From:	Carter, Paul
To:	Coffey, Bernard (Clerk of the Executive Council)
Cc:	Bown, Charles; Quinton, Diana; Quinlan, Krista; Parsons, Walter; McIntosh, Gordon
Subject:	FW: November-Dec IE Trip report
Date:	Friday, March 10, 2017 8:55:22 AM
Attachments:	2016-11-28 Nalcor - Nov 28 to Dec 01 2016 IE Site Visit.pdf

Just wanted to make all aware that Nalcor is planning on posting the IE report (attached) today to their website. Cory, Walter and I have reviewed. It is ok – some observations below that may pick up some public attention. Understand that Nalcor has provided some key messages to NR.

Cofferdam Repairs

IE does make linkage back to open rock/materials and fractured bedrock referenced in earlier report as possible reasons for the leakage based on observations and discussion with Nalcor staff and SNC in the absence having the actual known root cause available at the time of the visit.

IE also references the repair plans being localized to stations 280 to 400 rather than all of the of cofferdam, as we know it today.

IE describes the plan for cofferdam mitigation and repair as "a belt and braces" and appropriately conservative.

The IE concurs that the grouting program will repair defects in the cofferdam but recommends additional grouting take place in localized areas of high grout take (more holes/grouting in these locations) and suggests that compaction grouting (one of the three types of grouting remediation planned might not effectively seal zones in the core damaged by the November leakage and suggests permeation grouting with plastic mixes may be helpful.

The IE comments on the effects of no ice boom and ice cover on frazil ice and ice dam and the importance of raising the powerhouse cofferdam.

North Spur

Not much commentary one way or another.

SOBI Crossing

Identifies the water ingress issue. This will likely be the first time this issue is known publically. It is subject to an insurance claim. I do know that since this time, cables have past testing.

Paul Q. Carter
Executive Director – Muskrat Oversight Committee
Cabinet Secretariat, Executive Council
Government of Newfoundland and Labrador
PO Box 8700
St. John's, NL
A1B 2Z8
Phone: 709-729-3681
Email: paulcarter@gov.nl.ca

From: StevePellerin@lowerchurchillproject.ca [mailto:StevePellerin@lowerchurchillproject.ca]
Sent: Wednesday, March 08, 2017 12:24 PM
To: Carter, Paul
Subject: IE Trip report

Stephen Pellerin
Special Projects & 3rd Party Coordination Manager
PROJECT DELIVERY TEAM
Lower Churchill Project
t. **(709) 570-5969** c. **(709) 725-7308** f. **(709) 754-0787**
e. **StevePellerin@lowerchurchillproject.ca**
w. **muskratfalls.nalcorenergy.com**

MWH

MEETINGS IN ST. JOHN'S AND VISITS TO LOWER CHURCHILL PROJECT SITES, NOVEMBER 28 TO DECEMBER 01, 2016

Prepared for: Natural Resources Canada and Nalcor Energy

IE Point of Contact: Nik Argirov

Date: March 3, 2017

Quality Assurance Statement

Office Address	740-1185 W Georgia Street, Vancouver BC, V6E 4E6
Prepared by	John Young, Handy Khalil and Nik Argirov
Reviewed by	Nik Argirov and Howard Lee
Approved for Issue by	Howard Lee

This page left intentionally blank

MWH

TABLE OF CONTENTS

1. GENERAL 1
2. SOLDIERS POND 1
3. MUSKRAT FALLS POWERHOUSE 2
4. SPILLWAY 2
5. COFFERDAM 2
   - 5.1. General 2
   - 5.2. Upstream Cofferdam Description 3
   - 5.3. Leakage and Internal Erosion of the Upstream Cofferdam 3
   - 5.4. Remedial Repairs 5
   - 5.5. Effects of Delayed Impoundment on Downstream Ice Dam Formation and Impact on Powerhouse Cofferdam 7
6. NORTH SPUR 7
7. MUSKRAT FALLS SWITCHYARD 8
8. SOBI CROSSING 8
9. CONCLUSIONS AND COMMENTS 8

APPENDIX 1 - Site Photographs

This page left intentionally blank

1. GENERAL

The Independent Engineer (IE) team, together with a representative of Natural Resources Canada (NRCan) attended project briefings at the Lower Churchill Project Delivery Office in St. John's and participated in visits to Soldiers Pond and Muskrat Falls construction sites during November 28 to December 1, 2016. Humayun Soomro represented NRCan on the site visits, the Independent Engineer was represented by Nik Argirov (IE Team Lead), John Young (IE Geotechnical Subject Matter Expert (SME)) and Hamdy Khalil (IE Transmission Lines SME). Representatives from the Government of Newfoundland & Labrador also attended the various briefings and site visits. The itinerary and activities were as follows:

- Tuesday, November 29:
  - AM: A project briefing was carried out by Lower Churchill Management Corporation (LCMC) supervisory staff in the SNC/Nalcor Project offices in St John's The briefing presentations covered various aspects of the work and project progress.
  - PM: