of Penstock 3, one at the well in the intake structure, three manholes along the length of the penstock, and one through the scroll cases in the powerhouse.

Appendix A includes the original 1968 profile drawings of the penstock including original plate thicknesses. The penstock steel plate thicknesses range from 7/16 inches at the intake to 1-5/8 inches upstream of the bifurcation upstream of the powerhouse (plate thicknesses in this report are expressed in inches to match the drawings provided). The penstock is constructed of A285, G40.88 and HSB 50 steel. The penstock is 17.0 ft in diameter until STA 12+41 (CH 376.2), 15.25 ft in diameter between STA 12+41 (CH 376.2) and STA 27+50 (CH 833.3) where it then reduces to 13.5 ft in diameter for the remaining 1,581 ft (479.1 m) to the bifurcation. The welds are double V groove full penetration welds.

A majority of the penstock has a cover of 2 ft (0.61 m) of clayey soil and 1 ft (0.30 m) minimum thick layer of riprap. The penstock crosses underneath the switchyard and terminates at the powerhouse. Several weirs are located where the drainage daylights to the ditches and wells for inspection and monitoring purposes.

Table 2-1 summarizes the indications found and subsequent repairs that have occurred from 2017 and onwards.

Table 2-1 Penstock 3 – Previous Indications Observed and Repairs Completed

Year	Findings
2017	No magnetic particle (MP) testing completed.
2018	Indications found and weld repairs completed.
2019	No indications.
2020	No inspection completed.
2021	One (1) indication observed in Can No. 193S.
2022	No new indications.
2023	Eleven (11) indications observed in total – One (1) indication observed in each of Cans 11S, 32N, 59N, 69S, 77S, 127S, 140S and two (2) indications observed in each of Cans 138S and 217S. All indications above were repaired.
2024	Seven (7) indications observed in total - One (1) indication observed in each of Cans 55S, 61 Crown, 65S, 70N, 71S, 75S, and two (2) indications observed in Can No. 70S. All indications above were repaired.

3.0 INSPECTION

The lead inspecting engineer, Chris Vella and accompanying engineer Youssef Abdeldayem from Kleinschmidt performed a detailed interior visual inspection and an exterior walk of the penstock alignment. The inspection of Penstock 3 was conducted from November 17 to November 20, 2025, with the assistance of personnel from Technical Rope and Rescue (TRR), Eastern Technical Services (ETS), and NLH. NLH were present to participate in morning safe talks and to answer questions about the history, operation, and maintenance of the station. ETS assisted with the ultrasonic thickness (UT) and MT testing of the penstock steel and welds. TRR rope access personnel assisted with safe access, confined space entry protocols, communication, and provided standby at the penstock entry for rescue.

Kleinschmidt's inspection consisted of measuring shell thicknesses, identifying pitting or cracking, and an overall general condition assessment of the interior of the shell. ETS personnel performed MT weld tests on approximately 11% of the longitudinal welds overall. ETS took UT measurements from approximately 10% of the cans for the portion of penstock inspected.

The exterior of the buried penstock was examined for signs of leakage including around the surge tank. For this inspection, all references to penstock left and right are oriented looking downstream.

Table 3-1 Definitions for Condition Assessment

Term	Definition
Excellent	New or near new condition. No visible deterioration present and remedial action is not required
Good	General or light deterioration where performance is not affected, and remedial action is not expected to be required in the next 10 years
Fair	Medium deterioration or defects are visible that do not require maintenance in the next 12 months but may require preventative maintenance in the next 5 to 10 years
Poor	Significant deterioration is visible, and remediation is required in the next 1 to 5 years
Very Poor	Severe deterioration or defect is visible, and remediation is required within 1 year

3.1 Working Conditions

Kleinschmidt's inspection team reviewed confined space protocols and reviewed safety procedures and requirements with NLH on the morning of Monday November 17, 2025. The inspection team entered the penstock on the same day at Manhole 1 of Penstock 3. TRR assisted with confined space entrance and rigging for fall protection (Photo 1, Appendix B). The internal inspection finished on November 19, 2025. The exterior inspection commenced on November 20, 2025, and was completed by Kleinschmidt the same day. Kleinschmidt pre-marked welds to be inspected inside of the penstock so TRR and ETS could proceed with the internal inspection and weld testing while Kleinschmidt performed the external inspection. Air quality in the penstock remained good for the duration of the inspection.

The internal penstock inspection commenced at the headgate location. At the time of the inspection, leakage around the gate was low and this is expected given that the gate is relatively new. There were just a few spots of leakage including the left side seal, and two bolts as noted last year (Photos 2 through 4). The limited leakage allowed for easier and drier travel inside the penstock. More effort was required downstream of the surge tank to remove organics and clean welds as there were a greater quantity of existing welds not previously inspected.

The exterior inspection was completed in sunny, cold, and dry conditions (Photo 5). The ground surface was rocky with steep slopes with short vegetation. Some areas were noted to have significant alder bush growth and taller vegetation that was impeding inspection and sight of the ground surface (Photos 6 and 7). The ground was reasonably dry reducing slip potential. There were areas of saturated soil on the left-hand side of the penstock located adjacent and downstream of the surge tank, which has been noted in previous inspections as an area that is typically wet with runoff from the adjacent hill. The grade followed the penstock slope between the intake and the switchyard. The deeply buried sections under the dam and switchyard were not inspected from the exterior.

3.2 Interior Inspection

The penstock consists of approximately 435 "Cans" into the powerhouse scroll case. A can, referred to in this report is defined as a whole penstock pipe section from circumferential weld joint to the next circumferential weld joint. The Can number is used in this report to reference location within the penstock during the inspection, with Can No. 1 located at the upstream end of the penstock at the intake.

Penstock thickness readings were recorded at the interior surface at various locations. Shell thickness measurements were taken by ETS with a GE DMS Go+ digital thickness gauge (S/N GOBLS20020097) with a GE TC560 Probe (S/N 00H6Y6). The gauge was calibrated before the field measurements to an accuracy of 0.01 mm. The field measurements and Appendix A drawings were measured in inches, while the UT shell thicknesses were provided in millimeters.

Thickness readings were recorded from the interior of the penstock generally near the invert of the penstock, typically near 4 o'clock, 6 o'clock, and 8 o'clock based on an orientation looking downstream. Points higher up the side of the penstock were not safely accessible due to the slippery sides of the penstock. Appendix D provides the ETS report of shell thickness readings.

The following sections describe the interior shell, joint condition and presents our observations.

3.2.1 Interior Surface, Coating and Joint Condition

Penstock 3 is fabricated from 30 different plate sizes ranging from 7/16 to 1 5/8 inches with 21 of these plate sizes occurring downstream of the surge tank. Inspection thickness readings were taken of 7 plate sizes upstream of the surge tank, ranging from 7/16-inch (11 mm) to 3/4-inch (19 mm). The average measured change in material thickness upstream of the surge tank compared to design was found to be approximately -4.8%, the same as the result obtained during the 2024 inspection. The steel plate thicknesses downstream of the surge tank range from 0.638 inches (16 mm) to 1.625 inches (41 mm). The average change in material thickness below the surge tank was found to be approximately -0.8%, compared to approximately −1.2% measured during the 2024 inspection. Appendix D provides the ETS report of the UT testing.

The interior of the penstock is generally in fair condition with consistent moderate corrosion and pitting with tubercles and growth (Photos 8 and 9). Pitting was moderate, relative to the plate thickness, and got more significant and deeper further downstream. A significant number of weld repairs were observed, and the previous weld repair work made this inspection a little easier as much of the organic build-up had been previously removed (Photos 10 and 11). Sporadic areas within the 17 ft diameter portion of the penstock exhibited a hollow sound under foot relative to adjacent areas during the inspection. This is most prominent just downstream of the first bend for about 2 or 3 cans. This observation may indicate localized variation in support beneath the pipe due to possible erosion; however, the cause and extent were not confirmed as part of this inspection.

Welds in Penstock 3 were cleaned with a wire wheel on a grinder, then wiped clean and painted with a white contrast paint to facilitate the MT weld test. MT testing included 71 full-length longitudinal welds and approximately 2 ft of each of the 142 circumferential welds adjacent to the tested longitudinal welds. An initial visual inspection of the weld was conducted, concentrating on the condition of the bead with regard to pitting, corrosion, cracking, undermining or washout. Particular attention was paid to welds not previously tested or repaired as part of Kleinschmidt's annual inspections. The welded joints inspected included original joints and previously repaired joints. The condition of the welded joints varied. On average welds were in fair condition and most did not exhibit excessive deterioration. Some undercutting and pitting was observed in the welds inspected this year.

Fourteen weld indications were identified during the 2025 weld inspection. A complete list of indications are as follows. Annotated photographs showing measurements are provided in Appendix C (Figures 1 to 24), and close-up photographs of the indications are provided in Appendix B (Photos 12 to 27). Pit depth measurements were not recorded during inspection.

- Can 17 South – Two Indications noted toe of longitudinal weld; one intermittent over 70 mm and one localized, approximately 19 mm long. Repair recommended.
- Can 35 North – Indication noted toe of longitudinal weld, intermittent over approximately 65 mm. Repair recommended.
- Can 67 South - Indication noted toe of longitudinal weld, intermittent over approximately 195 mm. Repair recommended.
- Can 77 South - Indication noted toe of longitudinal weld, intermittent over approximately 150 mm. Repair recommended.
- Can 79 South - Indication noted toe of longitudinal weld, intermittent over approximately 75 mm. Repair recommended.
- Can 102 South - Indication noted toe of longitudinal weld, intermittent over approximately 40 mm. Repair recommended.

- Can 254 North - Indication noted toe of longitudinal weld, over approximately 25 mm. Indication is visible and deemed acceptable by Kleinschmidt. No further repair required.
- Can 263 South - Indication noted toe of longitudinal weld, over approximately 20 mm. Indication is visible and deemed acceptable by Kleinschmidt. No further repair required.
- Can 273 North - Indication noted; removed with grinding. No further repair required.
- Can 303 North - Indication noted; removed with grinding. No further repair required.
- Can 322 North - Indication noted; removed with grinding. No further repair required.
- Can 332 North - Indication noted toe of longitudinal weld, over approximately 10 mm. Indication is visible and deemed acceptable by Kleinschmidt. No further repair required.
- Can 353 North - Indication noted; removed with grinding. No further repair required.

The repairs recommended above for six Cans 17, 35, 67, 77, 79, 102, should be completed in 2026.

During the previous inspection in 2024, the surge tank transition welds were being tested and repaired following leakage found after the 2023 surge tank transition repairs. During the 2025 inspection, leakage was observed on the upstream side of the transition (Photos 28 and 29). No seepage or leakage was observed on the downstream side at the time of inspection (Photo 30). This condition should be monitored during future inspections.

3.2.2 Appurtenances

Penstock appurtenances include vents, valves, access ports, manholes, and other components of the penstock other than supports. Bay d'Espoir's Penstock 3 has three large manholes and a bifurcation at the powerhouse.

The penstock drainage pipes and culverts were noted to be in fair condition (Photo 31 through 37). The wooded area to the left of Penstock 3 had been cleared for a new pole line and this made it easier to locate the drainage areas. Kleinschmidt identified and inspected two monitoring weirs, labelled N–1 and N-2. Drainage weir N-1, located in a wooden shack, was in fair condition and had a small amount of drainage flowing through the weir. Vegetation surrounding the shack has been cut back allowing for easier inspection and rock and debris has been cleaned from the intake.

Drainage weir N-2 was in fair condition and also had a small amount of drainage flowing through the weir. Light moss growth was noted within the drainage pipe but was less than previous years. Moss should continue to be kept clear. The drainage layout is depicted along the length of the penstock in Drawing F2106-C-1 (Appendix A); however, the termination of the drainage plumbing, and weirs are not shown.

3.3 Exterior Inspection

Kleinschmidt began the exterior inspection on November 20, 2025 at the intake and proceeded to move downstream. The inspection was completed the same day and terminated at the switchyard. The penstock is buried along its entire length with rock fill over the penstock. Kleinschmidt observed the exterior ground surface for evidence of signs of leakage such as sloughing of the soil or depressions while walking the length of the penstock. No obvious indications were observed during the 2025 exterior inspection of the penstock. An NLH operations crew was also present during the inspection and was conducting repair work along the exterior of the penstock (Photo 44).

Vegetation was observed growing in proximity to the penstock alignment. Trees should not be allowed to establish on or immediately adjacent to the penstock, and the birch tree observed should be cut/mowed and routinely controlled. When clearing brush, cut material should not be piled or stored on the penstock to avoid impediments to future inspection access.

During the 2019 exterior inspection of the penstock, a sink hole was discovered 9 ft downstream of the surge tank concrete encasement, located on the left side of the penstock. The hole was about 4 ft in diameter and 4 ft deep and was repaired and maintained in following years. The 2025 inspection had once again found the repair of the sink hole holding with no further settlement observed (Photos 38 to 41).

Along the north side of the lower portion of the penstock, sags and dips were observed at the toe of the penstock. These areas should be monitored during future inspections to confirm whether the condition is stable or progressing, and to assess any potential implications to local support conditions and drainage.

Kleinschmidt engineer Youssef Abdeldayem had observed test pits being excavated on September 23, 2025, prior to the November 2025 inspection (see Photos 42 and 43). The test pits were completed at several locations along the length of Penstock 3 upstream of the bridge crossing. Following completion of the work, the excavated areas were backfilled and restored to normal conditions. During the November inspection, remnants of the excavation activity (e.g., disturbed ground/backfill evidence) were still visible at select locations.

4.0 EVALUATION

The purpose of the evaluation is to assess the condition of the penstock and its suitability for continued operation and to identify repairs or maintenance that may be required to ensure its safe operation. Based on Kleinschmidt's experience and judgment, the four potential ways that the penstock could fail are:

1) bursting due to excessive internal pressure or loss of shell thickness;
2) general buckling due to external pressure;
3) local buckling leading to tensile cracking or general buckling; and
4) local weld failure due to improper weld procedures during construction.

4.1 Loading Conditions and Allowable Stresses

The loading conditions and allowable stresses were determined from the criteria presented in the American Society of Civil Engineers (ASCE) Manuals and Reports on Engineering Practice No. 79 Steel Penstocks, 2nd Edition. The allowable primary stress intensity is the lesser of the material yield stress (F_y) divided by 1.5 or of the ultimate tensile stress (F_u) divided by 2.4. A summary of assumed yield stress, ultimate tensile stress, and allowable stress intensity for each section of penstock can be found in Appendix E. The allowable steel stress used in this analysis was 17,000 pounds per square inch (psi) for the ASTM A285 steel and 24,000 psi for the CSA G40.8 Grade B steel.

The strength of the welded seams is reduced compared to the base material. The strength reductions are designated as "joint efficiency" and are included in the penstock stress tables in Appendix E. A joint efficiency of 70 percent was assumed for all welded joints per Table 3-3 of ASCE No. 79. A higher joint efficiency could be used for the analysis if weld testing is performed to verify the integrity of the welds. As per Manual No. 79, a joint efficiency of:

- 0.8 or 0.85 could be used if radiographic testing (RT) of the welds is performed on a percentage of welds and shows no issues; and
- 0.9 to 1.0 could be used if RT or ultrasonic testing of 100% of the welds requiring higher joint efficiency is performed.

Load cases considered include:

- stresses in the penstock under normal operating conditions;
- transient stresses in the penstock during a load rejection at normal pond elevations; and
- external surcharge loads in a dewatered condition.

4.2 Shell Stresses Induced by Internal Pressure

Table 4-1 summarizes the analysis of steel-shell thickness data and internal pressure steel stress analysis results. See Appendix D for detailed thickness data and stress calculations.

The minimum thickness measurement was determined for each penstock can and was used to calculate the allowable stresses within each penstock section. Three thickness measurements were taken at each location, A, B, and C, for each can that was inspected with a UT gauge, with nine thickness measurements in total for each can.

The maximum hoop stress in the penstock shell is due to internal static and dynamic water pressures. The stress ratio is the maximum hoop stress divided by the allowable steel stress. A hoop stress ratio less than 1.0 indicates that the penstock meets industry-standard factors of safety as designated in *ASCE Engineering Practice No. 79, Steel Penstocks* (2012).

Normal pond or Full Supply Level (FSL) and dynamic water hammer pressures were determined based on elevations given in the Appendix A drawings. Normal pond static pressures were based on an elevation of 182.7 m (599.4 ft) at the intake. Transient pressures were conservatively taken 1.3 times the static pressure applied to the entire alignment of the penstock from the intake to the powerhouse. Kleinschmidt recommends a water hammer analysis be conducted to verify peak internal pressures within the penstock. The maximum stress ratio at a joint was determined to be 1.43 (Can 221) for transient pressure load case, greater than the current allowable industry guidelines for new design. When the hoop stress is compared to the plate yield stress, also shown in Table 4-1, the minimum factor of safety is 1.05 (Can 221), which is unacceptable for the late 1960 steel pipe.

An increase in the joint efficiency factor can be justified through weld testing to verify the existing pipe joint integrity. A factor of 0.9 to 1.0 could be used for the joint efficiency upon 100 percent RT or UT of the joints. By utilizing a higher joint efficiency factor, the joint stress ratios would decrease while the factor of safety would increase. The calculations, as provided in Appendix E, include joint stress ratios calculated with an efficiency factor of 0.7.

For the steel plate away from the joints, the material has a maximum stress ratio of 1.00 and a safety factor of 1.49 at Can 221, which is not acceptable for current design practices.

Table 4-1 Summary of Thickness Data and Stresses Due to Internal Pressure

Can	Joint Stress (FSL)[1,3] (psi	Max Base Material Stress (Transient) (psi)	Dynamic Hoop Stress Increase[1,3] (psi)	Total Water Hammer Stress (Surge at Joints)[1,3] (psi)	Allowable Stress (psi)	Max Joint Stress Ratio[1,2,3]	Max Base Material Stress Ratio	Factor of Safety Against Yield (Joints)	Factor of Safety Against Yield (Base Material)
7	5,697.2	5,184.5	1,709.2	7,406.4	17,000	0.44	0.30	3.51	5.01
17	6,651.5	6,052.8	1,995.4	8,646.9	17,000	0.51	0.36	3.01	4.30
27	7,270.5	6,616.2	2,181.2	9,451.7	17,000	0.56	0.39	2.75	3.93
35	8,357.2	7,605.0	2,507.1	10,864.3	17,000	0.64	0.45	2.39	3.42
45	9,923.2	9,030.2	2,977.0	12,900.2	17,000	0.76	0.53	2.02	2.88
57	11,666.1	10,616.2	3,499.8	15,166.0	17,000	0.89	0.62	1.71	2.45
66	13,584.2	12,361.6	4,075.3	17,659.5	17,000	1.04	0.73	1.47	2.10
77	14,921.5	13,578.5	4,476.4	19,397.9	17,000	1.14	0.80	1.34	1.91
101	18,498.1	16,833.2	5,549.4	24,047.5	24,000	1.00	0.70	1.50	2.14
111	19,474.9	17,722.1	5,842.5	25,317.3	24,000	1.05	0.74	1.42	2.03
122	21,363.1	19,440.4	6,408.9	27,772.0	24,000	1.16	0.81	1.30	1.85
131	16,370.5	14,897.1	4,911.1	21,281.6	24,000	0.89	0.62	1.69	2.42
151	20,303.7	18,476.4	6,091.1	26,394.8	24,000	1.10	0.77	1.36	1.95
161	20,048.5	18,244.2	6,014.6	26,063.1	24,000	1.09	0.76	1.38	1.97
174	24,714.2	22,489.9	7,414.3	32,128.5	24,000	1.34	0.94	1.12	1.60
182	22,605.6	20,571.1	6,781.7	29,387.2	24,000	1.22	0.86	1.23	1.75
193	18,924.9	17,221.7	5,677.5	24,602.4	24,000	1.03	0.72	1.46	2.09
221	26,483.1	24,099.6	7,944.9	34,428.0	24,000	1.43	1.00	1.05	1.49
230	23,755.9	21,617.8	7,126.8	30,882.6	24,000	1.29	0.90	1.17	1.67
242	20,400.1	18,564.1	6,120.0	26,520.1	24,000	1.11	0.77	1.36	1.94
261	25,379.3	23,095.2	7,613.8	32,993.1	24,000	1.37	0.96	1.09	1.56
272	25,217.1	22,947.5	7,565.1	32,782.2	24,000	1.37	0.96	1.10	1.57
283	24,556.6	22,346.5	7,367.0	31,923.6	24,000	1.33	0.93	1.13	1.61
291	24,171.8	21,996.3	7,251.5	31,423.3	24,000	1.31	0.92	1.15	1.64
303	23,529.7	21,412.1	7,058.9	30,588.7	24,000	1.27	0.89	1.18	1.68
314	23,211.4	21,122.4	6,963.4	30,174.9	24,000	1.26	0.88	1.19	1.70
321	24,086.8	21,919.0	7,226.1	31,312.9	24,000	1.30	0.91	1.15	1.64
331	22,047.7	20,063.4	6,614.3	28,662.0	24,000	1.19	0.84	1.26	1.79
341	22,303.4	20,296.1	6,691.0	28,994.5	24,000	1.21	0.85	1.24	1.77
352	22,599.5	20,565.5	6,779.8	29,379.3	24,000	1.22	0.86	1.23	1.75
361	22,817.8	20,764.2	6,845.3	29,663.1	24,000	1.24	0.87	1.21	1.73

Notes: [1] Joint efficiency of 0.7 included
[2] Total stress / Allowable stress
[3] Uses minimum can thickness
[4] SF = Fy/Total stress

4.3 General Buckling Induced by External Loads

General shell buckling occurs when an external pressure implodes the penstock shell along its longitudinal axis. The penstock was analyzed for buckling due to external loads applied to the top 120 degrees of the pipe. Per the National Building Code of Canada, the snow load calculated is 20.61 pounds per square foot (psf), and the depth of soil cover on the penstock was assumed to be 0.9 m (3 ft). Conservatively, an additional live load of 100 psf was used for analysis to account for potential off-road vehicle loads or equipment. Three external loading combinations were considered in the analysis of the penstock. Load combinations include the following:

1. DL (water and steel) + internal vacuum pressure
2. DL (water and steel) + snow load
3. DL (water and steel) + combination snow (75%) and live load (75%)

Notes:

- No vehicular loading was used in the analysis where it does not pass under roadways and, because of the rough rock cover, could not be driven over.
- The penstock is buried; therefore, wind and earthquake were not used in the analysis. Seismic loading was not included, as the Bay d'Espoir site is located in a region of relatively low seismic hazard. An earthquake analysis could be performed, but it would be more involved and time-consuming and was not included in the scope of work.
- We assume the penstock is located in cohesive fine-grained soil above the local groundwater table, with drainage piping provided underneath the penstock. External water pressure on the dewatered penstock is not considered an applicable loading condition as there is adequate drainage.

The maximum pressure calculated was for the 5.2-m (17-ft) diameter pipe due to shell dead load, soil cover, live load, and snow load. The maximum pressure was determined to be 3.72 psi, which is less than the allowable buckling pressure of 4.05 psi. The 4.6-m (15.25-ft) and 4.1-m (13.5-ft) diameter sections were also analyzed, and the max pressures are summarized in Table 4-2.

4.3.1 Surcharge Load Analysis

A surcharge load analysis was completed for the shallow buried sections of penstock with 100 pounds per square foot external live load with the snow load combination. Lowest measured steel thickness values were used.

Table 4-2 Summary of Surcharge Load Analysis

Penstock Diameter (ft)	Allowable External Pressure (psi)	Snow Load (psi)	Snow + 100 psf Live Load (psi)
17.00	4.05	3.24	3.72
15.25	7.18	3.91	4.39
13.50	10.81	4.30	4.78

There was no new vehicular surcharge analysis conducted as we are not expecting changes in the results from the original analysis conducted by Kleinschmidt in 2016 for Penstock No. 2. The 2016 analysis for Penstock No. 2 showed the soil pressures due to an HS-20 truck load per AASHTO Standard Specifications (AWWA 2004), which is a 72,000-pound, three-axle truck with axles spaced at 4.3 m (14 ft) from the front axle to the middle axle, then variable from 4.3 to 8.5 m (14 to 28 ft) to the rear axle, was approximately five times less than the allowable buckling loads at that location. For the section of penstock analyzed, live loads have minimal increase in soil pressures to the penstock given the depth of overburden. This conclusion is also considered applicable to Penstock No. 3 due to the similarity in design and configuration between Penstocks No. 2 and No. 3.

4.3.2 Sub-atmospheric Internal Penstock Pressure Analysis

Sub-atmospheric internal pressure can occur if the penstock is dewatered quickly without adequate venting downstream of a headgate or as the result of a negative transient wave pressure. Evaluating negative internal pressures due to transient pressures was outside the scope of this project and a detailed hydrodynamic model was not created for this report, but the likelihood of occurrence of sub-atmospheric pressure is minimal, and allowable buckling pressures are greater than potential negative pressures due to transient waves at startup. Vent capacity was evaluated according to the *Hydroelectric Handbook*, Section 31 – Air Inlets (Creager and Justin 1950), assuming that water is stopped due to a headgate closing and that the full flow of the penstock is stopped all at once at the intake. Based on this calculation the required vent area is approximately 0.29 m^2 (3.07 ft^2), which is well below the area provided by the approximately 5.1-m^2 (55-ft^2) existing openings.

4.4 Local Buckling and Stresses

Local buckling occurs when a point load causes a small area of the shell to be stressed beyond its material buckling stress limits, and it becomes permanently deformed. Boulders and rocks could be a source of point loads, but no serious deformations were noted in the inspection. The penstock is continuously supported by the soil, so it is unlikely there are excessive local buckling stresses in the penstock.

5.0 CONCLUSIONS

Based on inspection findings and evaluation, the existing steel plating has about 50 years of remaining service life. However, the 17 ft section of the penstock should be replaced, the remaining welds refurbished, and the interior of the penstock re-coated to prevent further corrosion. Replacing the welds from the inside of the penstock only may not fully mitigate the issues in the 17 ft section of penstock and will prove costly while resulting in a repair that does not instill confidence in the longevity of the repair and continued safe operation. This has been highlighted again this year with multiple indications discovered in Penstock 3 in previously repaired welds. Indications found in 7-year-old welds indicates that the weld repairs may have a limited life expectancy. Most indications were found in the 17-ft diameter section this year indicating again that this section of penstock is particularly prone to weld indications. This section of penstock has the largest diameter and the thinnest plate, is made of a different steel grade than the rest of the penstock and has peaking induced residual stresses at the joints. The 17-ft diameter section of Penstock 3 should be replaced to remove the risk of future failures during operation and to provide confidence in the 17 ft section that will not be gained by repairing the welds. The remainder of the penstock should have extensive weld replacement from the inside and the outside if it can be completed both economically and effectively within 5 years.

5.1 Shell Condition and Thickness

Measurements of the penstock shell thickness indicate minimal loss of material thickness over design. Significant moderate pitting was noted with organic material buildup on the interior penstock surface. Assuming similar rates of material loss, the penstock should have 50 to 70 years of service life remaining if recoated. The base plate material away from the joints can tolerate up to 3 mm (1/8 inch) further material loss in many locations and maintain a stress ratio below 1.0, but some cans may require reinforcement depending on further analysis.

5.2 Internal Pressure Strength

Stress ratios for a combined static and dynamic internal pressures peak at 1.49 (Table 4-1). This indicates that the penstock does not meet present day design criteria for new penstock design. When the hoop stress is compared to the plate yield stress the minimum factor of safety is 1.05. As noted previously this assumes a joint efficiency of 0.7 which can be improved upon with RT testing of the welds as noted in Section 4.1. The first step should be to perform at least spot RT testing per the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII, Division 1. Positive results will validate the use of a higher joint efficiency, improving the results by lowering the stress ratios and improving confidence in the performance of the penstock.

The second step should be to run a more accurate surge stress analysis if one has not already been completed to verify the pressures. Consideration should be given to coating the penstock to limit further deterioration.

5.3 Remaining Service Life

The expected service life for a steel penstock is typically at least 80 years (ASCE 2012). This approximately 50-year-old penstock has shown little loss of thickness from the original plate thicknesses, but the stress analyses indicate sections of the penstock do not meet acceptable factors of safety at the joints by today's standards and there have been issues with the welds that justify the use of the 0.7 joint efficiency factor.

6.0 RECOMMENDATIONS

Penstock 3 17-ft diameter section should be replaced within five years. In order of priority, Penstock 3 should be refurbished before Penstock 2. The penstock plating is in fair condition and Kleinschmidt has the following recommendations to extend the life of the penstock provided that the penstock welds are replaced. These recommendations include:

- Repair the indications in Cans 17, 35, 67, 77, 79, 102
- recoating the interior of the penstock;
- Radiographic testing of the welds if possible;
- Surge Analysis to verify peak pressure and resulting stresses;
- inspection and repair of the drainage system;
- monitoring of the exterior for signs of leakage; and
- continued inspections of the interior including MP weld testing. An increase in testing in the 17-ft diameter section is recommended as noted in Section 6.3 below.

The Surge Analysis should be completed before refurbishment to confirm stresses that may be used in weld sizing. Monitoring for leakage is something that should be done for every penstock regardless of age, construction, or condition. It is an early indicator of issues. Leakage for buried penstocks is most effectively done by monitoring drainage pipes and looking for wet areas and sink holes along the penstock alignment. MP weld testing after coating is applied may not be possible without removing the coating but not unheard of and will be dependent on coating system used. Other forms of weld testing are available that can test through paint such as the MagnaFORM Probe from Olympus. Considering indications were found at previously repaired welds this is something that will require further investigation and consideration.

6.1 Coating

Kleinschmidt recommends coating the interior of the penstock in the next 5 years. At this stage, Kleinschmidt is unable to estimate the rate of corrosion of the steel. There is no standard rate of corrosion as there are many variables; the specific properties and components of the steel, the acidic properties of the water, silt amounts in the water, the acidity and corrosiveness of the surrounding solids, and the penstock also has organic build-up along the pipe which can either contribute to accelerated corrosion on bare steel or help build a protective barrier. Stress ratios are high enough that it would be prudent to plan for a recoating to reduce loss of material thickness and extend the service life of the penstock. A quality field applied penstock coating can last 20-40 years. If the penstock is recoated prior to significant steel deterioration every 20-40 years, NLH can anticipate extending the life of the penstock potentially another 80 years depending on the section loss realized when cleaning the penstock. The coating will not prevent the eventual corrosion of the shell from the exterior. The exterior is currently coated, but it is difficult to tell its condition.

6.2 Exterior Inspection

The repaired sinkhole downstream of the surge tank should continue to be monitored.

It is recommended that the observation well downstream, and to the left of the surge tank, be inspected from the bottom. It is recommended that the drainage system be scoped with a camera from the bottom of this well and from the other wells in the area to determine if there is blockage upstream or downstream of the wells. A properly functioning and monitored penstock drainage system can provide early warning of penstock leakage. It would be good to have a better understanding of the drainage system prior to penstock refurbishment to scope modifications if required.

Kleinschmidt recommends continuing to monitor the exterior of the penstocks for signs of leakage. Drainpipes should also be monitored at times with consistent weather conditions.

6.3 Interior Inspections

Kleinschmidt recommends that NLH conducts a Level II inspection with MP testing of the welds and UT thickness measurements every year the penstock is dewatered until the life extension work is complete. Weld indications continue to be found and yearly testing is warranted. Based on 2025 findings in Penstock 3 and subsequent repairs, it is recommended that the quantity of welds tested remain at a minimum of 10 percent in the 7/16-inch-thick plated section in 2026. It is also noted that the majority of indications have been found closer to the spring line which can be reached from the TRR standard platform. Interior inspections should continue yearly until the penstock is refurbished.

Seven indications in six Cans requiring repairs were found in 2025. Although they were relatively small and did not require immediate repairs, they should be repaired in 2026.

7.0 REFERENCES

Acres International Limited. 1988. Regulation Study of Bay D'Espoir System. Study Report to Newfoundland and Labrador Hydro. St John's, Newfoundland.

American Society of Civil Engineers (ASCE). 1995. Guidelines for Evaluation of Aging Penstocks. American Society of Civil Engineers. New York, New York.

American Society of Civil Engineers (ASCE). 2012. Steel Penstocks – ASCE Manuals and Reports on Engineering Practice No. 79. 2nd Edition. American Society of Civil Engineers. Reston, Virginia.

American Society of Mechanical Engineers (ASME). 2004. Boiler and Pressure Vessel Code Section VIII Division 1. American Society of Mechanical Engineers New York, New York.

America Water Works Association (AWWA). 2004. Steel Pipe – A Guide for Design and Installation, Manual M11. 4th Edition. American Water Works Association. Denver, Colorado.

Creager, W. P., and J. D. Justin. 1950. Hydroelectric Handbook. 2nd Edition. Wiley. Minneapolis, Minnesota.

Hatch. 2018. Bay d'Espoir Level II Condition Assessment of Penstocks No. 1, 2, and 3. Rev 0 Final. December 13, 2018.

Hatch. 2019. Newfoundland and Labrador Hydro Final Report for Condition Assessment and Refurbishment Options for Penstocks No. 1, 2 and 3. Rev 0. March 28, 2019.

Kleinschmidt Associates. 2016. Crack Investigation and Repair Report, Penstock No. 1 Bay d'Espoir Hydroelectric Development. Kleinschmidt Technical Report to Newfoundland and Labrador Hydro.

SIGNATURE PAGE

KLEINSCHMIDT ASSOCIATES CANADA INC.

REGISTERED PROFESSIONAL ENGINEER
PEG Newfoundland and Labrador
CHRISTOPHER M. VELLA
SIGNATURE
April 27, 2026
DATE
NEWFOUNDLAND & LABRADOR

Chris M. Vella, P.Eng.
Project Manager

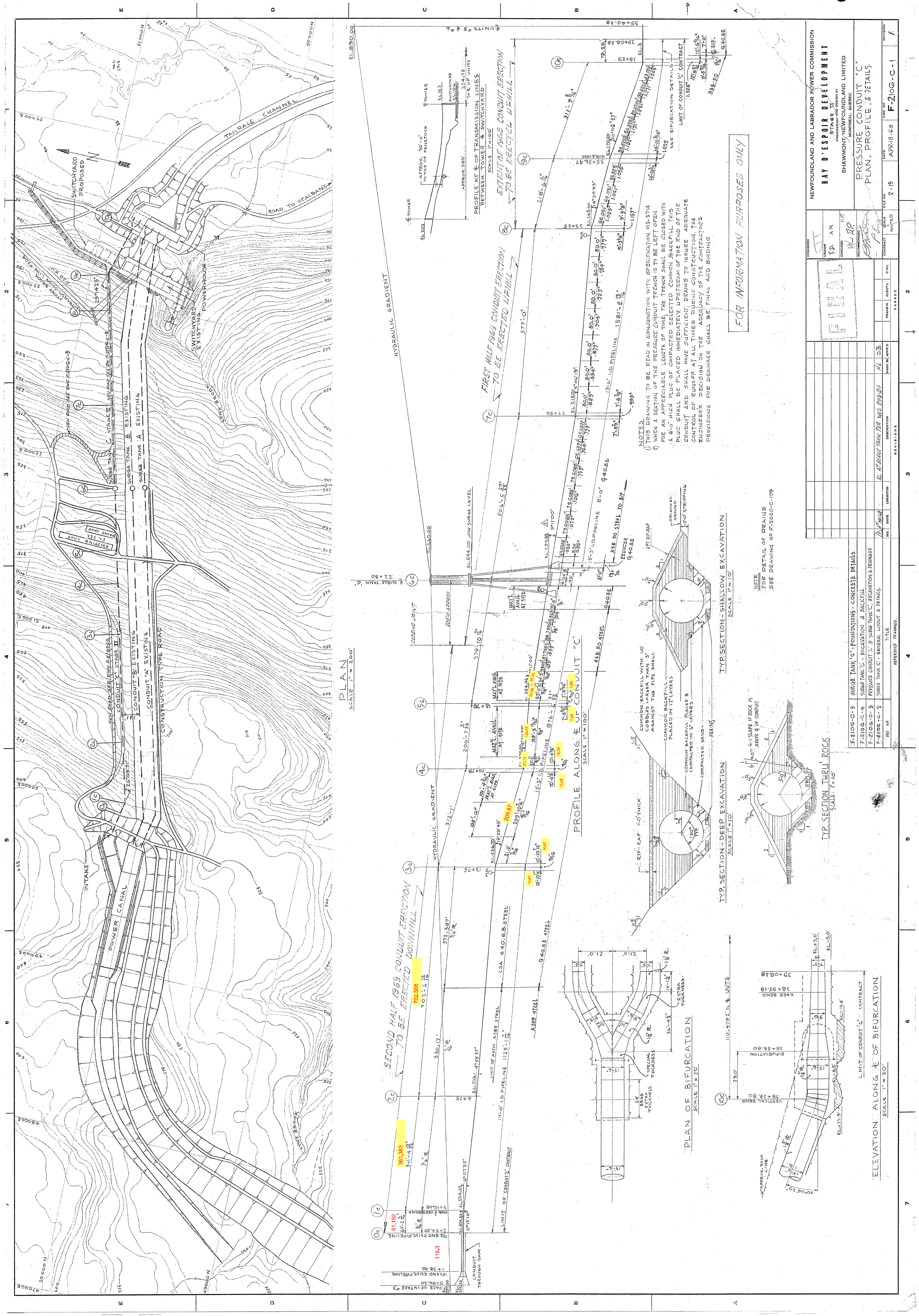
CMV:SCB

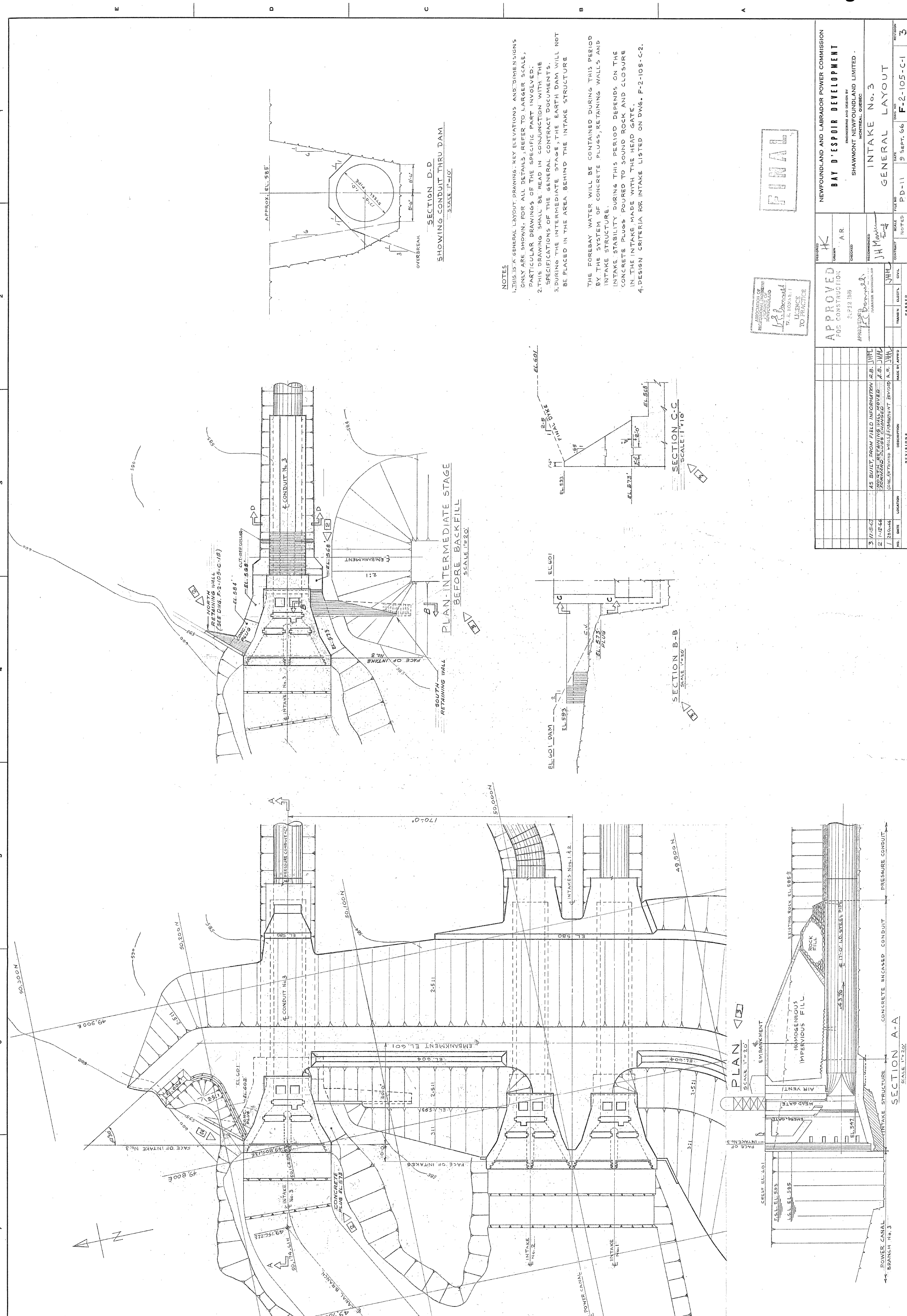
PROVINCE OF NEWFOUNDLAND AND LABRADOR
PEG Newfoundland and Labrador
PERMIT HOLDER
This Permit Allows
KLEINSCHMIDT ASSOCIATES CANADA INC.
To practice Professional Engineering in Newfoundland and Labrador.
Permit No. as issued by PEGNL N0708
which is valid for the year 2026

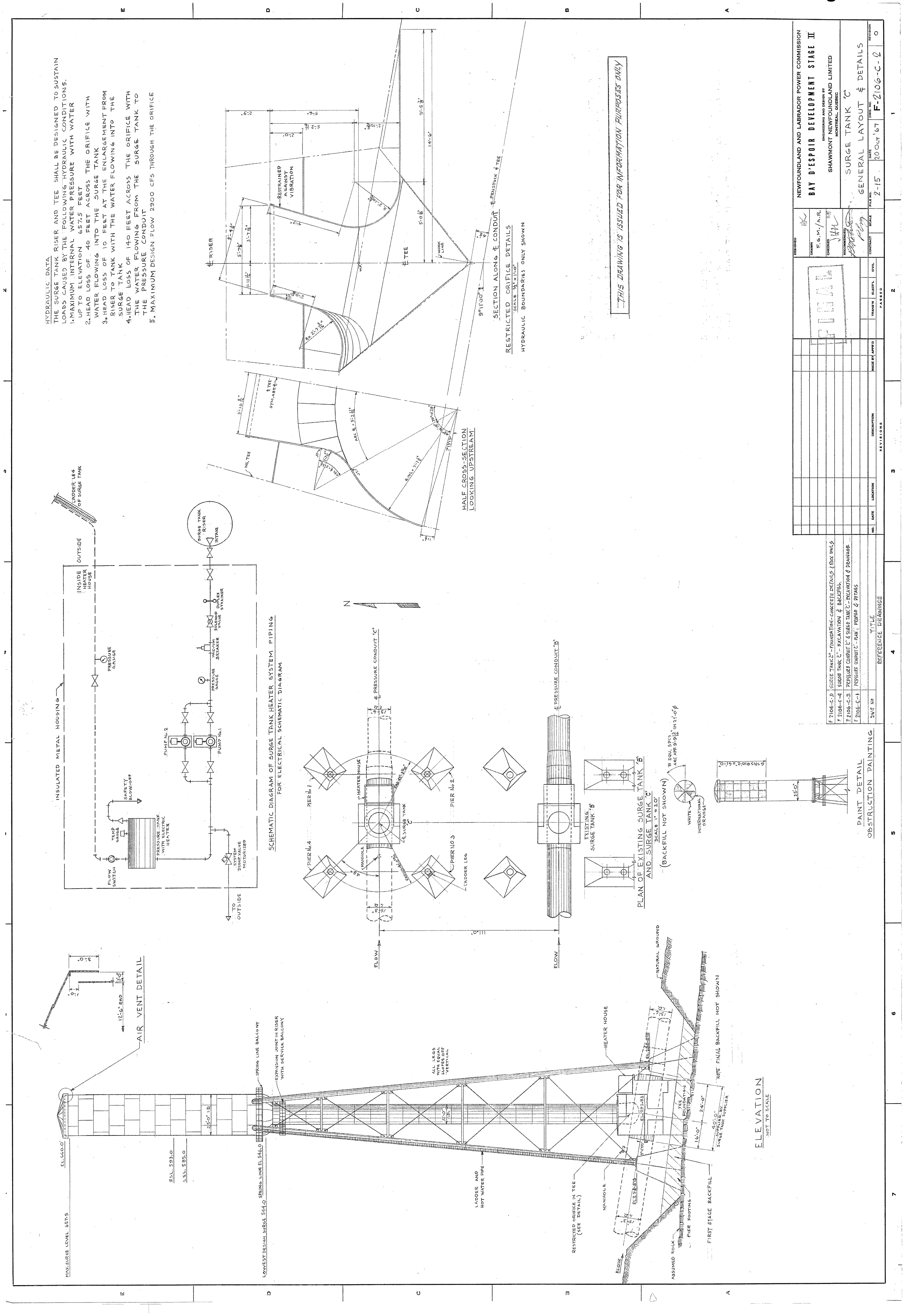
\\EgnyteDrive\Kleinschmidt\Jobs\2670\043\Docs\2025 Penstock Inspections\Penstock 3

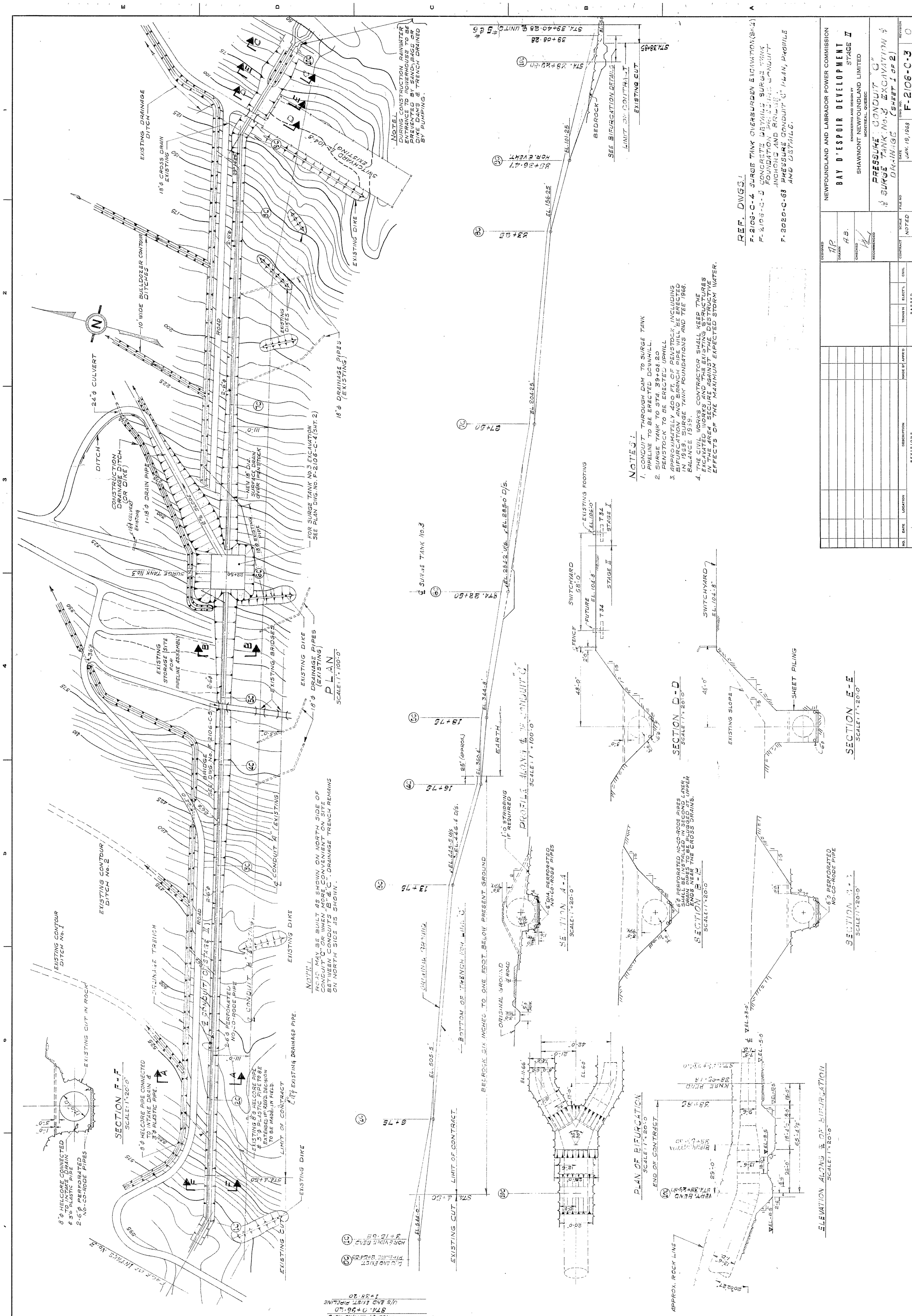
APPENDIX A

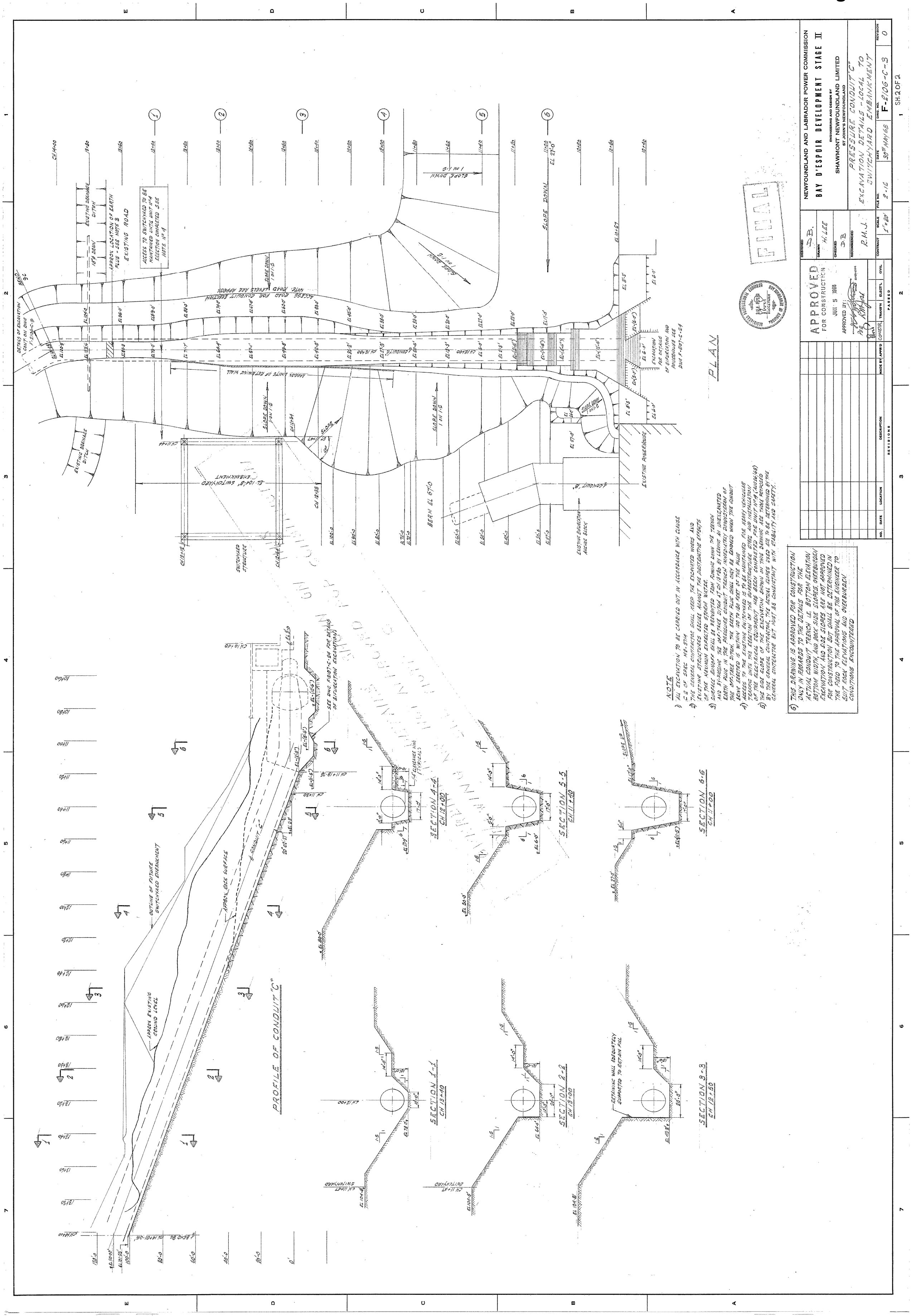
PENSTOCK LAYOUT DRAWINGS

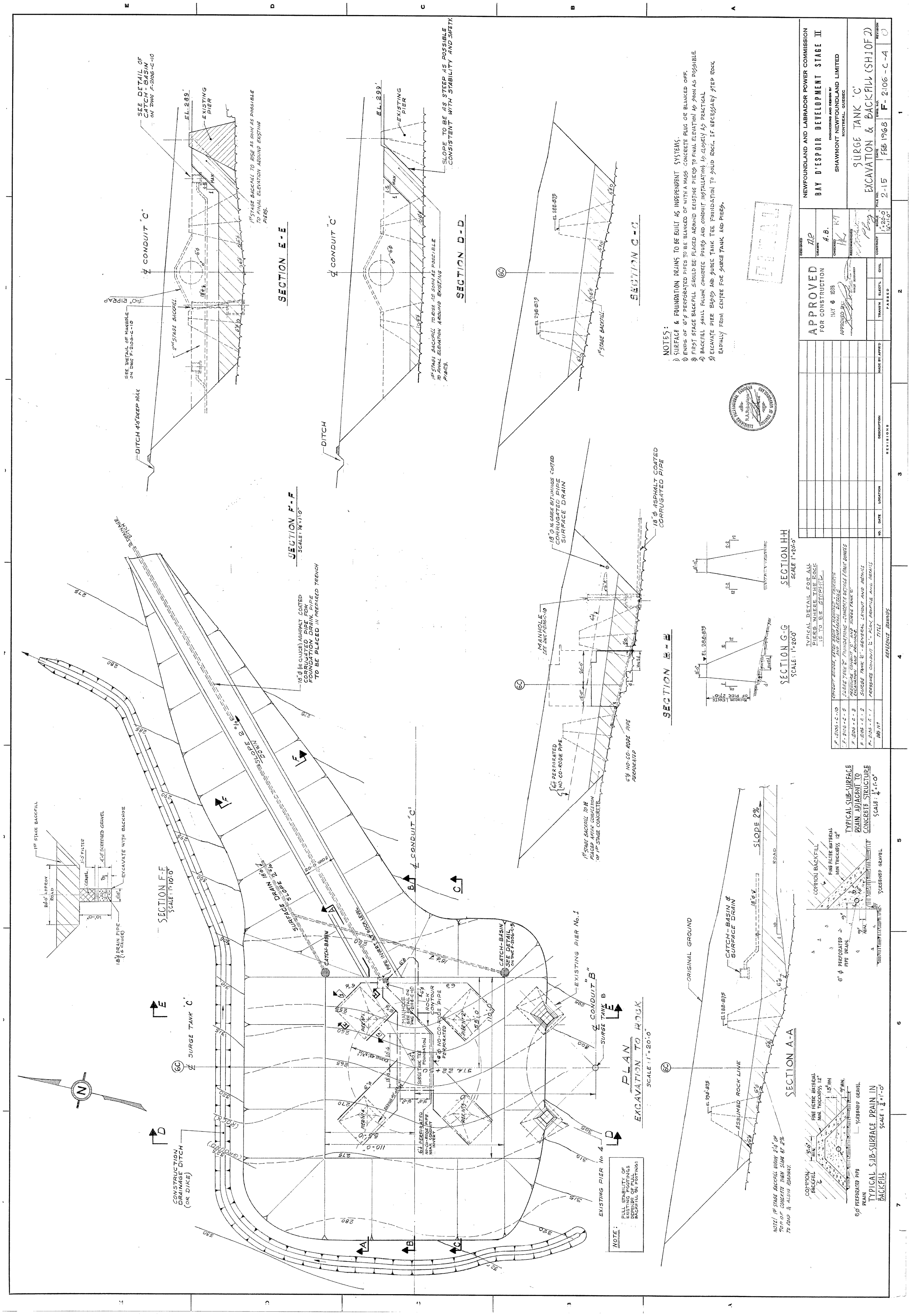

NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT
SHAWMONT/NEWFOUNDLAND LIMITED
PRESSURE CONDUIT "C"
PLAN, PROFILE, & DETAILS
F-210G-C-1
FOR INFORMATION PURPOSES ONLY
PLAN
PROFILE ALONG ℄ CONDUIT "C"
PLAN OF BIFURCATION
ELEVATION ALONG ℄ OF BIFURCATION
TYP. SECTION - SHALLOW EXCAVATION
TYP. SECTION - DEEP EXCAVATION
TYP. SECTION THRU' ROCK
FIRST HALF 1969 CONDUIT ERECTION TO BE ERECTED UPHILL
SECOND HALF 1969 CONDUIT ERECTION TO BE ERECTED DOWNHILL
HYDRAULIC GRADIENT
POWER CANAL
INTAKE
TAILRACE CHANNEL
ROAD TO ST. ALBANS
SWITCHYARD PROPOSED
POWERHOUSE

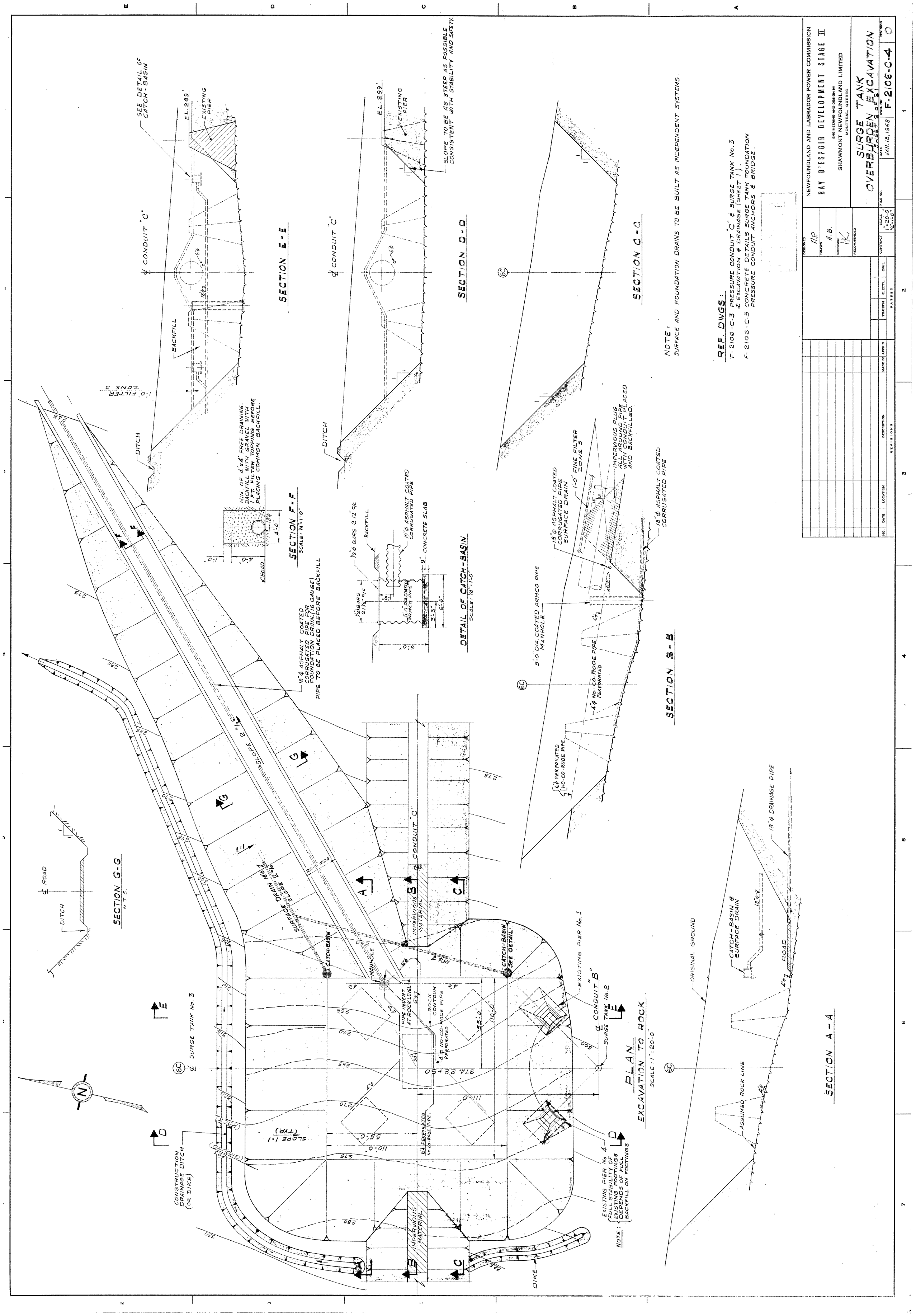

NOTES
1. THIS IS A GENERAL LAYOUT DRAWING. KEY ELEVATIONS AND DIMENSIONS ONLY ARE SHOWN. FOR ALL DETAILS, REFER TO LARGER SCALE, PARTICULAR DRAWINGS OF THE SPECIFIC PART INVOLVED.
2. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATIONS OF THE GENERAL CONTRACT DOCUMENTS.
3. DURING THE INTERMEDIATE STAGE, THE EARTH DAM WILL NOT BE PLACED IN THE AREA BEHIND THE INTAKE STRUCTURE.
THE FOREBAY WATER WILL BE CONTAINED DURING THIS PERIOD BY THE SYSTEM OF CONCRETE PLUGS, RETAINING WALLS AND INTAKE STRUCTURE.
INTAKE STABILITY DURING THIS PERIOD DEPENDS ON THE CONCRETE PLUGS POURED TO SOUND ROCK AND CLOSURE IN THE INTAKE MADE WITH THE HEAD GATE.
4. DESIGN CRITERIA FOR INTAKE LISTED ON DWG. F-2-105-C-2.
PLAN
SCALE 1"=20'
SECTION A-A
SCALE 1"=20'
PLAN-INTERMEDIATE STAGE BEFORE BACKFILL
SCALE 1"=20'
SECTION B-B
SCALE 1"=20'
SECTION C-C
SCALE 1"=10'
SECTION D-D
SHOWING CONDUIT THRU DAM
SCALE 1"=10'
NORTH RETAINING WALL (SEE DWG. F-2-105-C-18)
SOUTH RETAINING WALL
FACE OF INTAKE No. 3
CONDUIT No. 3
INTAKE No. 1
INTAKE No. 2
INTAKE No. 3
INTAKES Nos. 1 & 2
POWER CANAL
CANAL BRANCH
CONCRETE PLUG EL. 573'
EMBANKMENT EL. 601
HOMOGENEOUS IMPERVIOUS FILL
ROCK FILL
EXISTING ROCK EL. 586±
17'-0" I.D. STEEL PIPE
AIR VENT
HEAD GATE
POWER CANAL BRANCH No. 3
INTAKE STRUCTURE
CONCRETE ENCASED CONDUIT
PRESSURE CONDUIT
APPROX. EL. 585'
OVERBREAK
FINAL DYKE
FINAL
APPROVED FOR CONSTRUCTION
LICENCE TO PRACTICE
AS BUILT, FROM FIELD INFORMATION
NORTH RETAINING WALL MOVED FORWARD, PLUGS CHANGED
CONC. RETAINING WALLS & EMBANKMENT REVISED
REVISIONS
NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT
ENGINEERING AND DESIGN BY
SHAWMONT NEWFOUNDLAND LIMITED
MONTREAL, QUEBEC
INTAKE No. 3
GENERAL LAYOUT
NOTED
PD-11
9 SEPT. 66
F-2-105-C-1
3

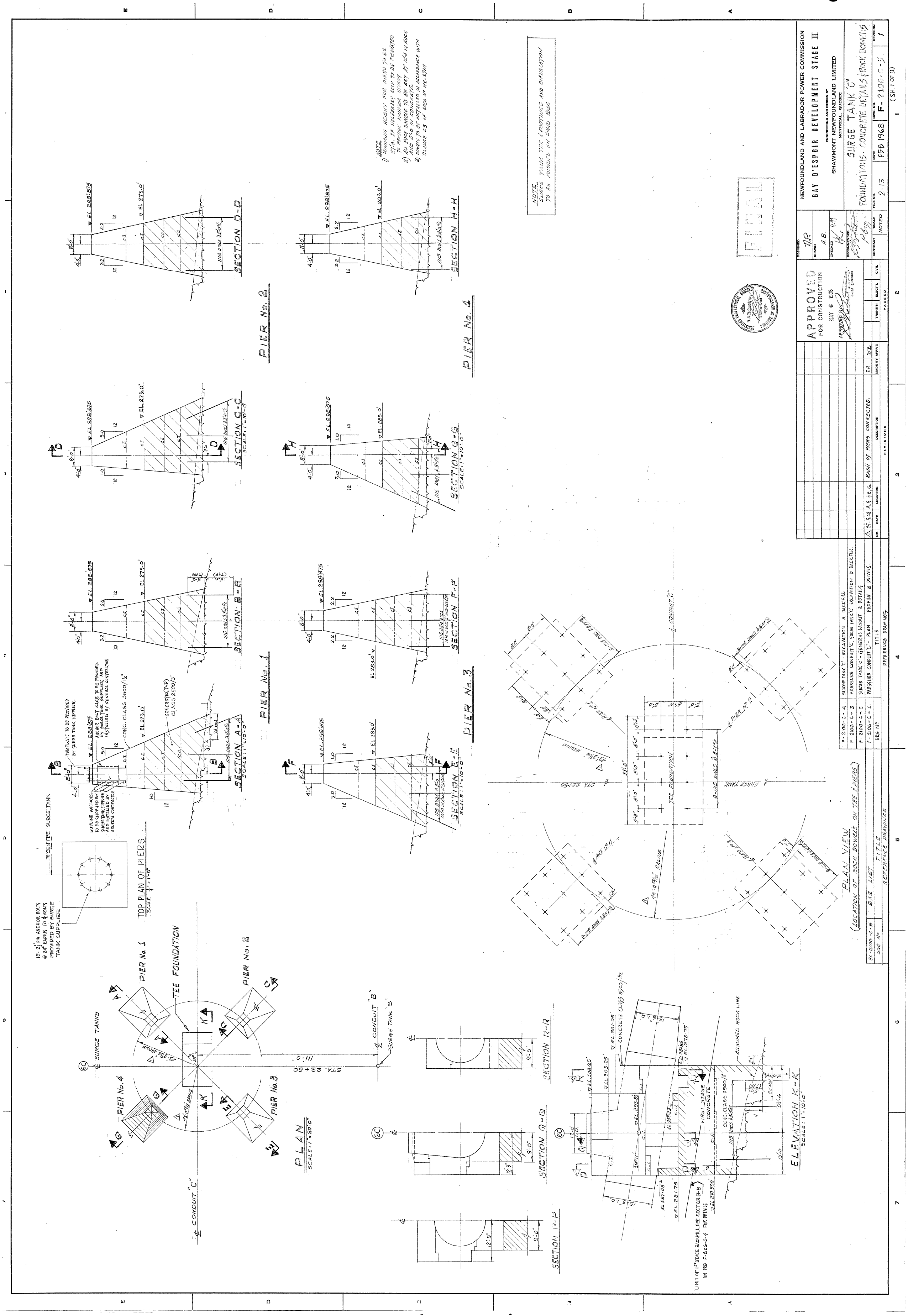

HYDRAULIC DATA
THE SURGE TANK RISER AND TEE SHALL BE DESIGNED TO SUSTAIN LOADS CAUSED BY THE FOLLOWING HYDRAULIC CONDITIONS.
1. MAXIMUM INTERNAL WATER PRESSURE WITH WATER UP TO ELEVATION 657.5 FEET
2. HEAD LOSS OF 40 FEET ACROSS THE ORIFICE WITH WATER FLOWING INTO THE SURGE TANK
3. HEAD LOSS OF 10 FEET AT THE ENLARGEMENT FROM RISER TO TANK WITH THE WATER FLOWING INTO THE SURGE TANK
4. HEAD LOSS OF 140 FEET ACROSS THE ORIFICE WITH THE WATER FLOWING FROM THE SURGE TANK TO THE PRESSURE CONDUIT
5. MAXIMUM DESIGN FLOW 2900 CFS THROUGH THE ORIFICE
SECTION ALONG ℄ CONDUIT
RESTRICTED ORIFICE DETAILS
HYDRAULIC BOUNDARIES ONLY SHOWN
HALF CROSS-SECTION LOOKING UPSTREAM
THIS DRAWING IS ISSUED FOR INFORMATION PURPOSES ONLY
SCHEMATIC DIAGRAM OF SURGE TANK HEATER SYSTEM PIPING
FOR ELECTRICAL SCHEMATIC DIAGRAM
INSULATED METAL HOUSING
PLAN OF EXISTING SURGE TANK 'B' AND SURGE TANK 'C'
(BACKFILL NOT SHOWN)
PAINT DETAIL
OBSTRUCTION PAINTING
AIR VENT DETAIL
ELEVATION
NOT TO SCALE
REFERENCE DRAWINGS
NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
SURGE TANK 'C'
GENERAL LAYOUT & DETAILS
F-2106-C-2

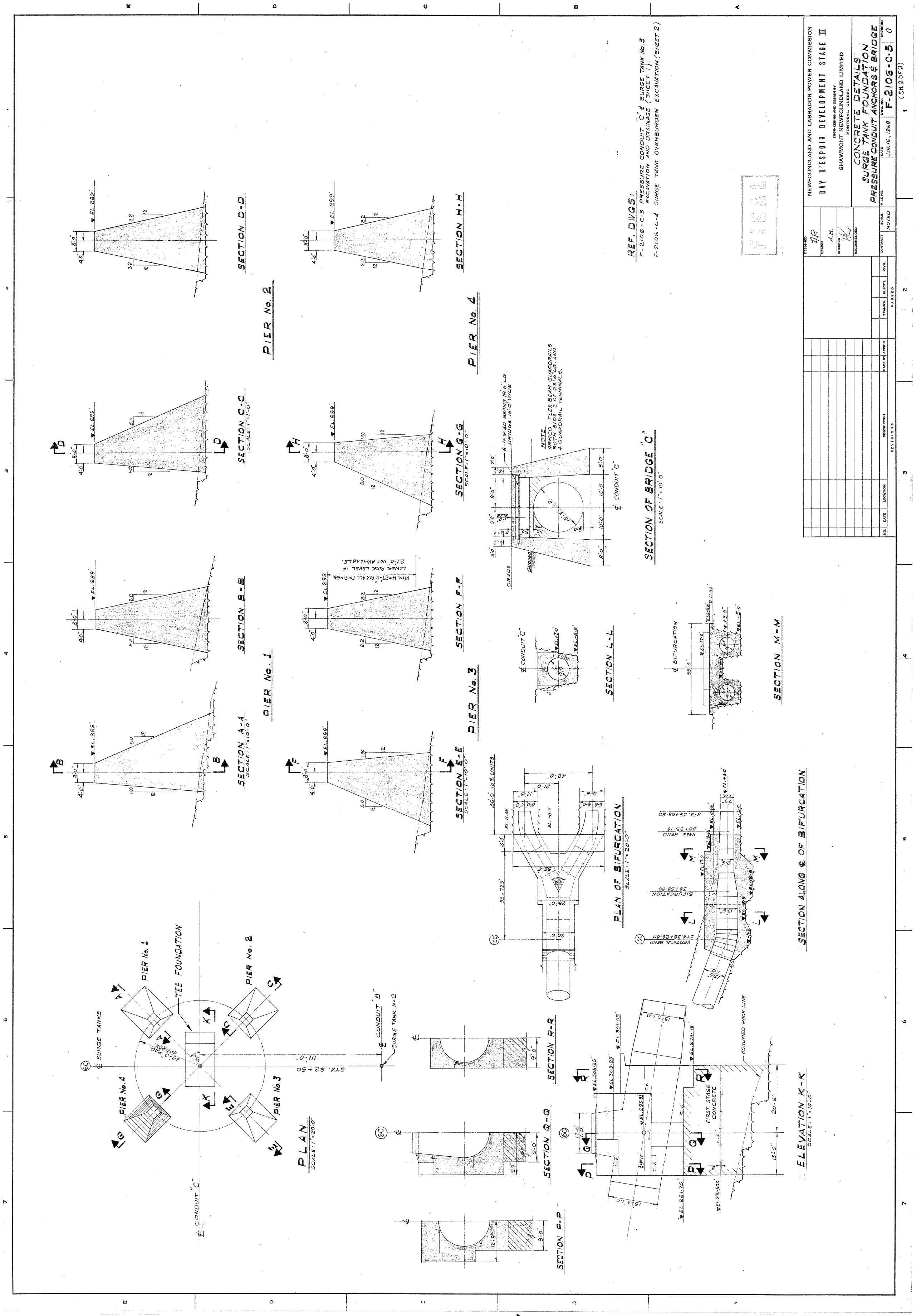

NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT
STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
F-2106-C-3
PLAN
SECTION D-D
SECTION E-E
SECTION F-F
PLAN OF BIFURCATION
ELEVATION ALONG ℄ OF BIFURCATION
SURGE TANK No.3
EXISTING DIKE
EXISTING DRAINAGE DITCH
24"ϕ CULVERT
SWITCHYARD

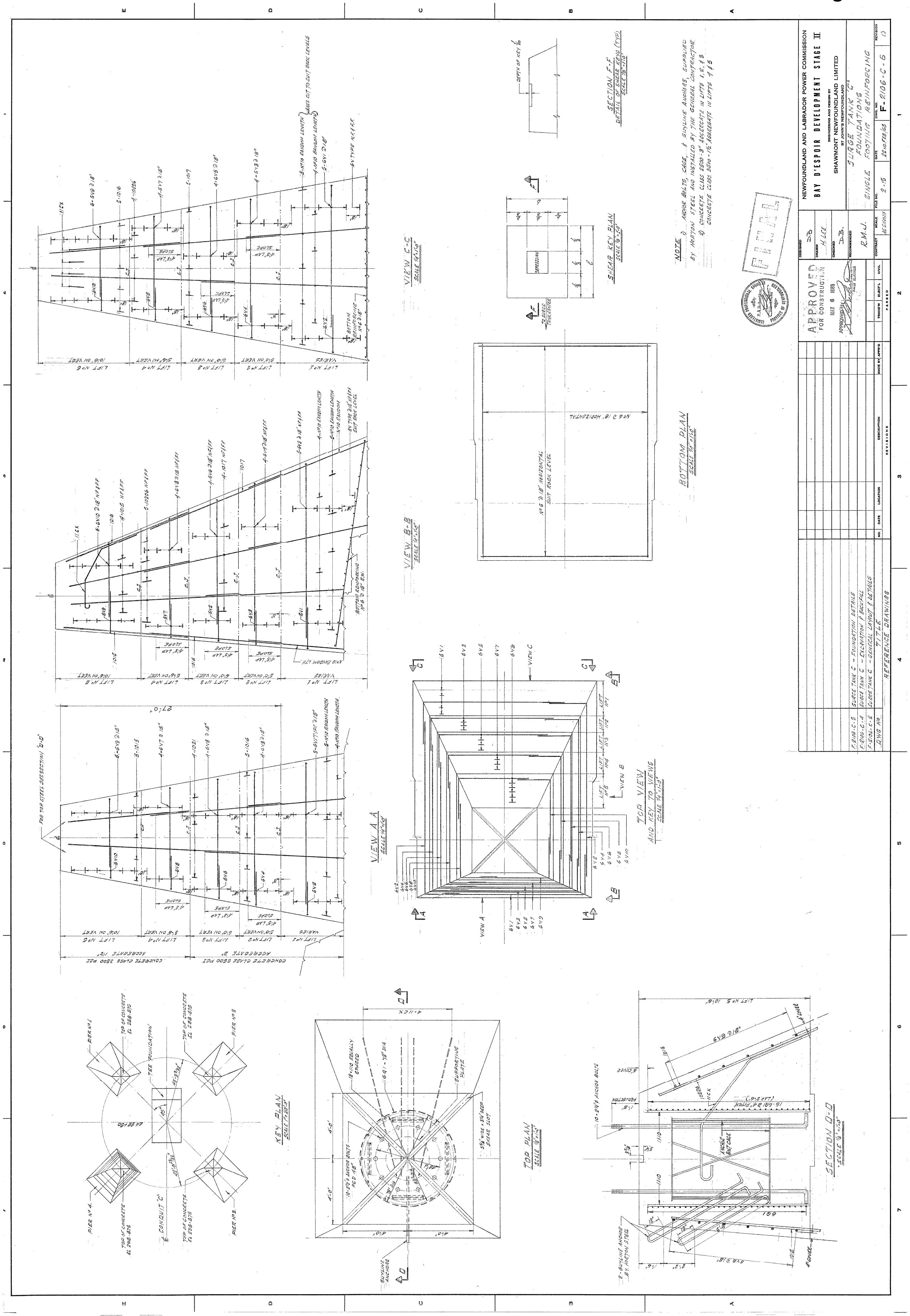

NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
PLAN
PROFILE OF CONDUIT "C"
APPROVED FOR CONSTRUCTION
FINAL
F-2106-C-3

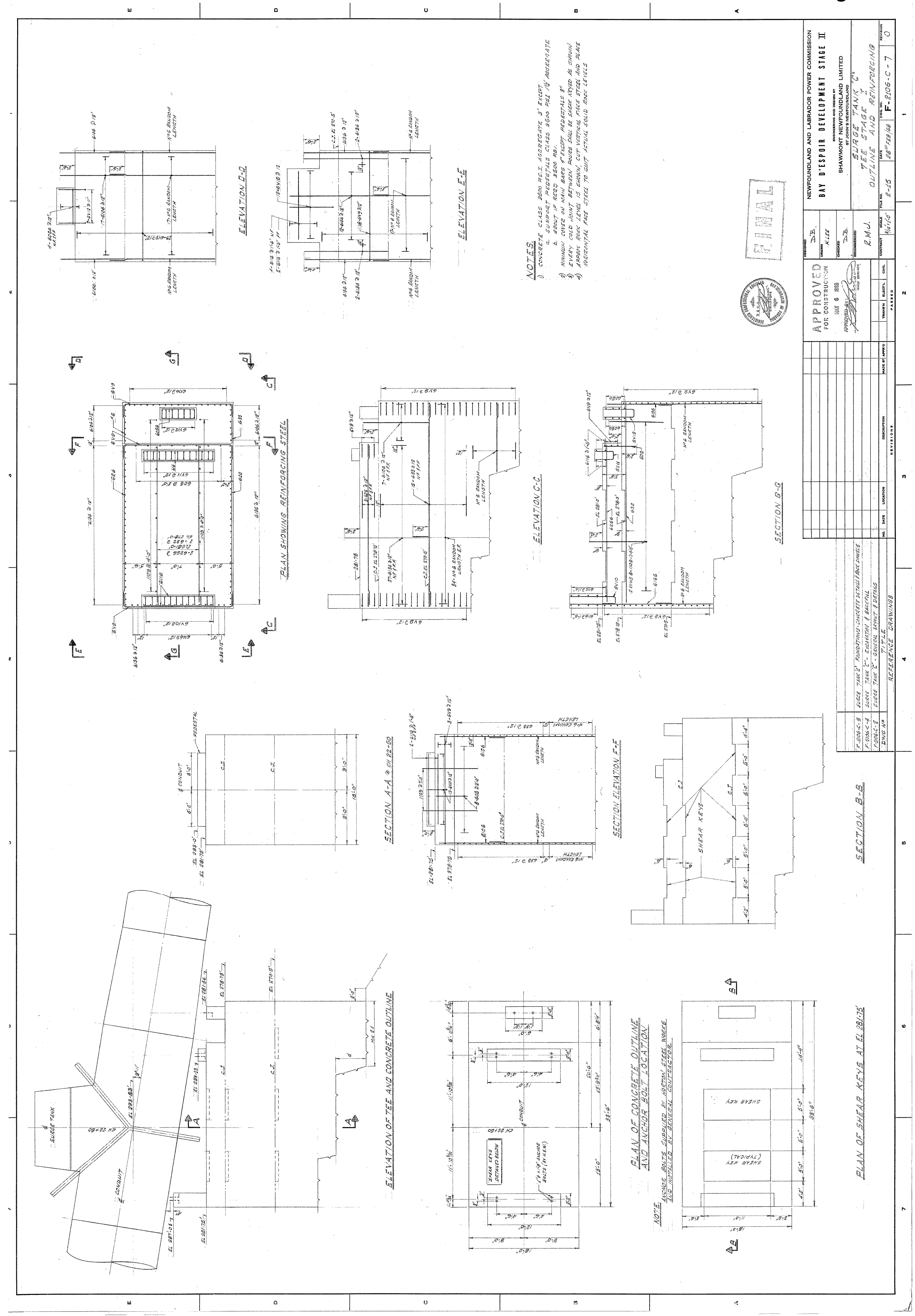


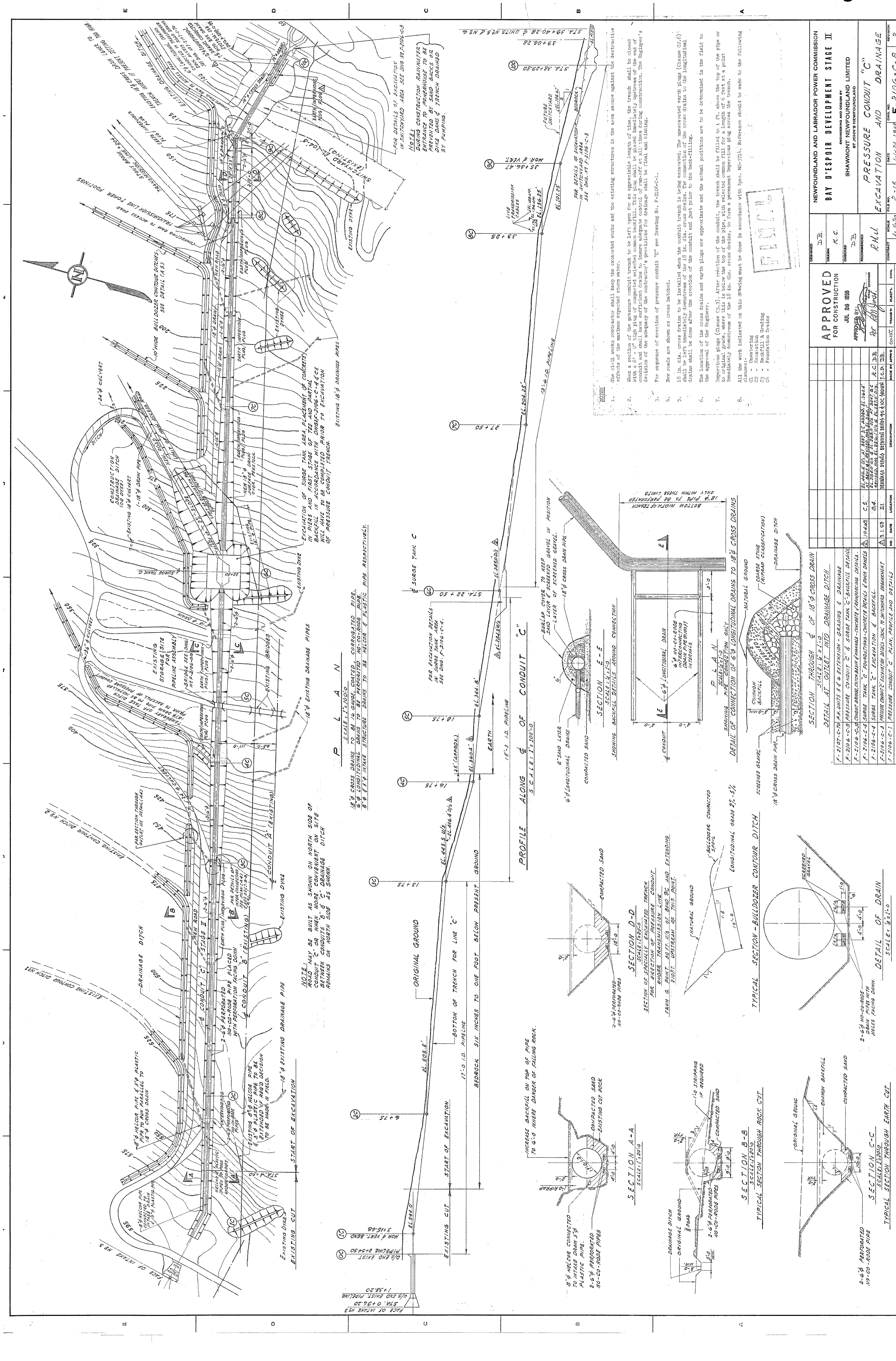

NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
MONTREAL, QUEBEC
SURGE TANK
OVERBURDEN EXCAVATION
F-2106-C-4
JAN. 18, 1968
SECTION E-E
SECTION D-D
SECTION C-C
SECTION B-B
SECTION A-A
SECTION F-F
SECTION G-G
DETAIL OF CATCH-BASIN
PLAN
EXCAVATION TO ROCK
SCALE 1"=20'-0
NOTE:
SURFACE AND FOUNDATION DRAINS TO BE BUILT AS INDEPENDENT SYSTEMS.
REF. DWGS.:
F-2106-C-3 PRESSURE CONDUIT "C" & SURGE TANK No. 3
F-2106-C-5 CONCRETE DETAILS SURGE TANK FOUNDATION PRESSURE CONDUIT ANCHORS & BRIDGE.
SLOPE TO BE AS STEEP AS POSSIBLE CONSISTENT WITH STABILITY AND SAFETY.

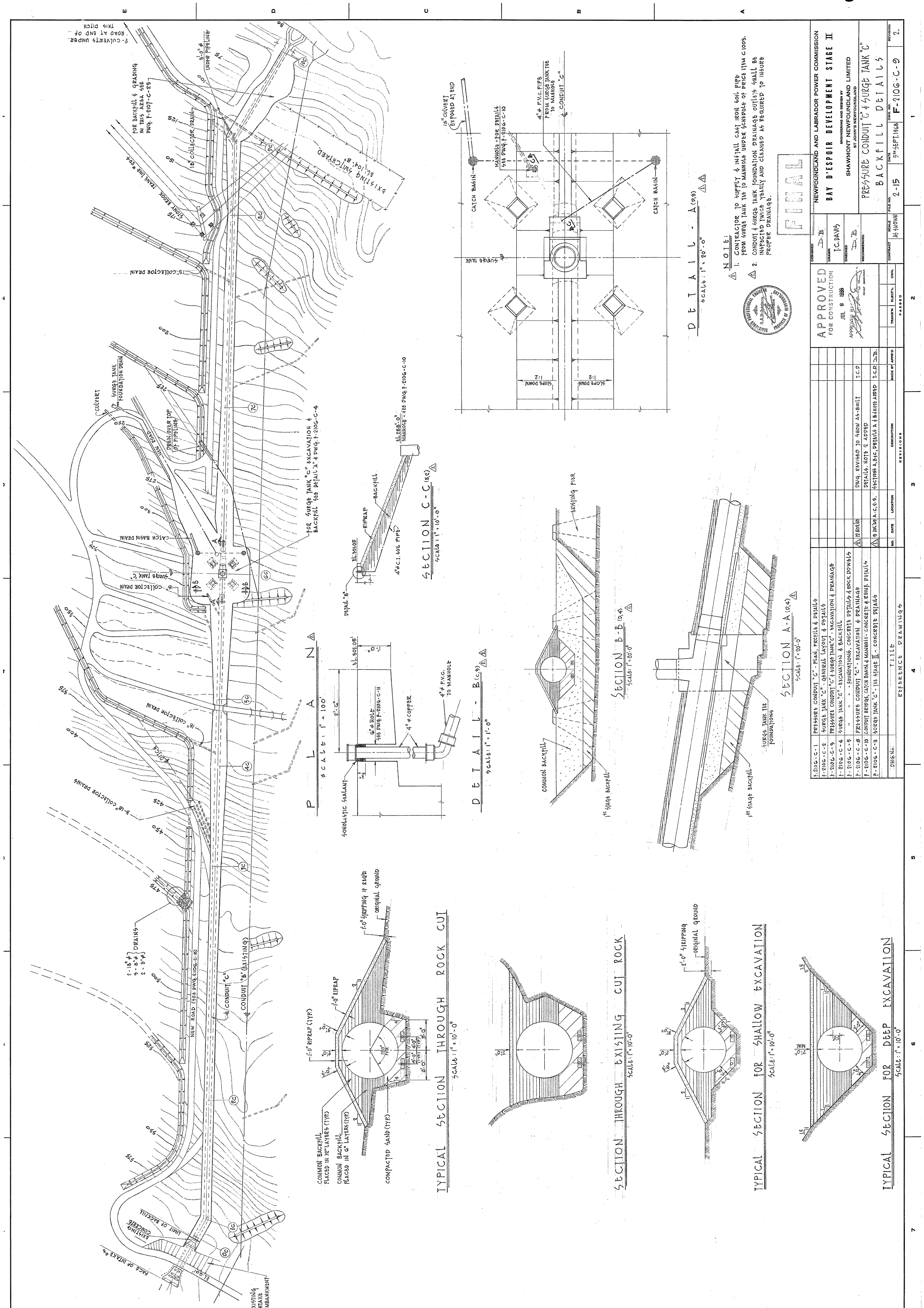

NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
APPROVED FOR CONSTRUCTION
PIER No. 1
PIER No. 2
PIER No. 3
PIER No. 4
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
SECTION G-G
SECTION H-H
TOP PLAN OF PIERS
PLAN
PLAN VIEW
TEE FOUNDATION
SECTION P-P
SECTION Q-Q
SECTION R-R
ELEVATION K-K
CONDUIT "C"
CONDUIT "B"
FIRST STAGE CONCRETE
ASSUMED ROCK LINE

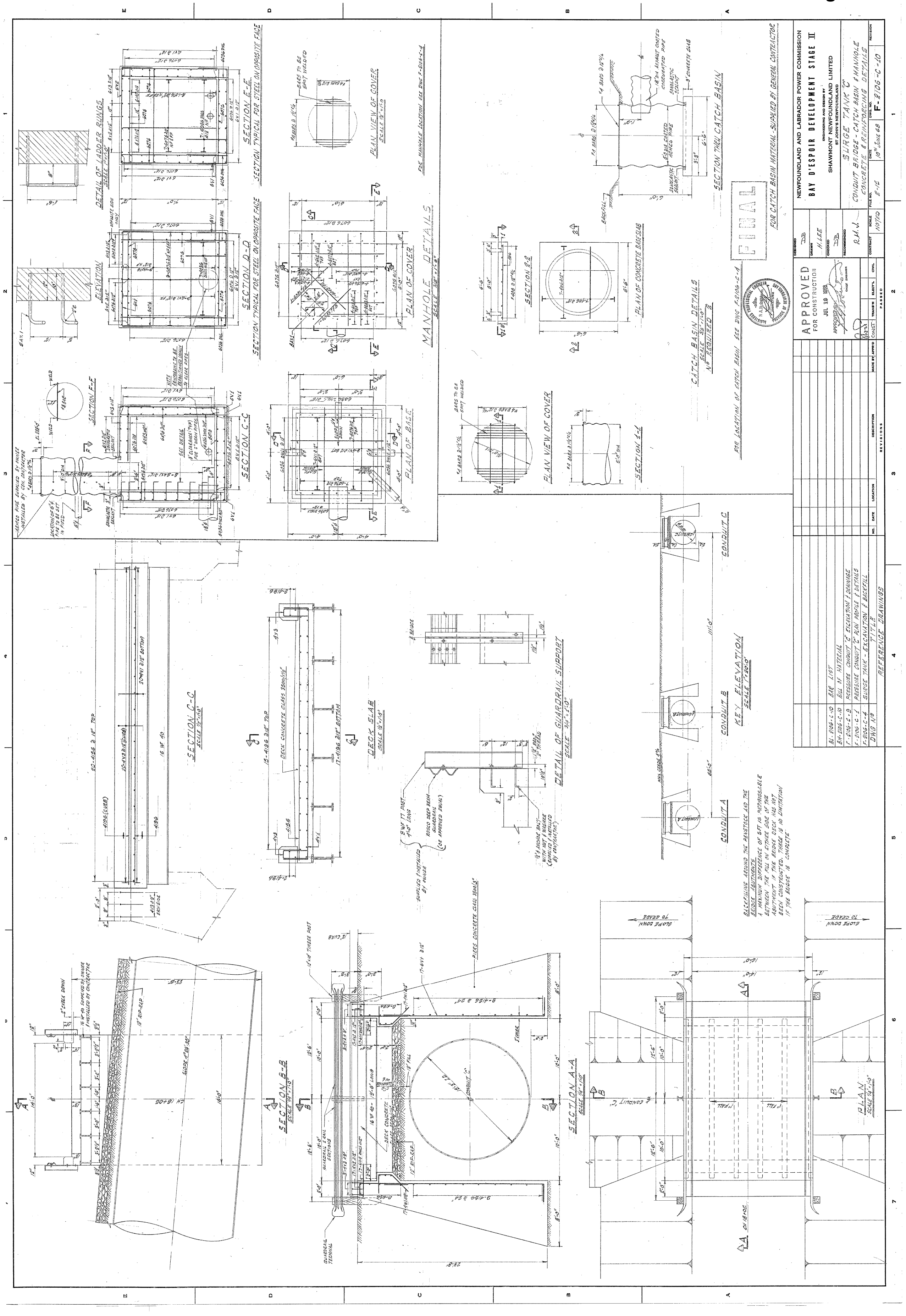

NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
CONCRETE DETAILS
SURGE TANK FOUNDATION
PRESSURE CONDUIT ANCHORS & BRIDGE
F-2106-C-5
(SH. 2 OF 2)
JAN. 16., 1968
REF. DWGS:
F-2106-C-3 PRESSURE CONDUIT "C" & SURGE TANK No. 3 EXCAVATION AND DRAINAGE (SHEET 1).
F-2106-C-4 SURGE TANK OVERBURDEN EXCAVATION (SHEET 2)
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
PIER No. 1
PIER No. 2
SECTION E-E
SECTION F-F
SECTION G-G
SECTION H-H
PIER No. 3
PIER No. 4
SECTION OF BRIDGE "C"
SECTION L-L
SECTION M-M
PLAN OF BIFURCATION
SECTION ALONG ℄ OF BIFURCATION
PLAN
SECTION R-R
SECTION Q-Q
SECTION P-P
ELEVATION K-K
TEE FOUNDATION
FIRST STAGE CONCRETE
ASSUMED ROCK LINE

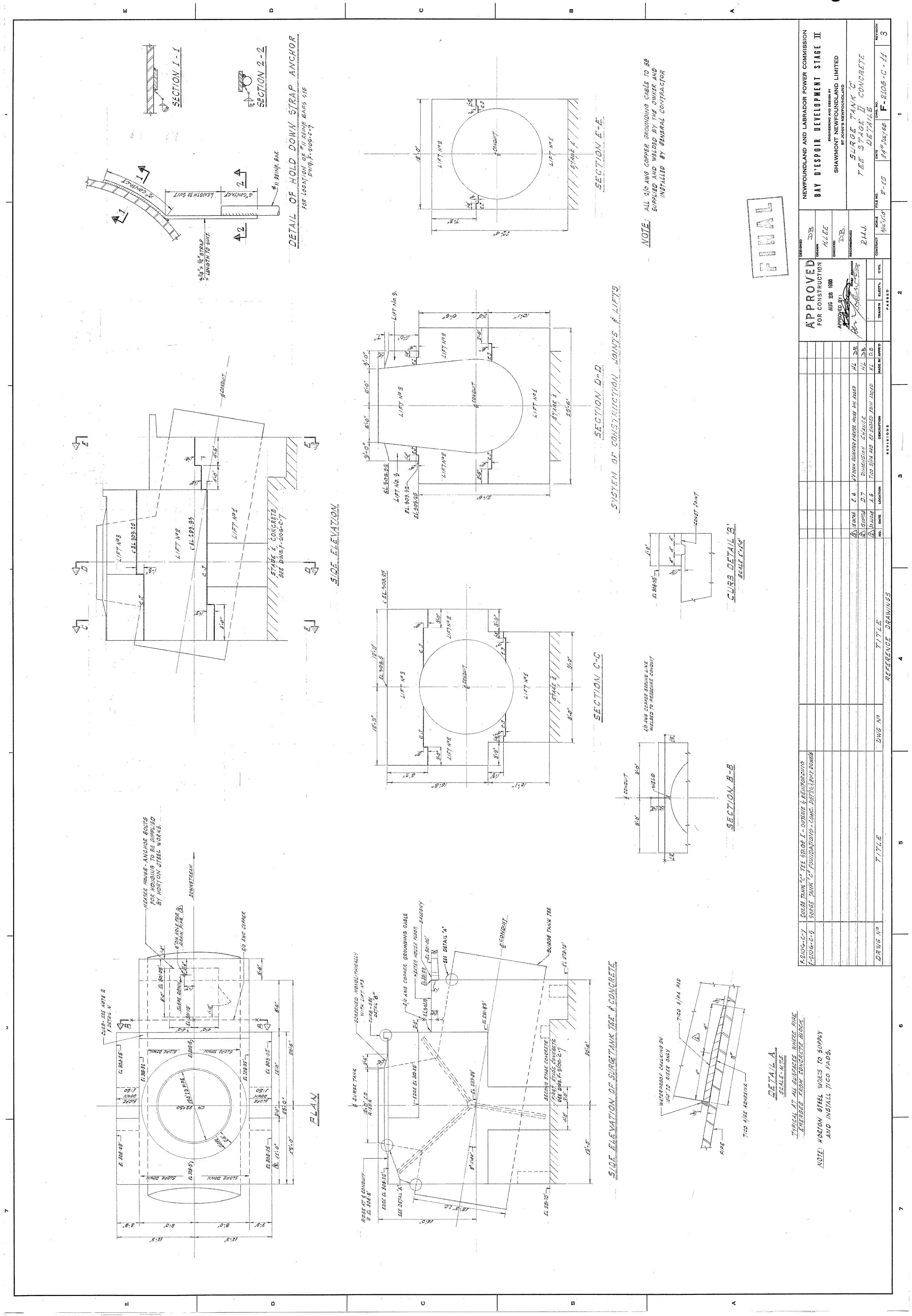

NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
SURGE TANK "C" FOUNDATIONS SINGLE FOOTING REINFORCING
F-2106-C-6

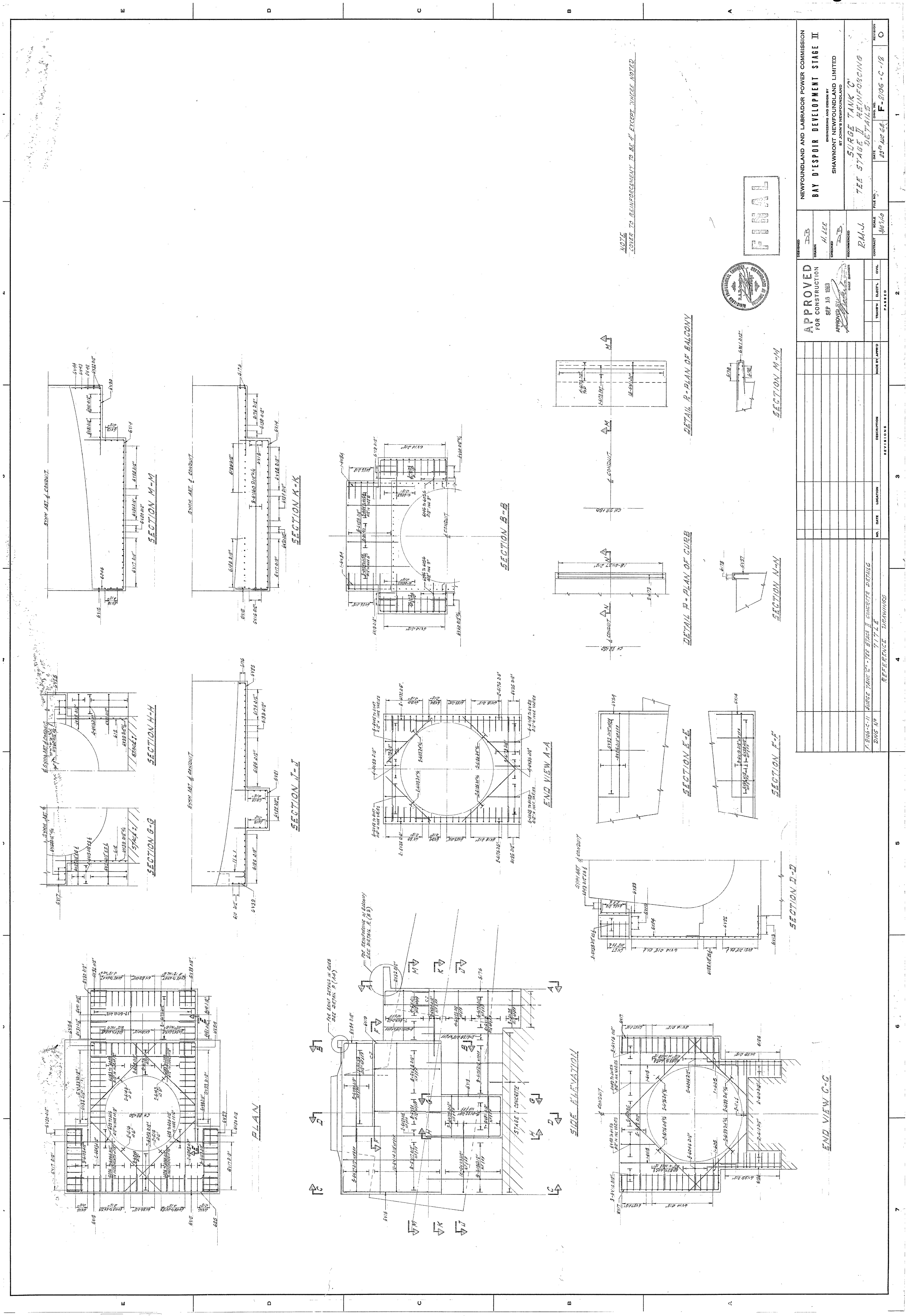

NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
APPROVED FOR CONSTRUCTION
FINAL
NOTES
ELEVATION D-D
ELEVATION E-E
PLAN SHOWING REINFORCING STEEL
ELEVATION C-C
SECTION G-G
SECTION A-A
SECTION ELEVATION F-F
SECTION B-B
ELEVATION OF TEE AND CONCRETE OUTLINE
PLAN OF CONCRETE OUTLINE AND ANCHOR BOLT LOCATION
PLAN OF SHEAR KEYS
REFERENCE DRAWINGS

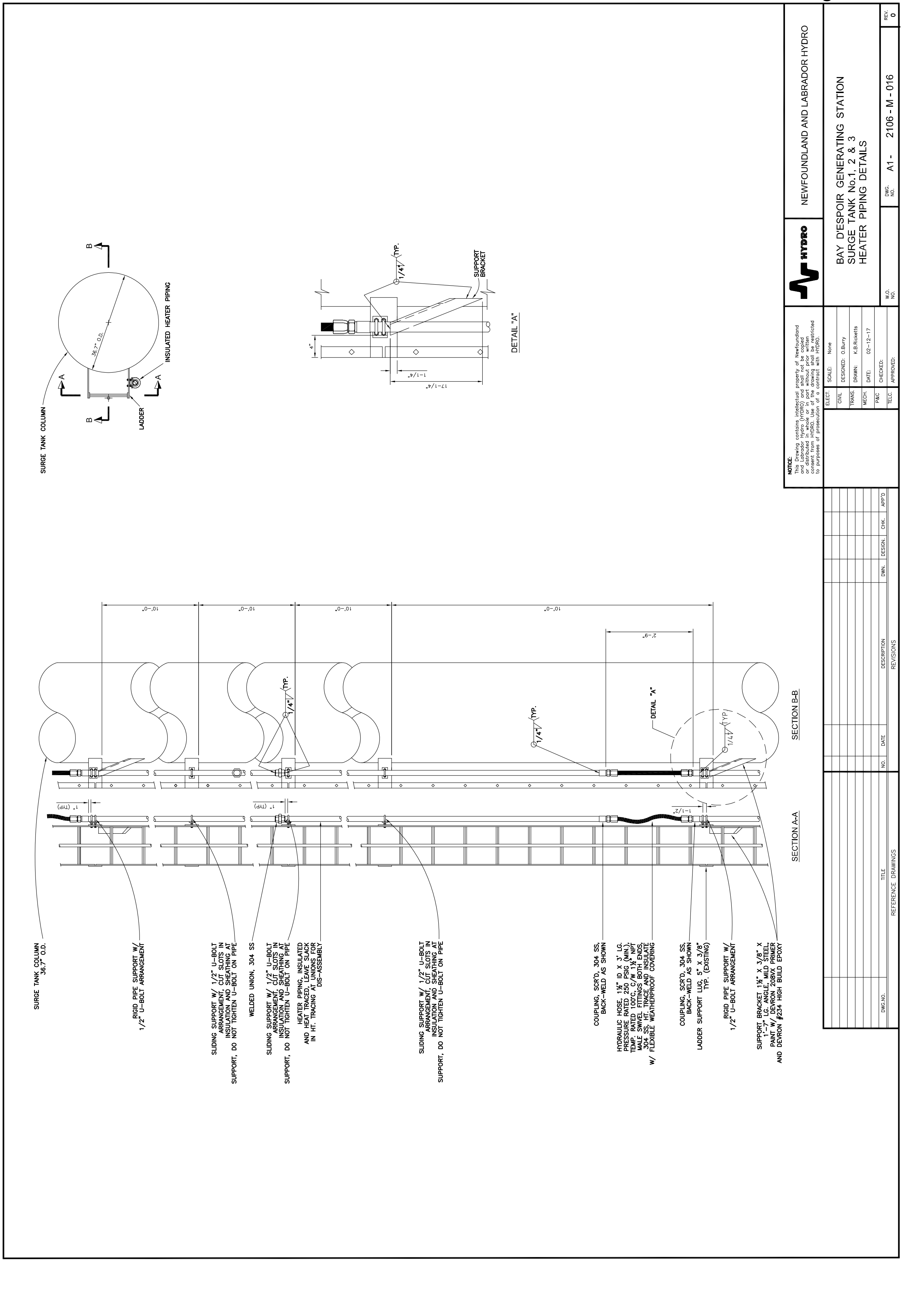

NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
ENGINEERING AND DESIGN BY
SHAWMONT NEWFOUNDLAND LIMITED
ST JOHN'S NEWFOUNDLAND
PRESSURE CONDUIT "C"
EXCAVATION AND DRAINAGE
APPROVED
FOR CONSTRUCTION
JUL 26 1968
F-2106-C-8
PLAN
PROFILE ALONG ℄ OF CONDUIT "C"

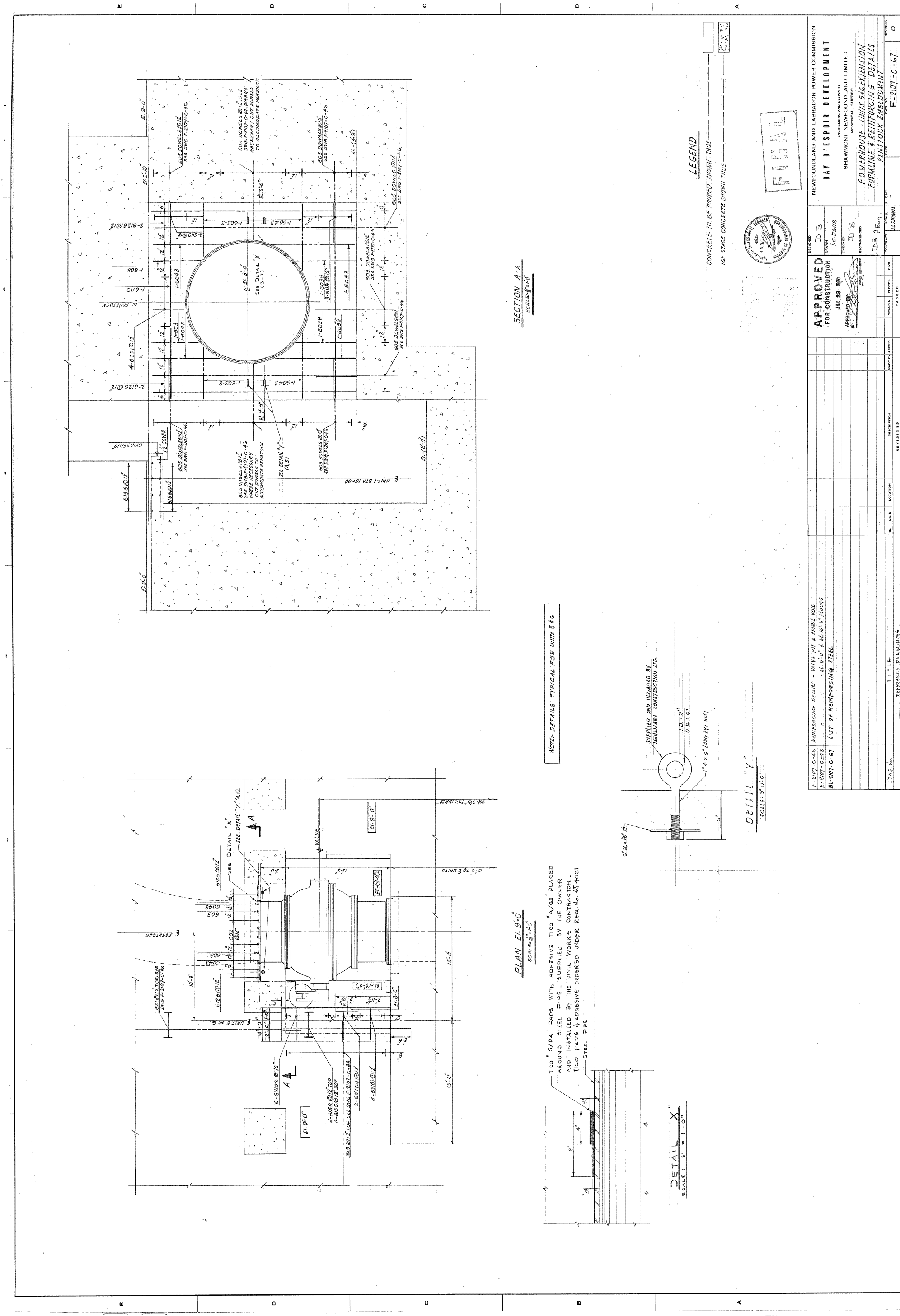

PLAN
DETAIL - A
SECTION C-C
DETAIL - B
SECTION B-B
SECTION A-A
TYPICAL SECTION THROUGH ROCK CUT
SECTION THROUGH EXISTING CUT ROCK
TYPICAL SECTION FOR SHALLOW EXCAVATION
TYPICAL SECTION FOR DEEP EXCAVATION
APPROVED FOR CONSTRUCTION
FINAL
NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
PRESSURE CONDUIT "C" & SURGE TANK "C"
BACKFILL DETAILS
F-2106-C-9


NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
APPROVED FOR CONSTRUCTION
FINAL
MANHOLE DETAILS
CATCH BASIN DETAILS
SECTION A-A
SECTION B-B
SECTION C-C
DECK SLAB
DETAIL OF GUARDRAIL SUPPORT
KEY ELEVATION
PLAN
F-2106-C-10


NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
SURGE TANK 'C' TEE STAGE II CONCRETE DETAILS
F-2106-C-11
APPROVED FOR CONSTRUCTION
FINAL
SECTION 1-1
SECTION 2-2
DETAIL OF HOLD DOWN STRAP ANCHOR
SECTION E-E
SECTION D-D
SYSTEM OF CONSTRUCTION JOINTS & LIFTS
SECTION C-C
SECTION B-B
SIDE ELEVATION
CURB DETAIL 'B'
PLAN
SIDE ELEVATION OF SURGETANK TEE & CONCRETE
DETAIL A
REFERENCE DRAWINGS


NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT STAGE II
SHAWMONT NEWFOUNDLAND LIMITED
SURGE TANK 'C' TEE STAGE II REINFORCING DETAILS
APPROVED FOR CONSTRUCTION
FINAL
NOTE
COVER TO REINFORCEMENT TO BE 4" EXCEPT WHERE NOTED
SECTION M-M
SECTION K-K
SECTION B-B
DETAIL P - PLAN OF BALCONY
DETAIL P - PLAN OF CURB
SECTION N-N
SECTION H-H
SECTION G-G
SECTION J-J
END VIEW A-A
SECTION E-E
SECTION F-F
SECTION D-D
PLAN
SIDE ELEVATION
END VIEW C-C


NEWFOUNDLAND AND LABRADOR HYDRO
HYDRO
BAY D'ESPOIR GENERATING STATION
SURGE TANK No.1, 2 & 3
HEATER PIPING DETAILS
DWG. NO. A1- 2106 - M - 016
REV. 0
PLOT SCALE = 1:1
C.A.D.
NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO.
SCALE: None
DESIGNED: O.Burry
DRAWN: K.B.Ricketts
DATE: 02-12-17
CHECKED:
APPROVED:
ELECT.
CIVIL
TRANS.
MECH.
P&C
TELC.
W.O. NO.
NO.
DATE
DESCRIPTION
DWN.
DESIGN.
CHK.
APP'D
REVISIONS
DWG.NO.
TITLE
REFERENCE DRAWINGS
SURGE TANK COLUMN
36.7" O.D.
INSULATED HEATER PIPING
LADDER
DETAIL "A"
SUPPORT BRACKET
1/4" TYP.
SECTION B-B
SECTION A-A
10'-0"
2'-9"
1-1/2"
1" (TYP)
SURGE TANK COLUMN 36.7" O.D.
RIGID PIPE SUPPORT W/ 1/2" U-BOLT ARRANGEMENT
SLIDING SUPPORT W/ 1/2" U-BOLT ARRANGEMENT, CUT SLOTS IN INSULATION AND SHEATHING AT SUPPORT, DO NOT TIGHTEN U-BOLT ON PIPE
WELDED UNION, 304 SS
HEATER PIPING, INSULATED AND HEAT TRACED, LEAVE SLACK IN HT. TRACING AT UNIONS FOR DIS-ASSEMBLY
COUPLING, SCR'D, 304 SS, BACK-WELD AS SHOWN
HYDRAULIC HOSE, 1½" ID X 3' LG. PRESSURE RATED 250 PSIG (MIN.), TEMP. RATED 100°C, C/W 1½" NPT MALE SWIVEL FITTINGS BOTH ENDS, 304 SS, HT. TRACE AND INSULATE W/ FLEXIBLE WEATHERPROOF COVERING
LADDER SUPPORT LUG, 5" X 3/8" TYP. (EXISTING)
SUPPORT BRACKET 1½" X 3/8" X 1'-7" LG. ANGLE, MILD STEEL, PAINT W/ DEVRON 208VX PRIMER AND DEVRON #234 HIGH BUILD EPOXY
02-12-19
9:51 AM


SECTION A-A
PLAN El. 9'-0"
DETAIL "X"
DETAIL "Y"
LEGEND
CONCRETE TO BE POURED SHOWN THUS
1st STAGE CONCRETE SHOWN THUS
NOTE- DETAILS TYPICAL FOR UNITS 5 & 6
SUPPLIED AND INSTALLED BY McNAMARA CONSTRUCTION LTD.
FINAL
APPROVED FOR CONSTRUCTION
NEWFOUNDLAND AND LABRADOR POWER COMMISSION
BAY D'ESPOIR DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
POWERHOUSE - UNITS 5 & 6 EXTENSION
FORMLINE & REINFORCING DETAILS
PENSTOCK EMBEDDMENT
F-2107-C-67

APPENDIX B

PHOTOGRAPHS

Photo 1 TRR's Access Setup at Manhole 2

Photo 2 Overall view of gate

Photo 3 Leakage through bolts on left side of gate

Photo 4 Leakage through seal on left side of gate

Photo 5 Condition of exterior inspection

Photo 6 Brush impeding access to exterior of penstock

Photo 7 Vegetation impeding visual access to exterior of penstock

Photo 8 Interior surface condition of penstock by Manhole 3

Photo 9 Interior surface condition of penstock by Can 193

Photo 10 Weld 7N prior to being cleaned and tested

Photo 11 Close-up of Weld 7N prior to being cleaned and tested

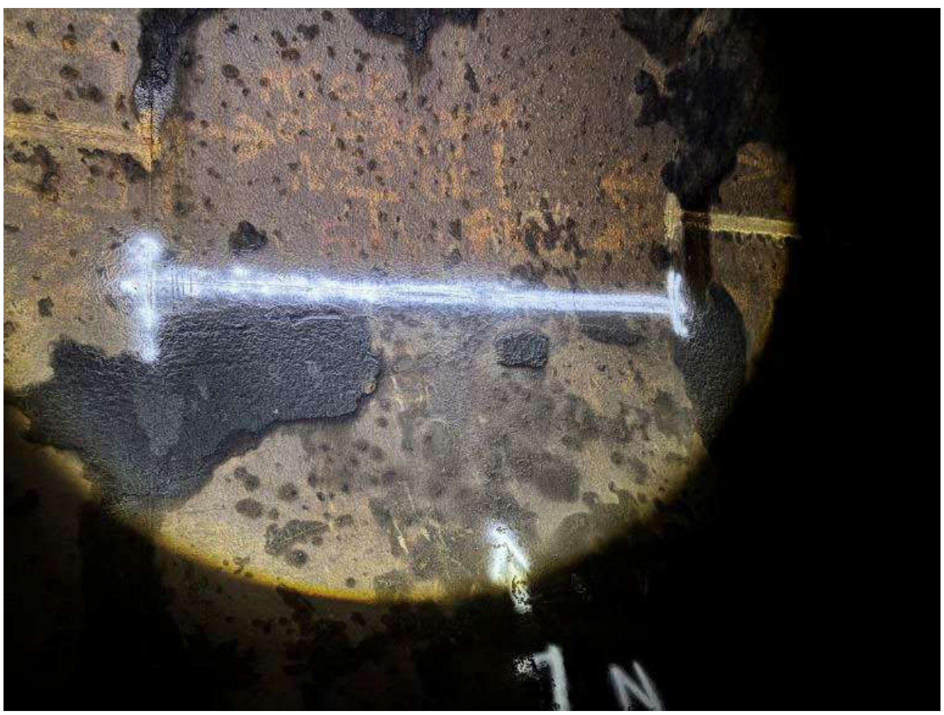


Photo 12 Weld 7N after cleaning and testing

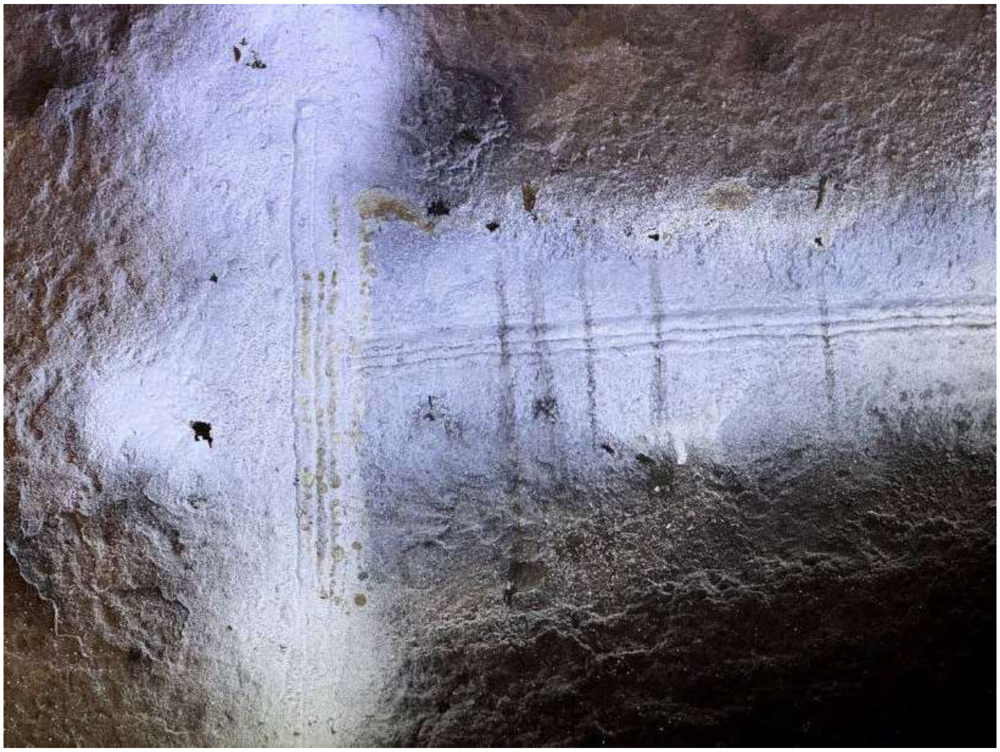


Photo 13 Close-up of circumferential and longitudinal weld tested at Can 7N

Photo 14 Close-up of intermittent weld indication at Can 17S

Photo 15 Close-up of weld indication at Can 17S

Photo 16 Close-up of intermittent weld indication at Can 35N

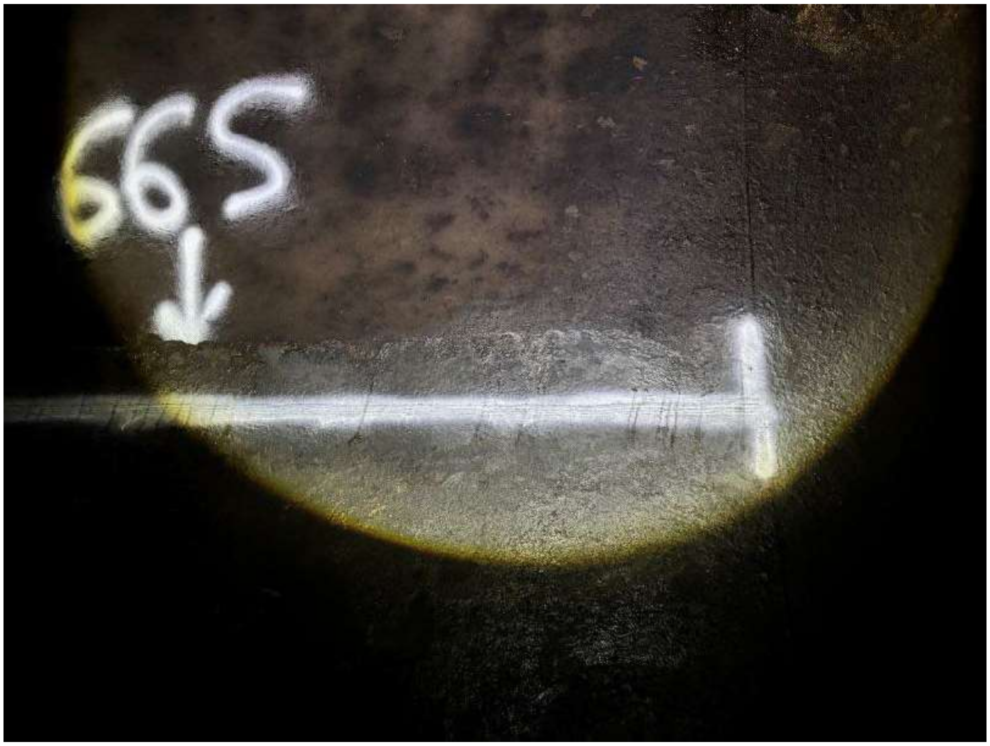


Photo 17 Weld at Can 66S

Photo 18 Close-up of intermittent weld indication at Can 67S

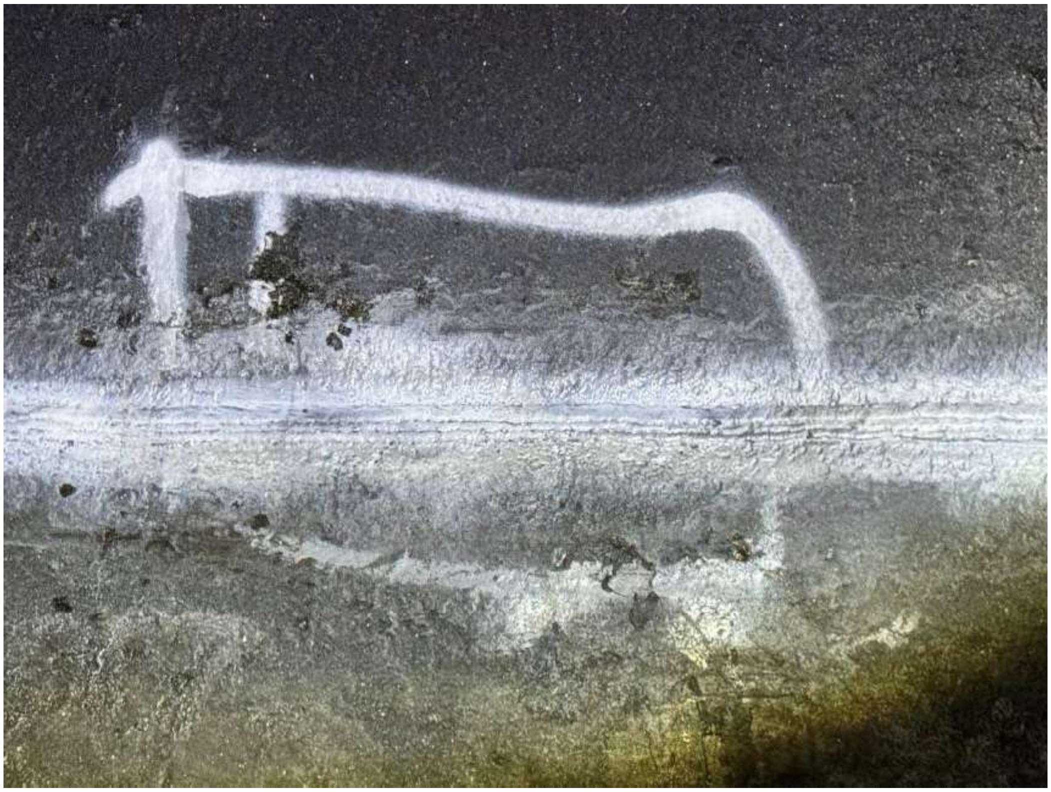


Photo 19 Close-up of intermittent weld indication at Can 79S

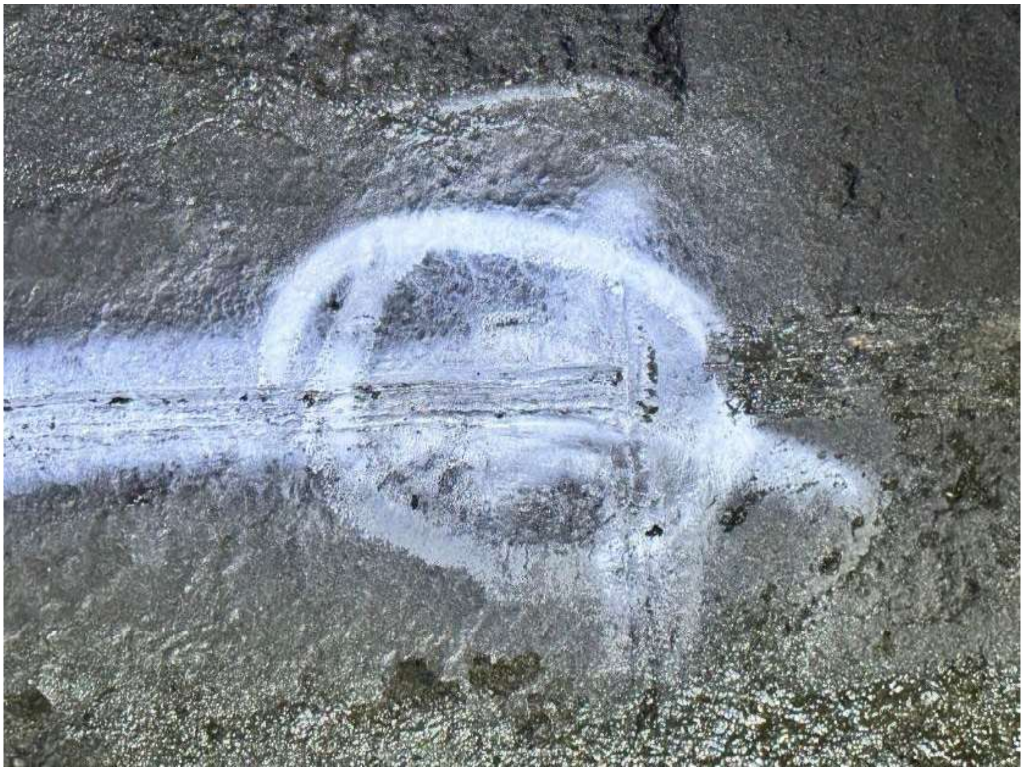


Photo 20 Close-up of intermittent weld indication at Can 102S

Photo 21 Close-up of weld indication at Can 254N

Photo 22 Close-up of weld indication at Can 263S

Photo 23 Close-up of weld indication removed with grinding at Can 273N

Photo 24 Close-up of weld indication removed with grinding at Can 303N

Photo 25 Close-up of weld indication removed with grinding at Can 322N

Photo 26 Close-up of weld indication at Can 332N

Photo 27 Close-up of weld indication removed with grinding at Can 353N

Photo 28 Leakage observed at upstream side of surge tank transition

Photo 29 Leakage observed at repairs at upstream side of surge tank transition

Photo 30 Downstream side of surge tank transition appears to be dry

Photo 31 Condition of monitoring weir at N-1

Photo 32 Condition of culvert with water flow to weir at N-1

Photo 33 Flow through drainage pipe at STA. 0+903

Photo 34 Condition of culvert at STA. 0+722

Photo 35 Condition of observation well downstream and to left of surge tank

Photo 36 Condition of culvert directly upstream of bridge crossing

Photo 37 Condition of culverts at N-2 Weir

Photo 38 Condition of drainage pipe directly downstream of surge tank concrete base

Photo 39 Condition of concrete at right side of downstream face of surge tank concrete base

Photo 40 Sinkhole downstream of surge tank concrete base

Photo 41 Sinkhole downstream of surge tank concrete base

Photo 42 Condition of concrete at left side of downstream face of surge tank concrete base

Photo 43 Test pit conducted at exterior of P3 (Sept 23rd 2025)

Photo 44 Approximate relative location of Test pit in Photo 42

Photo 45 Work conducted by NLH crew along exterior of penstock during inspection

APPENDIX C

WELD TEST

Visual Inspections
Radiography & Ultrasonics
Mag & Penetrant Inspections
Eddy Current Testing
Structural Steel & Torque

Eastern Technical Services Ltd.
PO Box 13517, St. John's, NL., A1B 4B8
709-726-4622 27 Austin St. Fax 726-4626

Technical Reports
Engineering Studies
Gas Free Testing
Destructive Testing
Insurance Reports

Report

ETS No.:	25-981-1	Copy:	
Date:	20 November 2025	Date Received:	16 November 2025
Client:	Technical Rope & Rescue Inc. 1155 Bauline Line Bauline, NL A1K 1E7	Inspected by:	C. Murphy, SNT TC-1A: UT, ET, PT and MT Level II CAN/CGSB 48.9712 MT/PT Level II, UT Level I XRF Level I
Attn:	Todd LeGrow		
P.O. No.	250153-1.2		
Project:	Bay d'Espoir Hydroelectric Power Station - Penstock #3		
Testing Required:	Magnetic Particle Inspection	Signed:	NDT Inspector

Remarks

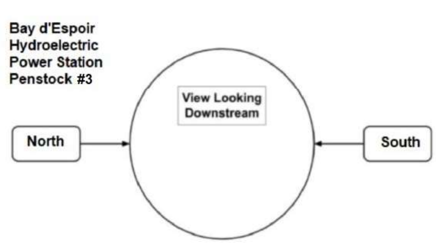
As directed, our technicians performed magnetic particle inspections on existing horizontal and circumferential welds of the above noted penstock. The magnetic particle inspection was carried out using the wet continuous visible method, to detect surface cracks. Testing was performed as per the requirements of A.S.T.M. E709 Standard Practice for Magnetic Particle Examination and the ETS Procedure for magnetic particle inspections (Procedure No. MT-02). Items inspected as detailed in attached tables and pictures.

Results

Indications noted and still in welds on the follow cans :
Can 17S, 35N, 67S, 77S, 79S, 102S, See below for location and approximate size. All other areas were found to be acceptable as per the above noted criterial.

Notes

Can 254N - Indication Noted. Indication is visible and deemed acceptable by Chris Vella
Can 263S - Indication Noted. Indication is visible and deemed acceptable by Chris Vella
Can 273N - Indication Noted. Indication removed with grinding.
Can 303N - Indication Noted. Indication removed with grinding.
Can 322N - Indication Noted. Indication removed with grinding.
Can 332N - Indication Noted. Indication is visible and deemed acceptable by Chris Vella
Can 353N - Indication Noted. Indication removed with grinding.



ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Equipment Used

Parker Probe P2 (120 V.A.C.)(Ser. No 3457)
Magnaflux WCP-2 white background paint. (Batch No. 23F10C)
Magnaflux 7-HF black magnetic ink. (Batch No. 23L13C)

Can Number	Details	Result	Image #
7	- Longitudinal right (south) weld. - Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
17	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
17	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indications Noted**	**Figure 1,2,3**
27	- Longitudinal left (north) weld. - Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
35	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indications Noted**	**Figure 4,5**
35	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
45	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
47	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
57	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
59	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Can Number	Details	Result	Image #
66	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
67	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indications Noted**	**Figure 6,7**
77	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indications Noted** *Re Check Bottom Toe of Weld	**Figure 8,9**
79	Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indications Noted**	**Figure 10,11**
91	Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
92	Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
101	Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
102	Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indications Noted**	**Figures 12, 13**
111	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
112	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
122	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Can Number	Details	Result	Image #
123	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
131	- Longitudinal left (north) weld. - Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
139	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
140	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
151	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
152	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds South side only.	MT Acceptable	**N/A**
161	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
162	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
174	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
175	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
182	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Can Number	Details	Result	Image #
183	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
193	- Longitudinal left (north) weld. - Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
196	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
198	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
211	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
212	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
221	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
222	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
230	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
231	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Can Number	Details	Result	Image #
242	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
244	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
252	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
254	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indication Noted** MT Acceptable See Note Above	**Figure 14,15**
261	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
263	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indication Noted** MT Acceptable See Note Above	**Figure 16,17**
272	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
273	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indication Noted** MT Acceptable See Note Above	**Figure 18**
283	- Longitudinal left (north) weld. - Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Can Number	Details	Result	Image #
291	- Longitudinal left (north) weld. - Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
303	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indication Noted** MT Acceptable See Note Above	**Figure 19**
304	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
314	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
315	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
321	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
322	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indication Noted** MT Acceptable See Note Above	**Figure 20**
332	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indication Noted** MT Acceptable See Note Above	**Figure 21,22**
341	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
342	- Longitudinal right (south) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Can Number	Details	Result	Image #
352	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
353	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	**Indication Noted** MT Acceptable See Note Above	**Figure 23**,24
361	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**
362	- Longitudinal left (north) weld. - 12" Section of upstream & downstream circumferential welds adjacent to longitudinal weld.	MT Acceptable	**N/A**

Figure 1. Can 17 South - Indications Noted

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

	
Figure 2. Can 17 South - Indication #1 - Intermittent Indication Noted	**Figure 3.** Can 17 South - Indication #2

Figure 4. Can 35 North - Indication Noted

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Figure 5. Can 35 North - Indication #3 - Intermittent Indication Noted

Figure 6. Can 67 South - Indication Noted

Figure 7. Can 67 South - Indication #4 Intermittent Indication Noted

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d’Espoir - Penstock #3
Magnetic Particle Inspection

Figure 8. Can 77 South - Indication Noted

Figure 9. Can 77 South - Indication #5 Intermittent Indication Noted

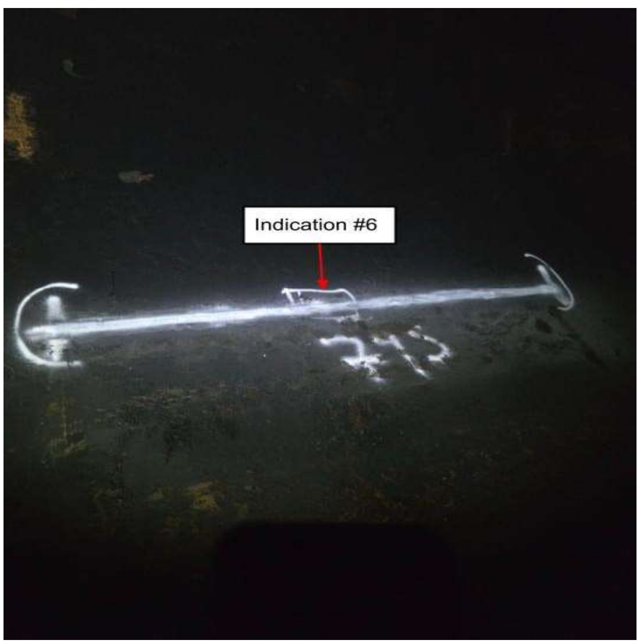


Figure 10. Can 79 South - Indication Noted

Figure 11. Can 79 South - Indication #6 Intermittent Indication Noted

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

	
Figure 12. Can 102 South - Indication Noted	**Figure 13.** Can 102 South - Indication #7

	
Figure 14. Can 254 South - Indication Noted - Post Grinding	**Figure 15.** Can 254 South - Post Grinding

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Figure 16. Can 263 South - Indication Noted - Post Grinding

Figure 17. Can 263 South - Post Grinding

Figure 18. Can 273 North - Post Grinding - Indication Removed

Figure 19. Can 303 North - Post Grinding - Indication Removed

ETS No.: 25-981-1 Date: 20 November 2025
Client: Technical Rope & Rescue
Location: Bay d'Espoir - Penstock #3
Magnetic Particle Inspection

Figure 20. Can 322 North - Post Grinding - Indication Removed

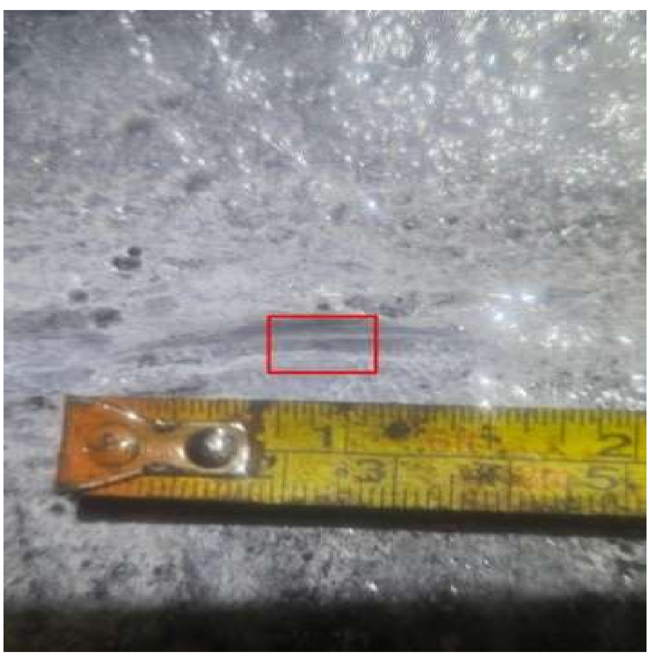


Figure 21. Can 332 North - Indication Noted - Post Grinding

Figure 22. Can 332 North - Post Grinding

	
Figure 23. Can 353 North - Post Grinding - Indication Removed	**Figure 24.** Can 353 North - Post Grinding

APPENDIX D

THICKNESS MEASUREMENTS DATA

Visual Inspections
Radiography & Ultrasonics
Mag & Penetrant Inspections
Eddy Current Testing
Structural Steel & Torque

Eastern Technical Services Ltd.
PO Box 13517, St. John's, NL., A1B 4B8
709-726-4622 27 Austin St. Fax 726-4626

Technical Reports
Engineering Studies
Gas Free Testing
Destructive Testing
Insurance Reports

Report

ETS No.:	25-981-2	Copy:	
Date:	20 November, 2025	Date Received:	16 November, 2025
Client:	Technical Rope & Rescue Inc. 1155 Bauline Line Bauline, NL A1K 1E7	Inspected by:	C. Murphy, SNT TC-1A: UT, ET, PT and MT Level II CAN/CGSB 48.9712 MT/PT Level II, UT Level I XRF Level I
Attn:	Todd LeGrow		
P.O. No.	250153-1.2		
Project:	Bay d'Espoir Hydroelectric Power Station - Penstock #3		
Testing Required:	Ultrasonic Thickness Measurements	Signed:	Conor Murphy NDT Inspector

Remarks

As directed, ultrasonic thickness readings were taken on the above noted penstock. Readings are shown in mm's on the attached tables.

Equipment Used
GE DMS Go+ (SN GOBLS20020097)
GE TC560 probe (S/N 00H6Y6).
Various calibration blocks & 0.100 to 1.000 " steel step wedge.
Ultragel couplant. (Batch No. 23J022)

UTM Data Logger #	Can	Location ID	Reading (mm) A	Reading (mm) B	Reading (mm) C	Original Thickness (mm)	Comments
#3 → Penstock #2 - (Shot 1: South, Shot 2: Bottom, Shot 3: North)							
1a	7	1	11.9	12.0	11.9	11.1	
1b	7	2	11.9	11.9	11.8	11.1	
1c	7	3	11.8	11.8	11.8	11.1	
2a	17	1	10.3	10.5	10.5	11.1	
2b	17	2	10.5	10.5	10.4	11.1	
2c	17	3	10.3	10.3	10.2	11.1	
3a	27	1	10.0	10.1	10.1	11.1	
3b	27	2	10.1	10.2	10.3	11.1	
3c	27	3	10.4	10.4	10.3	11.1	
4a	35	1	10.3	10.4	10.4	11.1	
4b	35	2	10.5	10.5	10.5	11.1	
4c	35	3	10.5	10.4	10.4	11.1	
5a	45	1	10.5	10.5	10.4	11.1	
5b	45	2	10.8	10.6	10.8	11.1	
5c	45	3	10.7	10.8	10.7	11.1	
6a	57	1	10.7	10.7	10.6	11.1	
6b	57	2	10.8	10.8	10.8	11.1	
6c	57	3	10.7	10.7	10.7	11.1	
7a	66	1	10.3	10.3	10.5	11.1	
7b	66	2	10.1	10.2	10.3	11.1	
7c	66	3	10.3	10.1	10.2	11.1	
8a	77	1	10.2	10.3	10.3	11.1	
8b	77	2	10.5	10.5	10.5	11.1	
8c	77	3	10.5	10.4	10.4	11.1	
9a	92	1	10.2	10.1	10.1	11.1	
9b	92	2	10.4	10.2	10.3	11.1	
9c	92	3	10.7	10.6	10.7	11.1	
10a	101	1	10.4	10.5	10.4	11.1	
10b	101	2	10.0	10.1	10.0	11.1	
10c	101	3	10.2	10.2	10.1	11.1	
11a	111	1	10.8	10.7	10.7	11.1	
11b	111	2	10.4	10.4	10.4	11.1	
11c	111	3	10.2	10.4	10.3	11.1	
12a	122	1	10.7	10.7	10.6	11.1	

UTM Data Logger #	Can	Location ID	Reading (mm) A	Reading (mm) B	Reading (mm) C	Original Thickness (mm)	Comments
#3 → **Penstock #2 - (Shot 1: South, Shot 2: Bottom, Shot 3: North)**							
12b	**122**	**2**	10.1	10.0	10.1	11.1	
12c	**122**	**3**	10.5	10.5	10.5	11.1	
13a	**131**	**1**	14.0	13.9	14.0	14.2	
13b	**131**	**2**	13.9	14.0	13.8	14.2	
13c	**131**	**3**	13.8	13.8	13.8	14.2	
14a	**140**	**1**	13.3	13.5	13.5	14.2	
14b	**140**	**2**	13.6	13.6	13.6	14.2	
14c	**140**	**3**	13.6	13.6	13.5	14.2	
15a	**151**	**1**	13.2	13.3	13.2	14.2	
15b	**151**	**2**	14.0	13.9	13.8	14.2	
15c	**151**	**3**	13.3	13.4	13.4	14.2	
16a	**161**	**1**	15.5	15.5	15.2	14.2	
16b	**161**	**2**	15.6	15.1	15.2	14.2	
16c	**161**	**3**	15.5	15.6	15.6	14.2	
17a	**174**	**1**	13.4	13.4	13.5	14.2	
17b	**174**	**2**	13.9	13.9	13.8	14.2	
17c	**174**	**3**	13.7	13.6	13.8	14.2	
18a	**182**	**1**	15.3	15.0	15.2	15.8	
18b	**182**	**2**	15.6	15.5	15.5	15.8	
18c	**182**	**3**	15.8	15.7	15.8	15.8	
19a	**193**	**1**	18.8	18.7	18.8	19.1	
19b	**193**	**2**	19.1	19.1	18.9	19.1	
19c	**193**	**3**	18.6	18.6	18.5	19.1	
20a	**201**	**1**	16.5	16.5	16.6	17.2	
20b	**201**	**2**	17.0	17.0	16.9	17.2	
20c	**201**	**3**	17.2	17.2	17.2	17.2	
21a	**212**	**1**	14.4	14.4	14.5	14.2	
21b	**212**	**2**	14.3	14.3	14.3	14.2	
21c	**212**	**3**	14.6	14.7	14.6	14.2	
22a	**221**	**1**	16.4	16.1	15.8	15.9	
22b	**221**	**2**	15.4	15.5	15.4	15.9	
22c	**221**	**3**	15.5	15.5	15.5	15.9	
23a	**230**	**1**	18.1	18.1	18.1	19.1	
23b	**230**	**2**	19.3	19.3	18.6	19.1	

UTM Data Logger #	Can	Location ID	Reading (mm) A	Reading (mm) B	Reading (mm) C	Original Thickness (mm)	Comments
#3 → Penstock ~~#2~~ - (Shot 1: South, Shot 2: Bottom, Shot 3: North)							
23c	230	3	18.1	18.1	18.0	19.1	
24a	242	1	19.9	19.8	19.8	20.6	
24b	242	2	20.8	20.0	20.0	20.6	
24c	242	3	19.7	19.5	19.5	20.6	
25a	252	1	16.7	16.6	16.6	17.9	
25b	252	2	-	-	-	17.9	Void Reading
25c	252	3	16.6	16.6	16.6	17.9	
26a	261	1	17.2	17.2	17.2	17.9	
26b	261	2	17.5	17.5	17.6	17.9	
26c	261	3	17.3	17.3	17.3	17.9	
27a	272	1	18.2	18.3	18.2	18.8	
27b	272	2	18.6	18.5	18.5	18.8	
27c	272	3	18.2	18.4	18.3	18.8	
28a	283	1	19.6	19.6	19.6	21.1	
28b	283	2	20.1	20.0	20.1	21.1	
28c	283	3	19.7	19.6	19.6	21.1	
29a	291	1	20.4	20.5	20.4	21.7	
29b	291	2	20.6	20.5	20.5	21.7	
29c	291	3	20.8	21.0	20.9	21.7	
30a	303	1	21.5	21.5	21.5	21.7	
30b	303	2	21.5	21.5	21.5	21.7	
30c	303	3	21.5	21.5	21.6	21.7	
31a	314	1	22.3	22.4	22.3	23.0	
31b	314	2	22.3	22.4	22.4	23.0	
31c	314	3	22.4	22.3	22.4	23.0	
32a	321	1	22.1	22.1	22.2	23.6	
32b	321	2	22.1	22.1	22.1	23.6	
32c	321	3	21.8	21.8	21.9	23.6	
33a	331	1	24.4	24.4	24.3	24.9	
33b	331	2	25.1	25.0	25.1	24.9	
33c	331	3	24.6	24.5	24.5	24.9	
34a	341	1	24.5	24.5	24.6	26.0	
34b	341	2	25.0	25.0	25.0	26.0	
34c	341	3	24.7	24.7	24.8	26.0	

UTM Data Logger #	Can	Location ID	Reading (mm) A	Reading (mm) B	Reading (mm) C	Original Thickness (mm)	Comments
#3 → ~~Penstock #2~~ - (Shot 1: South, Shot 2: Bottom, Shot 3: North)							
35a	352	1	25.2	25.2	25.2	26.0	
35b	352	2	25.3	25.2	25.2	26.0	
35c	352	3	25.5	25.5	25.7	26.0	
36a	361	1	26.7	26.7	26.7	27.8	
36b	361	2	27.3	27.3	27.3	27.8	
36c	361	3	26.2	26.2	26.2	27.8	

APPENDIX E

PENSTOCK EVALUATION CALCULATIONS

TABLE 1 - FULL SUPPLY LEVEL (FSL)
PENSTOCK 3 THICKNESS MEASURMENTS AND STRESSES

Unit weight of water=	62.4	pcf	Project No:	2670043
Normal pond EL=	597	feet	Date:	8-Jan-26
Joint Efficiency=	0.7		By:	YA
D_1 ID=	17.00	feet	Checked	
D_2 ID=	15.25	feet		
D_3 ID=	13.50	feet		

Can #	Distance From Fwd Edge of Can 1 (Ft)	Radius (ft)	Reading Number	Thickness Reading (mm)	Thickness Reading (in)	Design Plate Thickness (in)	%Change in Material	Min Thickness (in)	C.L. EL. (ft)	Allowable Steel Stress[3] (psi)	Base Material		At Joints		Notes
											Stress (psi)[2]	Stress Ratio[4]	Stress (psi)[2]	Stress Ratio[4]	
			1	11.9000	0.4685	0.5000	-6.3%			17000					A285 Steel
7-1			2	12.0000	0.4724	0.5000	-5.5%			17000					
			3	11.9000	0.4685	0.5000	-6.3%			17000					
			4	11.9000	0.4685	0.5000	-6.3%			17000					
7-2	53.67	8.50	5	11.9000	0.4685	0.5000	-6.3%	0.4646	555.0832	17000	3988.1	0.23	5697.2	0.34	
			6	11.8000	0.4646	0.5000	-7.1%			17000					
			7	11.8000	0.4646	0.5000	-7.1%			17000					
7-3			8	11.8000	0.4646	0.5000	-7.1%			17000					
			9	11.8000	0.4646	0.5000	-7.1%			17000					
			1	10.3000	0.4055	0.4375	-7.3%			17000					
17-1			2	10.5000	0.4134	0.4375	-5.5%			17000					
			3	10.5000	0.4134	0.4375	-5.5%			17000					
			4	10.5000	0.4134	0.4375	-5.5%			17000					
17-2	143.92	8.50	5	10.5000	0.4134	0.4375	-5.5%	0.4016	554.6982	17000	4656.0	0.27	6651.5	0.39	
			6	10.4000	0.4094	0.4375	-6.4%			17000					
			7	10.3000	0.4055	0.4375	-7.3%			17000					
17-3			8	10.3000	0.4055	0.4375	-7.3%			17000					
			9	10.2000	0.4016	0.4375	-8.2%			17000					
			1	10.0000	0.3937	0.4375	-10.0%			17000					
27-1			2	10.1000	0.3976	0.4375	-9.1%			17000					
			3	10.1000	0.3976	0.4375	-9.1%			17000					
			4	10.1000	0.3976	0.4375	-9.1%			17000					
27-2	204.50	8.50	5	10.2000	0.4016	0.4375	-8.2%	0.3937	551.6677	17000	5089.4	0.30	7270.5	0.43	
			6	10.3000	0.4055	0.4375	-7.3%			17000					
			7	10.4000	0.4094	0.4375	-6.4%			17000					
27-3			8	10.4000	0.4094	0.4375	-6.4%			17000					
			9	10.3000	0.4055	0.4375	-7.3%			17000					
			1	10.3000	0.4055	0.4375	-7.3%			17000					
35-1			2	10.4000	0.4094	0.4375	-6.4%			17000					
			3	10.4000	0.4094	0.4375	-6.4%			17000					
			4	10.5000	0.4134	0.4375	-5.5%			17000					
35-2	282.67	8.50	5	10.5000	0.4134	0.4375	-5.5%	0.4055	543.3293	17000	5850.0	0.34	8357.2	0.49	
			6	10.5000	0.4134	0.4375	-5.5%			17000					
			7	10.5000	0.4134	0.4375	-5.5%			17000					
35-3			8	10.4000	0.4094	0.4375	-6.4%			17000					
			9	10.4000	0.4094	0.4375	-6.4%			17000					
			1	10.5000	0.4134	0.4375	-5.5%			17000					
45-1			2	10.5000	0.4134	0.4375	-5.5%			17000					
			3	10.4000	0.4094	0.4375	-6.4%			17000					
			4	10.8000	0.4252	0.4375	-2.8%			17000					
45-2	382.75	8.50	5	10.6000	0.4173	0.4375	-4.6%	0.4094	532.6531	17000	6946.3	0.41	9923.2	0.58	
			6	10.8000	0.4252	0.4375	-2.8%			17000					
			7	10.7000	0.4213	0.4375	-3.7%			17000					
45-3			8	10.8000	0.4252	0.4375	-2.8%			17000					
			9	10.7000	0.4213	0.4375	-3.7%			17000					
			1	10.7000	0.4213	0.4375	-3.7%			17000					
57-1			2	10.7000	0.4213	0.4375	-3.7%			17000					
			3	10.6000	0.4173	0.4375	-4.6%			17000					
			4	10.8000	0.4252	0.4375	-2.8%			17000					
57-2	502.33	8.50	5	10.8000	0.4252	0.4375	-2.8%	0.4173	519.8967	17000	8166.3	0.48	11666.1	0.69	
			6	10.8000	0.4252	0.4375	-2.8%			17000					
			7	10.7000	0.4213	0.4375	-3.7%			17000					
57-3			8	10.7000	0.4213	0.4375	-3.7%			17000					
			9	10.7000	0.4213	0.4375	-3.7%			17000					
			1	10.3000	0.4055	0.4375	-7.3%			17000					
66-1			2	10.3000	0.4055	0.4375	-7.3%			17000					
			3	10.5000	0.4134	0.4375	-5.5%			17000					
			4	10.1000	0.3976	0.4375	-9.1%			17000					
66-2	592.08	8.50	5	10.2000	0.4016	0.4375	-8.2%	0.3976	511.4546	17000	9509.0	0.56	13584.2	0.80	
			6	10.3000	0.4055	0.4375	-7.3%			17000					
			7	10.3000	0.4055	0.4375	-7.3%			17000					
66-3			8	10.1000	0.3976	0.4375	-9.1%			17000					
			9	10.2000	0.4016	0.4375	-8.2%			17000					
			1	10.2000	0.4016	0.4375	-8.2%			17000					
77-1			2	10.3000	0.4055	0.4375	-7.3%			17000					
			3	10.3000	0.4055	0.4375	-7.3%			17000					
			4	10.5000	0.4134	0.4375	-5.5%			17000					
77-2	701.58	8.50	5	10.5000	0.4134	0.4375	-5.5%	0.4016	502.1030	17000	10445.0	0.61	14921.5	0.88	
			6	10.5000	0.4134	0.4375	-5.5%			17000					
			7	10.5000	0.4134	0.4375	-5.5%			17000					
77-3			8	10.4000	0.4094	0.4375	-6.4%			17000					
			9	10.4000	0.4094	0.4375	-6.4%			17000					
			1	10.4000	0.4094	0.4375	-6.4%			27000					G40.8B Steel
101-1			2	10.5000	0.4134	0.4375	-5.5%			27000					Allowable stress = 27000 psi for G40.B
			3	10.4000	0.4094	0.4375	-6.4%			27000					Steel and Thickess ≤ 0.625"
			4	10.0000	0.3937	0.4375	-10.0%			27000					
101-2	940.92	8.50	5	10.1000	0.3976	0.4375	-9.1%	0.3937	481.6634	27000	12948.7	0.48	18498.1	0.69	
			6	10.0000	0.3937	0.4375	-10.0%			27000					
			7	10.2000	0.4016	0.4375	-8.2%			27000					
101-3			8	10.2000	0.4016	0.4375	-8.2%			27000					
			9	10.1000	0.3976	0.4375	-9.1%			27000					

Can #	Distance From Fwd Edge of Can 1 (Ft)	Radius (ft)	Reading Number	Thickness Reading (mm)	Thickness Reading (in)	Design Plate Thickness (in)	%Change in Material	Min Thickness (in)	C.L. EL. (ft)	Allowable Steel Stress[3] (psi)	Base Material		At Joints		Notes
											Stress (psi)[2]	Stress Ratio[4]	Stress (psi)[2]	Stress Ratio[4]	
			1	10.8000	0.4252	0.4375	-2.8%			27000					
111-1			2	10.7000	0.4213	0.4375	-3.7%			27000					
			3	10.7000	0.4213	0.4375	-3.7%			27000					
			4	10.4000	0.4094	0.4375	-6.4%			27000					
111-2	1040.67	8.50	5	10.4000	0.4094	0.4375	-6.4%	0.4016	473.1445	27000	13632.4	0.50	19474.9	0.72	
			6	10.4000	0.4094	0.4375	-6.4%			27000					
			7	10.2000	0.4016	0.4375	-8.2%			27000					
111-3			8	10.4000	0.4094	0.4375	-6.4%			27000					
			9	10.3000	0.4055	0.4375	-7.3%			27000					
			1	10.7000	0.4213	0.4375	-3.7%			27000					
122-1			2	10.7000	0.4213	0.4375	-3.7%			27000					
			3	10.6000	0.4173	0.4375	-4.6%			27000					
			4	10.1000	0.3976	0.4375	-9.1%			27000					
122-2	1150.08	8.50	5	10.0000	0.3937	0.4375	-10.0%	0.3937	463.8000	27000	14954.1	0.55	21363.1	0.79	
			6	10.1000	0.3976	0.4375	-9.1%			27000					
			7	10.5000	0.4134	0.4375	-5.5%			27000					
122-3			8	10.5000	0.4134	0.4375	-5.5%			27000					
			9	10.5000	0.4134	0.4375	-5.5%			27000					
			1	14.0000	0.5512	0.5625	-2.0%			27000					
131-1			2	13.9000	0.5472	0.5625	-2.7%			27000					
			3	14.0000	0.5512	0.5625	-2.0%			27000					
			4	13.9000	0.5472	0.5625	-2.7%			27000					
131-2	1239.75	8.50	5	14.0000	0.5512	0.5625	-2.0%	0.5433	456.1423	27000	11459.3	0.42	16370.5	0.61	
			6	13.8000	0.5433	0.5625	-3.4%			27000					
			7	13.8000	0.5433	0.5625	-3.4%			27000					
131-3			8	13.8000	0.5433	0.5625	-3.4%			27000					
			9	13.8000	0.5433	0.5625	-3.4%			27000					
			1	13.2000	0.5197	0.5625	-7.6%			27000					
151-1			2	13.3000	0.5236	0.5625	-6.9%			27000					
			3	13.2000	0.5197	0.5625	-7.6%			27000					
			4	14.0000	0.5512	0.5625	-2.0%			27000					
151-2	1405.75	7.63	5	13.9000	0.5472	0.5625	-2.7%	0.5197	410.7188	27000	14212.6	0.53	20303.7	0.75	
			6	13.8000	0.5433	0.5625	-3.4%			27000					
			7	13.3000	0.5236	0.5625	-6.9%			27000					
151-3			8	13.4000	0.5276	0.5625	-6.2%			27000					
			9	13.4000	0.5276	0.5625	-6.2%			27000					
			1	15.5000	0.6102	0.5625	8.5%			27000					
161-1			2	15.5000	0.6102	0.5625	8.5%			27000					
			3	15.2000	0.5984	0.5625	6.4%			27000					
			4	15.6000	0.6142	0.5625	9.2%			27000					
161-2	1493.33	7.63	5	15.1000	0.5945	0.5625	5.7%	0.5945	386.5837	27000	14034.0	0.52	20048.5	0.74	
			6	15.2000	0.5984	0.5625	6.4%			27000					
			7	15.5000	0.6102	0.5625	8.5%			27000					
161-3			8	15.6000	0.6142	0.5625	9.2%			27000					
			9	15.6000	0.6142	0.5625	9.2%			27000					
			1	13.4000	0.5276	0.6250	-15.6%			25000					
174-1			2	13.4000	0.5276	0.6250	-15.6%			25000					Allowable stress = 25000 psi for G40.B Steel 0.625"< Thickess ≤ 1.0"
			3	13.5000	0.5315	0.6250	-15.0%			25000					
			4	13.9000	0.5472	0.6250	-12.4%			25000					
174-2	1594.58	7.63	5	13.9000	0.5472	0.6250	-12.4%	0.5276	366.8181	25000	17299.9	0.69	24714.2	0.99	
			6	13.8000	0.5433	0.6250	-13.1%			25000					
			7	13.7000	0.5394	0.6250	-13.7%			25000					
174-3			8	13.6000	0.5354	0.6250	-14.3%			25000					
			9	13.8000	0.5433	0.6250	-13.1%			25000					
			1	15.3000	0.6024	0.6250	-3.6%			25000					
182-1			2	15.0000	0.5905	0.6250	-5.5%			25000					
			3	15.2000	0.5984	0.6250	-4.3%			25000					
			4	15.6000	0.6142	0.6250	-1.7%			25000					
182-2	1665.58	7.63	5	15.5000	0.6102	0.6250	-2.4%	0.5905	361.3179	25000	15823.9	0.63	22605.6	0.90	
			6	15.5000	0.6102	0.6250	-2.4%			25000					
			7	15.8000	0.6220	0.6250	-0.5%			25000					
182-3			8	15.7000	0.6181	0.6250	-1.1%			25000					
			9	15.8000	0.6220	0.6250	-0.5%			25000					

Can #	Distance From Fwd Edge of Can 1 (Ft)	Radius (ft)	Reading Number	Thickness Reading (mm)	Thickness Reading (in)	Design Plate Thickness (in)	%Change in Material	Min Thickness (in)	C.L. EL. (ft)	Allowable Steel Stress[3] (psi)	Base Material		At Joints		Notes
											Stress (psi)[2]	Stress Ratio[4]	Stress (psi)[2]	Stress Ratio[4]	
			1	18.8000	0.7402	0.7500	-1.3%			25000					
193-1			2	18.7000	0.7362	0.7500	-1.8%			25000					
			3	18.8000	0.7402	0.7500	-1.3%			25000					
			4	19.1000	0.7520	0.7500	0.3%			25000					
193-2	1759.17	7.63	5	19.1000	0.7520	0.7500	0.3%	0.7283	353.6530	25000	13247.5	0.53	18924.9	0.76	
			6	18.9000	0.7441	0.7500	-0.8%			25000					
			7	18.6000	0.7323	0.7500	-2.4%			25000					
193-3			8	18.6000	0.7323	0.7500	-2.4%			25000					
			9	18.5000	0.7283	0.7500	-2.9%			25000					
			1	16.4000	0.6457	0.6250	3.3%			24000					HSB50 Steel
221-1			2	16.1000	0.6339	0.6250	1.4%			24000					Allowable stress = 24000 psi
			3	15.8000	0.6220	0.6250	-0.5%			24000					
			4	15.4000	0.6063	0.6250	-3.0%			24000					
221-2	2010.58	7.63	5	15.5000	0.6102	0.6250	-2.4%	0.6063	313.5284	24000	18538.2	0.77	26483.1	1.10	
			6	15.4000	0.6063	0.6250	-3.0%			24000					
			7	15.5000	0.6102	0.6250	-2.4%			24000					
221-3			8	15.5000	0.6102	0.6250	-2.4%			24000					
			9	15.5000	0.6102	0.6250	-2.4%			24000					
			1	18.1000	0.7126	0.7500	-5.0%			25000					G40.8B
230-1			2	18.1000	0.7126	0.7500	-5.0%			25000					
			3	18.1000	0.7126	0.7500	-5.0%			25000					
			4	19.3000	0.7598	0.7500	1.3%			25000					
230-2	2096.67	7.63	5	19.3000	0.7598	0.7500	1.3%	0.7087	299.7900	25000	16629.1	0.67	23755.9	0.95	
			6	18.6000	0.7323	0.7500	-2.4%			25000					
			7	18.1000	0.7126	0.7500	-5.0%			25000					
230-3			8	18.1000	0.7126	0.7500	-5.0%			25000					
			9	18.0000	0.7087	0.7500	-5.5%			25000					
			1	19.9000	0.7835	0.6380	22.8%			24000					HSB50 Steel
242-1			2	19.8000	0.7795	0.6380	22.2%			24000					
			3	19.8000	0.7795	0.6380	22.2%			24000					
			4	20.8000	0.8189	0.6380	28.4%			24000					
242-2	2191.42	6.75	5	20.0000	0.7874	0.6380	23.4%	0.7677	284.6635	24000	14280.1	0.60	20400.1	0.85	
			6	20.0000	0.7874	0.6380	23.4%			24000					
			7	19.7000	0.7756	0.6380	21.6%			24000					
242-3			8	19.5000	0.7677	0.6380	20.3%			24000					
			9	19.5000	0.7677	0.6380	20.3%			24000					
			1	17.2000	0.6772	0.7060	-4.1%			24000					
261-1			2	17.2000	0.6772	0.7060	-4.1%			24000					
			3	17.2000	0.6772	0.7060	-4.1%			24000					
			4	17.5000	0.6890	0.7060	-2.4%			24000					
261-2	2381.92	6.75	5	17.5000	0.6890	0.7060	-2.4%	0.6772	254.2608	24000	17765.5	0.74	25379.3	1.06	
			6	17.6000	0.6929	0.7060	-1.9%			24000					
			7	17.3000	0.6811	0.7060	-3.5%			24000					
261-3			8	17.3000	0.6811	0.7060	-3.5%			24000					
			9	17.3000	0.6811	0.7060	-3.5%			24000					
			1	18.2000	0.7165	0.7390	-3.0%			24000					
272-1			2	18.3000	0.7205	0.7390	-2.5%			24000					
			3	18.2000	0.7165	0.7390	-3.0%			24000					
			4	18.6000	0.7323	0.7390	-0.9%			24000					
272-2	2492.25	6.75	5	18.5000	0.7283	0.7390	-1.4%	0.7165	236.6522	24000	17651.9	0.74	25217.1	1.05	
			6	18.5000	0.7283	0.7390	-1.4%			24000					
			7	18.2000	0.7165	0.7390	-3.0%			24000					
272-3			8	18.4000	0.7244	0.7390	-2.0%			24000					
			9	18.3000	0.7205	0.7390	-2.5%			24000					
			1	19.6000	0.7717	0.7980	-3.3%			24000					
283-1			2	19.6000	0.7717	0.7980	-3.3%			24000					
			3	19.6000	0.7717	0.7980	-3.3%			24000					
			4	20.1000	0.7913	0.7980	-0.8%			24000					
283-2	2602.25	6.75	5	20.0000	0.7874	0.7980	-1.3%	0.7717	219.0969	24000	17189.6	0.72	24556.6	1.02	
			6	20.1000	0.7913	0.7980	-0.8%			24000					
			7	19.7000	0.7756	0.7980	-2.8%			24000					
283-3			8	19.6000	0.7717	0.7980	-3.3%			24000					
			9	19.6000	0.7717	0.7980	-3.3%			24000					

Can #	Distance From Fwd Edge of Can 1 (Ft)	Radius (ft)	Reading Number	Thickness Reading (mm)	Thickness Reading (in)	Design Plate Thickness (in)	%Change in Material	Min Thickness (in)	C.L. EL. (ft)	Allowable Steel Stress[3] (psi)	Base Material		At Joints		Notes
											Stress (psi)[2]	Stress Ratio[4]	Stress (psi)[2]	Stress Ratio[4]	
			1	20.4000	0.8031	0.8290	-3.1%			24000					
291-1			2	20.5000	0.8071	0.8290	-2.6%			24000					
			3	20.4000	0.8031	0.8290	-3.1%			24000					
			4	20.6000	0.8110	0.8290	-2.2%			24000					
291-2	2678.50	6.75	5	20.5000	0.8071	0.8290	-2.6%	0.8031	209.8363	24000	16920.2	0.71	24171.8	1.01	
			6	20.5000	0.8071	0.8290	-2.6%			24000					
			7	20.8000	0.8189	0.8290	-1.2%			24000					
291-3			8	21.0000	0.8268	0.8290	-0.3%			24000					
			9	20.9000	0.8228	0.8290	-0.7%			24000					
			1	21.5000	0.8465	0.8540	-0.9%			24000					
303-1			2	21.5000	0.8465	0.8540	-0.9%			24000					
			3	21.5000	0.8465	0.8540	-0.9%			24000					
			4	21.5000	0.8465	0.8540	-0.9%			24000					
303-2	2799.17	6.75	5	21.5000	0.8465	0.8540	-0.9%	0.8465	199.7980	24000	16470.8	0.69	23529.7	0.98	
			6	21.5000	0.8465	0.8540	-0.9%			24000					
			7	21.5000	0.8465	0.8540	-0.9%			24000					
303-3			8	21.5000	0.8465	0.8540	-0.9%			24000					
			9	21.6000	0.8504	0.8540	-0.4%			24000					
			1	22.3000	0.8780	0.9790	-10.3%			24000					
314-1			2	22.4000	0.8819	0.9790	-9.9%			24000					
			3	22.3000	0.8780	0.9790	-10.3%			24000					
			4	22.3000	0.8780	0.9790	-10.3%			24000					
314-2	2909.83	6.75	5	22.4000	0.8819	0.9790	-9.9%	0.8780	190.5917	24000	16248.0	0.68	23211.4	0.97	
			6	22.4000	0.8819	0.9790	-9.9%			24000					
			7	22.4000	0.8819	0.9790	-9.9%			24000					
314-3			8	22.3000	0.8780	0.9790	-10.3%			24000					
			9	22.4000	0.8819	0.9790	-9.9%			24000					
			1	22.1000	0.8701	0.9290	-6.3%			24000					
321-1			2	22.1000	0.8701	0.9290	-6.3%			24000					
			3	22.2000	0.8740	0.9290	-5.9%			24000					
			4	22.1000	0.8701	0.9290	-6.3%			24000					
321-2	2980.42	6.75	5	22.1000	0.8701	0.9290	-6.3%	0.8583	184.7199	24000	16860.8	0.70	24086.8	1.00	
			6	22.1000	0.8701	0.9290	-6.3%			24000					
			7	21.8000	0.8583	0.9290	-7.6%			24000					
321-3			8	21.8000	0.8583	0.9290	-7.6%			24000					
			9	21.9000	0.8622	0.9290	-7.2%			24000					
			1	24.4000	0.9606	0.9540	0.7%			24000					
331-1			2	24.4000	0.9606	0.9540	0.7%			24000					
			3	24.3000	0.9567	0.9540	0.3%			24000					
			4	25.1000	0.9882	0.9540	3.6%			24000					
331-2	3081.08	6.75	5	25.0000	0.9842	0.9540	3.2%	0.9567	176.3454	24000	15433.4	0.64	22047.7	0.92	
			6	25.1000	0.9882	0.9540	3.6%			24000					
			7	24.6000	0.9685	0.9540	1.5%			24000					
331-3			8	24.5000	0.9646	0.9540	1.1%			24000					
			9	24.5000	0.9646	0.9540	1.1%			24000					
			1	24.5000	0.9646	0.9790	-1.5%			24000					
341-1			2	24.5000	0.9646	0.9790	-1.5%			24000					
			3	24.6000	0.9685	0.9790	-1.1%			24000					
			4	25.0000	0.9842	0.9790	0.5%			24000					
341-2	3181.83	6.75	5	25.0000	0.9842	0.9790	0.5%	0.9646	167.9640	24000	15612.4	0.65	22303.4	0.93	
			6	25.0000	0.9842	0.9790	0.5%			24000					
			7	24.7000	0.9724	0.9790	-0.7%			24000					
341-3			8	24.7000	0.9724	0.9790	-0.7%			24000					
			9	24.8000	0.9764	0.9790	-0.3%			24000					
			1	25.2000	0.9921	1.0250	-3.2%			24000					
352-1			2	25.2000	0.9921	1.0250	-3.2%			24000					
			3	25.2000	0.9921	1.0250	-3.2%			24000					
			4	25.3000	0.9961	1.0250	-2.8%			24000					
352-2	3277.67	6.75	5	25.2000	0.9921	1.0250	-3.2%	0.9921	149.8480	24000	15819.6	0.66	22599.5	0.94	
			6	25.2000	0.9921	1.0250	-3.2%			24000					
			7	25.5000	1.0039	1.0250	-2.1%			24000					
352-3			8	25.5000	1.0039	1.0250	-2.1%			24000					
			9	25.7000	1.0118	1.0250	-1.3%			24000					
			1	26.7000	1.0512	1.0950	-4.0%			24000					
361-1			2	26.7000	1.0512	1.0950	-4.0%			24000					
			3	26.7000	1.0512	1.0950	-4.0%			24000					
			4	27.3000	1.0748	1.0950	-1.8%			24000					
361-2	3366.00	6.75	5	27.3000	1.0748	1.0950	-1.8%	1.0315	127.6138	24000	15972.4	0.67	22817.8	0.95	
			6	27.3000	1.0748	1.0950	-1.8%			24000					
			7	26.2000	1.0315	1.0950	-5.8%			24000					
361-3			8	26.2000	1.0315	1.0950	-5.8%			24000					
			9	26.2000	1.0315	1.0950	-5.8%			24000					

Equations:

1.Pressure:	$P = h\lambda_w = \frac{h * 62.4pcf}{144in/ft}$	2. Hoop Stress:	$\sigma_h = \frac{Pr}{et}$
3. Allowable Stress:	$S_A = \min(\frac{F_u}{2.4}, \frac{F_y}{1.5})$	4. Stress Ratio:	$\frac{\sigma_h}{S_A}$
5. Percent Section Loss in Thickness	$\frac{(Original\ Section\ Thickness)-(Thickness\ Reading)}{(Orignal\ Section\ Thickness)}*100$		

Minimum Wall Thickness	
All	0.3937
17dia	0.3937
15.25dia	0.5197
13.5dia	0.6063

Steel Tensile and Yield Strengths:

F_{y_A285}=	26 ksi	
F_{u_A285}=	50 ksi	
$F_{y\_G40.8B\_1}$=	40 ksi	Thickess ≤ 0.625"
$F_{y\_G40.8B\_2}$=	38 ksi	0.625"< Thickess ≤ 1.0"
$F_{y\_G40.8B\_3}$=	36 ksi	1.0"< Thickess ≤ 1.5"
$F_{U\_G40.8B}$=	65 ksi	
F_{y_HSB50}=	Unknown	
F_{u_HSB50}=	Unknown	

Allowable Stresses:

F_{all_A285}=	17 ksi	
$F_{all\_G40.8\_1}$=	27 ksi	Thickess ≤ 0.625"
$F_{all\_G40.8\_2}$=	25 ksi	0.625"< Thickess ≤ 1.0"
$F_{all\_G40.8\_3}$=	24 ksi	1.0"< Thickess ≤ 1.5"
$F_{all\_HSB\_50}$=	Unknown	

TABLE 2 - TRANSIENT
PENSTOCK 3 THICKNESS MEASURMENTS AND STRESSES

Unit weight of water=	62.4	pcf
Normal pond EL=	597	feet
Joint Efficiency=	0.7	
D_1 ID=	17.00	feet
D_2 ID=	15.25	feet
D_3 ID=	13.50	feet

Project No:	2670043
Date:	8-Jan-26
By:	YA
Checked	

Can #	Distance From Fwd Edge of Can 1 (Ft)	Radius (ft)	Reading Number	Thickness Reading (mm)	Thickness Reading (in)	Design Plate Thickness (in)	%Change in Material	Min Thickness (in)	C.L. EL. (ft)	Allowable Steel Stress[3] (psi)	Base Material		At Joints		Notes
											Stress (psi)[2]	Stress Ratio[4]	Stress (psi)[2]	Stress Ratio[4]	
			1	11.9000	0.4685	0.5000	-6.3%			17000					Start A285 Steel
7-1			2	12.0000	0.4724	0.5000	-5.5%			17000					
			3	11.9000	0.4685	0.5000	-6.3%			17000					
			4	11.9000	0.4685	0.5000	-6.3%			17000					
7-2	53.67	8.50	5	11.9000	0.4685	0.5000	-6.3%	0.4646	555.0832	17000	5184.5	0.30	7406.4	0.44	
			6	11.8000	0.4646	0.5000	-7.1%			17000					
			7	11.8000	0.4646	0.5000	-7.1%			17000					
7-3			8	11.8000	0.4646	0.5000	-7.1%			17000					
			9	11.8000	0.4646	0.5000	-7.1%			17000					
			1	10.3000	0.4055	0.4375	-7.3%			17000					
17-1			2	10.5000	0.4134	0.4375	-5.5%			17000					
			3	10.5000	0.4134	0.4375	-5.5%			17000					
			4	10.5000	0.4134	0.4375	-5.5%			17000					
17-2	143.92	8.50	5	10.5000	0.4134	0.4375	-5.5%	0.4016	554.6982	17000	6052.8	0.36	8646.9	0.51	
			6	10.4000	0.4094	0.4375	-6.4%			17000					
			7	10.3000	0.4055	0.4375	-7.3%			17000					
17-3			8	10.3000	0.4055	0.4375	-7.3%			17000					
			9	10.2000	0.4016	0.4375	-8.2%			17000					
			1	10.0000	0.3937	0.4375	-10.0%			17000					
27-1			2	10.1000	0.3976	0.4375	-9.1%			17000					
			3	10.1000	0.3976	0.4375	-9.1%			17000					
			4	10.1000	0.3976	0.4375	-9.1%			17000					
27-2	204.50	8.50	5	10.2000	0.4016	0.4375	-8.2%	0.3937	551.6677	17000	6616.2	0.39	9451.7	0.56	
			6	10.3000	0.4055	0.4375	-7.3%			17000					
			7	10.4000	0.4094	0.4375	-6.4%			17000					
27-3			8	10.4000	0.4094	0.4375	-6.4%			17000					
			9	10.3000	0.4055	0.4375	-7.3%			17000					
			1	10.3000	0.4055	0.4375	-7.3%			17000					
35-1			2	10.4000	0.4094	0.4375	-6.4%			17000					
			3	10.4000	0.4094	0.4375	-6.4%			17000					
			4	10.5000	0.4134	0.4375	-5.5%			17000					
35-2	282.67	8.50	5	10.5000	0.4134	0.4375	-5.5%	0.4055	543.3293	17000	7605.0	0.45	10864.3	0.64	
			6	10.5000	0.4134	0.4375	-5.5%			17000					
			7	10.5000	0.4134	0.4375	-5.5%			17000					
35-3			8	10.4000	0.4094	0.4375	-6.4%			17000					
			9	10.4000	0.4094	0.4375	-6.4%			17000					
			1	10.5000	0.4134	0.4375	-5.5%			17000					
45-1			2	10.5000	0.4134	0.4375	-5.5%			17000					
			3	10.4000	0.4094	0.4375	-6.4%			17000					
			4	10.8000	0.4252	0.4375	-2.8%			17000					
45-2	382.75	8.50	5	10.6000	0.4173	0.4375	-4.6%	0.4094	532.6531	17000	9030.2	0.53	12900.2	0.76	
			6	10.8000	0.4252	0.4375	-2.8%			17000					
			7	10.7000	0.4213	0.4375	-3.7%			17000					
45-3			8	10.8000	0.4252	0.4375	-2.8%			17000					
			9	10.7000	0.4213	0.4375	-3.7%			17000					
			1	10.7000	0.4213	0.4375	-3.7%			17000					
57-1			2	10.7000	0.4213	0.4375	-3.7%			17000					
			3	10.6000	0.4173	0.4375	-4.6%			17000					
			4	10.8000	0.4252	0.4375	-2.8%			17000					
57-2	502.33	8.50	5	10.8000	0.4252	0.4375	-2.8%	0.4173	519.8967	17000	10616.2	0.62	15166.0	0.89	
			6	10.8000	0.4252	0.4375	-2.8%			17000					
			7	10.7000	0.4213	0.4375	-3.7%			17000					
57-3			8	10.7000	0.4213	0.4375	-3.7%			17000					
			9	10.7000	0.4213	0.4375	-3.7%			17000					
			1	10.3000	0.4055	0.4375	-7.3%			17000					
66-1			2	10.3000	0.4055	0.4375	-7.3%			17000					
			3	10.5000	0.4134	0.4375	-5.5%			17000					
			4	10.1000	0.3976	0.4375	-9.1%			17000					
66-2	592.08	8.50	5	10.2000	0.4016	0.4375	-8.2%	0.3976	511.4546	17000	12361.6	0.73	17659.5	1.04	
			6	10.3000	0.4055	0.4375	-7.3%			17000					
			7	10.3000	0.4055	0.4375	-7.3%			17000					
66-3			8	10.1000	0.3976	0.4375	-9.1%			17000					
			9	10.2000	0.4016	0.4375	-8.2%			17000					
			1	10.2000	0.4016	0.4375	-8.2%			17000					
77-1			2	10.3000	0.4055	0.4375	-7.3%			17000					
			3	10.3000	0.4055	0.4375	-7.3%			17000					
			4	10.5000	0.4134	0.4375	-5.5%			17000					
77-2	701.58	8.50	5	10.5000	0.4134	0.4375	-5.5%	0.4016	502.1030	17000	13578.5	0.80	19397.9	1.14	
			6	10.5000	0.4134	0.4375	-5.5%			17000					
			7	10.5000	0.4134	0.4375	-5.5%			17000					
77-3			8	10.4000	0.4094	0.4375	-6.4%			17000					
			9	10.4000	0.4094	0.4375	-6.4%			17000					
			1	10.4000	0.4094	0.4375	-6.4%			27000					Start G40.8B Steel
101-1			2	10.5000	0.4134	0.4375	-5.5%			27000					Allowable stress = 27000 psi for G40.B
			3	10.4000	0.4094	0.4375	-6.4%			27000					Steel and Thickess ≤ 0.625"
			4	10.0000	0.3937	0.4375	-10.0%			27000					
101-2	940.92	8.50	5	10.1000	0.3976	0.4375	-9.1%	0.3937	481.6634	27000	16833.2	0.62	24047.5	0.89	
			6	10.0000	0.3937	0.4375	-10.0%			27000					
			7	10.2000	0.4016	0.4375	-8.2%			27000					
101-3			8	10.2000	0.4016	0.4375	-8.2%			27000					
			9	10.1000	0.3976	0.4375	-9.1%			27000					

			1	10.8000	0.4252	0.4375	-2.8%			27000					
111-1			2	10.7000	0.4213	0.4375	-3.7%			27000					
			3	10.7000	0.4213	0.4375	-3.7%			27000					
			4	10.4000	0.4094	0.4375	-6.4%			27000					
111-2	1040.67	8.50	5	10.4000	0.4094	0.4375	-6.4%	0.4016	473.1445	27000	17722.1	0.66	25317.3	0.94	
			6	10.4000	0.4094	0.4375	-6.4%			27000					
			7	10.2000	0.4016	0.4375	-8.2%			27000					
111-3			8	10.4000	0.4094	0.4375	-6.4%			27000					
			9	10.3000	0.4055	0.4375	-7.3%			27000					
			1	10.7000	0.4213	0.4375	-3.7%			27000					
122-1			2	10.7000	0.4213	0.4375	-3.7%			27000					
			3	10.6000	0.4173	0.4375	-4.6%			27000					
			4	10.1000	0.3976	0.4375	-9.1%			27000					
122-2	1150.08	8.50	5	10.0000	0.3937	0.4375	-10.0%	0.3937	463.8000	27000	19440.4	0.72	27772.0	1.03	
			6	10.1000	0.3976	0.4375	-9.1%			27000					
			7	10.5000	0.4134	0.4375	-5.5%			27000					
122-3			8	10.5000	0.4134	0.4375	-5.5%			27000					
			9	10.5000	0.4134	0.4375	-5.5%			27000					
			1	14.0000	0.5512	0.5625	-2.0%			27000					
131-1			2	13.9000	0.5472	0.5625	-2.7%			27000					
			3	14.0000	0.5512	0.5625	-2.0%			27000					
			4	13.9000	0.5472	0.5625	-2.7%			27000					
131-2	1239.75	8.50	5	14.0000	0.5512	0.5625	-2.0%	0.5433	456.1423	27000	14897.1	0.55	21281.6	0.79	
			6	13.8000	0.5433	0.5625	-3.4%			27000					
			7	13.8000	0.5433	0.5625	-3.4%			27000					
131-3			8	13.8000	0.5433	0.5625	-3.4%			27000					
			9	13.8000	0.5433	0.5625	-3.4%			27000					
			1	13.2000	0.5197	0.5625	-7.6%			27000					
151-1			2	13.3000	0.5236	0.5625	-6.9%			27000					
			3	13.2000	0.5197	0.5625	-7.6%			27000					
			4	14.0000	0.5512	0.5625	-2.0%			27000					
151-2	1405.75	7.63	5	13.9000	0.5472	0.5625	-2.7%	0.5197	410.7188	27000	18476.4	0.68	26394.8	0.98	
			6	13.8000	0.5433	0.5625	-3.4%			27000					
			7	13.3000	0.5236	0.5625	-6.9%			27000					
151-3			8	13.4000	0.5276	0.5625	-6.2%			27000					
			9	13.4000	0.5276	0.5625	-6.2%			27000					
			1	15.5000	0.6102	0.5625	8.5%			27000					
161-1			2	15.5000	0.6102	0.5625	8.5%			27000					
			3	15.2000	0.5984	0.5625	6.4%			27000					
			4	15.6000	0.6142	0.5625	9.2%			27000					
161-2	1493.33	7.63	5	15.1000	0.5945	0.5625	5.7%	0.5945	386.5837	27000	18244.2	0.68	26063.1	0.97	
			6	15.2000	0.5984	0.5625	6.4%			27000					
			7	15.5000	0.6102	0.5625	8.5%			27000					
161-3			8	15.6000	0.6142	0.5625	9.2%			27000					
			9	15.6000	0.6142	0.5625	9.2%			27000					
			1	13.4000	0.5276	0.6250	-15.6%			25000					Allowable stress = 25000 psi for 0.625"< Thickess ≤ 1.0"
174-1			2	13.4000	0.5276	0.6250	-15.6%			25000					
			3	13.5000	0.5315	0.6250	-15.0%			25000					
			4	13.9000	0.5472	0.6250	-12.4%			25000					
174-2	1594.58	7.63	5	13.9000	0.5472	0.6250	-12.4%	0.5276	366.8181	25000	22489.9	0.90	32128.5	1.29	
			6	13.8000	0.5433	0.6250	-13.1%			25000					
			7	13.7000	0.5394	0.6250	-13.7%			25000					
174-3			8	13.6000	0.5354	0.6250	-14.3%			25000					
			9	13.8000	0.5433	0.6250	-13.1%			25000					
			1	15.3000	0.6024	0.6250	-3.6%			25000					
182-1			2	15.0000	0.5905	0.6250	-5.5%			25000					
			3	15.2000	0.5984	0.6250	-4.3%			25000					
			4	15.6000	0.6142	0.6250	-1.7%			25000					
182-2	1665.58	7.63	5	15.5000	0.6102	0.6250	-2.4%	0.5905	361.3179	25000	20571.1	0.82	29387.2	1.18	
			6	15.5000	0.6102	0.6250	-2.4%			25000					
			7	15.8000	0.6220	0.6250	-0.5%			25000					
182-3			8	15.7000	0.6181	0.6250	-1.1%			25000					
			9	15.8000	0.6220	0.6250	-0.5%			25000					
			1	18.8000	0.7402	0.7500	-1.3%			25000					
193-1			2	18.7000	0.7362	0.7500	-1.8%			25000					
			3	18.8000	0.7402	0.7500	-1.3%			25000					
			4	19.1000	0.7520	0.7500	0.3%			25000					
193-2	1759.17	7.63	5	19.1000	0.7520	0.7500	0.3%	0.7283	353.6530	25000	17221.7	0.69	24602.4	0.98	
			6	18.9000	0.7441	0.7500	-0.8%			25000					
			7	18.6000	0.7323	0.7500	-2.4%			25000					
193-3			8	18.6000	0.7323	0.7500	-2.4%			25000					
			9	18.5000	0.7283	0.7500	-2.9%			25000					
			1	16.4000	0.6457	0.6250	3.3%			24000					HSB50 Steel
221-1			2	16.1000	0.6339	0.6250	1.4%			24000					
			3	15.8000	0.6220	0.6250	-0.5%			24000					
			4	15.4000	0.6063	0.6250	-3.0%			24000					
221-2	2010.58	7.63	5	15.5000	0.6102	0.6250	-2.4%	0.6063	313.5284	24000	24099.6	1.00	34428.0	1.43	
			6	15.4000	0.6063	0.6250	-3.0%			24000					
			7	15.5000	0.6102	0.6250	-2.4%			24000					
221-3			8	15.5000	0.6102	0.6250	-2.4%			24000					
			9	15.5000	0.6102	0.6250	-2.4%			24000					

			1	18.1000	0.7126	0.7500	-5.0%			25000					G40.8B
230-1			2	18.1000	0.7126	0.7500	-5.0%			25000					
			3	18.1000	0.7126	0.7500	-5.0%			25000					
			4	19.3000	0.7598	0.7500	1.3%			25000					
230-2	2096.67	7.63	5	19.3000	0.7598	0.7500	1.3%	0.7087	299.7900	25000	21617.8	0.86	30882.6	1.24	
			6	18.6000	0.7323	0.7500	-2.4%			25000					
			7	18.1000	0.7126	0.7500	-5.0%			25000					
230-3			8	18.1000	0.7126	0.7500	-5.0%			25000					
			9	18.0000	0.7087	0.7500	-5.5%			25000					
			1	19.9000	0.7835	0.6380	22.8%			24000					Start HSB50 Steel
242-1			2	19.8000	0.7795	0.6380	22.2%			24000					
			3	19.8000	0.7795	0.6380	22.2%			24000					
			4	20.8000	0.8189	0.6380	28.4%			24000					
242-2	2191.42	6.75	5	20.0000	0.7874	0.6380	23.4%	0.7677	284.6635	24000	18564.1	0.77	26520.1	1.11	
			6	20.0000	0.7874	0.6380	23.4%			24000					
			7	19.7000	0.7756	0.6380	21.6%			24000					
242-3			8	19.5000	0.7677	0.6380	20.3%			24000					
			9	19.5000	0.7677	0.6380	20.3%			24000					
			1	17.2000	0.6772	0.7060	-4.1%			24000					
261-1			2	17.2000	0.6772	0.7060	-4.1%			24000					
			3	17.2000	0.6772	0.7060	-4.1%			24000					
			4	17.5000	0.6890	0.7060	-2.4%			24000					
261-2	2381.92	6.75	5	17.5000	0.6890	0.7060	-2.4%	0.6772	254.2608	24000	23095.2	0.96	32993.1	1.37	
			6	17.6000	0.6929	0.7060	-1.9%			24000					
			7	17.3000	0.6811	0.7060	-3.5%			24000					
261-3			8	17.3000	0.6811	0.7060	-3.5%			24000					
			9	17.3000	0.6811	0.7060	-3.5%			24000					
			1	18.2000	0.7165	0.7390	-3.0%			24000					
272-1			2	18.3000	0.7205	0.7390	-2.5%			24000					
			3	18.2000	0.7165	0.7390	-3.0%			24000					
			4	18.6000	0.7323	0.7390	-0.9%			24000					
272-2	2492.25	6.75	5	18.5000	0.7283	0.7390	-1.4%	0.7165	236.6522	24000	22947.5	0.96	32782.2	1.37	
			6	18.5000	0.7283	0.7390	-1.4%			24000					
			7	18.2000	0.7165	0.7390	-3.0%			24000					
272-3			8	18.4000	0.7244	0.7390	-2.0%			24000					
			9	18.3000	0.7205	0.7390	-2.5%			24000					
			1	19.6000	0.7717	0.7980	-3.3%			24000					
283-1			2	19.6000	0.7717	0.7980	-3.3%			24000					
			3	19.6000	0.7717	0.7980	-3.3%			24000					
			4	20.1000	0.7913	0.7980	-0.8%			24000					
283-2	2602.25	6.75	5	20.0000	0.7874	0.7980	-1.3%	0.7717	219.0969	24000	22346.5	0.93	31923.6	1.33	
			6	20.1000	0.7913	0.7980	-0.8%			24000					
			7	19.7000	0.7756	0.7980	-2.8%			24000					
283-3			8	19.6000	0.7717	0.7980	-3.3%			24000					
			9	19.6000	0.7717	0.7980	-3.3%			24000					
			1	20.4000	0.8031	0.8290	-3.1%			24000					
291-1			2	20.5000	0.8071	0.8290	-2.6%			24000					
			3	20.4000	0.8031	0.8290	-3.1%			24000					
			4	20.6000	0.8110	0.8290	-2.2%			24000					
291-2	2678.50	6.75	5	20.5000	0.8071	0.8290	-2.6%	0.8031	209.8363	24000	21996.3	0.92	31423.3	1.31	
			6	20.5000	0.8071	0.8290	-2.6%			24000					
			7	20.8000	0.8189	0.8290	-1.2%			24000					
291-3			8	21.0000	0.8268	0.8290	-0.3%			24000					
			9	20.9000	0.8228	0.8290	-0.7%			24000					
			1	21.5000	0.8465	0.8540	-0.9%			24000					
303-1			2	21.5000	0.8465	0.8540	-0.9%			24000					
			3	21.5000	0.8465	0.8540	-0.9%			24000					
			4	21.5000	0.8465	0.8540	-0.9%			24000					
303-2	2799.17	6.75	5	21.5000	0.8465	0.8540	-0.9%	0.8465	199.7980	24000	21412.1	0.89	30588.7	1.27	
			6	21.5000	0.8465	0.8540	-0.9%			24000					
			7	21.5000	0.8465	0.8540	-0.9%			24000					
303-3			8	21.5000	0.8465	0.8540	-0.9%			24000					
			9	21.6000	0.8504	0.8540	-0.4%			24000					
			1	22.3000	0.8780	0.9790	-10.3%			24000					
314-1			2	22.4000	0.8819	0.9790	-9.9%			24000					
			3	22.3000	0.8780	0.9790	-10.3%			24000					
			4	22.3000	0.8780	0.9790	-10.3%			24000					
314-2	2909.83	6.75	5	22.4000	0.8819	0.9790	-9.9%	0.8780	190.5917	24000	21122.4	0.88	30174.9	1.26	
			6	22.4000	0.8819	0.9790	-9.9%			24000					
			7	22.4000	0.8819	0.9790	-9.9%			24000					
314-3			8	22.3000	0.8780	0.9790	-10.3%			24000					
			9	22.4000	0.8819	0.9790	-9.9%			24000					
			1	22.1000	0.8701	0.9290	-6.3%			24000					
321-1			2	22.1000	0.8701	0.9290	-6.3%			24000					
			3	22.2000	0.8740	0.9290	-5.9%			24000					
			4	22.1000	0.8701	0.9290	-6.3%			24000					
321-2	2980.42	6.75	5	22.1000	0.8701	0.9290	-6.3%	0.8583	184.7199	24000	21919.0	0.91	31312.9	1.30	
			6	22.1000	0.8701	0.9290	-6.3%			24000					
			7	21.8000	0.8583	0.9290	-7.6%			24000					
321-3			8	21.8000	0.8583	0.9290	-7.6%			24000					
			9	21.9000	0.8622	0.9290	-7.2%			24000					
			1	24.4000	0.9606	0.9540	0.7%			24000					
331-1			2	24.4000	0.9606	0.9540	0.7%			24000					
			3	24.3000	0.9567	0.9540	0.3%			24000					
			4	25.1000	0.9882	0.9540	3.6%			24000					
331-2	3081.08	6.75	5	25.0000	0.9842	0.9540	3.2%	0.9567	176.3454	24000	20063.4	0.84	28662.0	1.19	
			6	25.1000	0.9882	0.9540	3.6%			24000					
			7	24.6000	0.9685	0.9540	1.5%			24000					
331-3			8	24.5000	0.9646	0.9540	1.1%			24000					
			9	24.5000	0.9646	0.9540	1.1%			24000					
			1	24.5000	0.9646	0.9790	-1.5%			24000					
341-1			2	24.5000	0.9646	0.9790	-1.5%			24000					
			3	24.6000	0.9685	0.9790	-1.1%			24000					
			4	25.0000	0.9842	0.9790	0.5%			24000					
341-2	3181.83	6.75	5	25.0000	0.9842	0.9790	0.5%	0.9646	167.9640	24000	20296.1	0.85	28994.5	1.21	
			6	25.0000	0.9842	0.9790	0.5%			24000					
			7	24.7000	0.9724	0.9790	-0.7%			24000					
341-3			8	24.7000	0.9724	0.9790	-0.7%			24000					
			9	24.8000	0.9764	0.9790	-0.3%			24000					
			1	25.2000	0.9921	1.0250	-3.2%			24000					
352-1			2	25.2000	0.9921	1.0250	-3.2%			24000					
			3	25.2000	0.9921	1.0250	-3.2%			24000					
			4	25.3000	0.9961	1.0250	-2.8%			24000					
352-2	3277.67	6.75	5	25.2000	0.9921	1.0250	-3.2%	0.9921	149.8480	24000	20565.5	0.86	29379.3	1.22	
			6	25.2000	0.9921	1.0250	-3.2%			24000					
			7	25.5000	1.0039	1.0250	-2.1%			24000					
352-3			8	25.5000	1.0039	1.0250	-2.1%			24000					
			9	25.7000	1.0118	1.0250	-1.3%			24000					
			1	26.7000	1.0512	1.0950	-4.0%			24000					
361-1			2	26.7000	1.0512	1.0950	-4.0%			24000					
			3	26.7000	1.0512	1.0950	-4.0%			24000					
			4	27.3000	1.0748	1.0950	-1.8%			24000					
361-2	3366.00	6.75	5	27.3000	1.0748	1.0950	-1.8%	1.0315	127.6138	24000	20764.2	0.87	29663.1	1.24	
			6	27.3000	1.0748	1.0950	-1.8%			24000					
			7	26.2000	1.0315	1.0950	-5.8%			24000					
361-3			8	26.2000	1.0315	1.0950	-5.8%			24000					
			9	26.2000	1.0315	1.0950	-5.8%			24000					

Equations:

1.Pressure:	$P = h\lambda_w = \frac{h * 62.4pcf}{144in/ft}$	2. Hoop Stress:	$\sigma_h = \frac{Pr}{et}$
3. Allowable Stress:	$S_A = \min(\frac{F_u}{2.4}, \frac{F_y}{1.5})$	4. Stress Ratio:	$\frac{\sigma_h}{S_A}$
5. Percent Section Loss in Thickness	$\frac{(Original\ Section\ Thickness)-(Thickness\ Reading)}{(Orignal\ Section\ Thickness)}*100$		

Minimum Wall Thickness	
All	0.3937
17dia	0.3937
15.25dia	0.5197
13.5dia	0.6063

Steel Tensile and Yield Strengths:		
F_{y_A285}=	26 ksi	
F_{u_A285}=	50 ksi	
$F_{y\_G40.8B\_1}$=	40 ksi	Thickess ≤ 0.625"
$F_{y\_G40.8B\_2}$=	38 ksi	0.625"< Thickess ≤ 1.0"
$F_{y\_G40.8B\_3}$=	36 ksi	1.0"< Thickess ≤ 1.5"
$F_{U\_G40.8B}$=	65 ksi	
F_{y_HSB50}=	Unknown	
F_{u_HSB50}=	Unknown	

Allowable Stresses:		
F_{all_A285}=	17 ksi	
$F_{all\_G40.8\_1}$=	27 ksi	Thickess ≤ 0.625"
$F_{all\_G40.8\_2}$=	25 ksi	0.625"< Thickess ≤ 1.0"
$F_{all\_G40.8\_3}$=	24 ksi	1.0"< Thickess ≤ 1.5"
$F_{all\_HSB\_50}$=	Unknown	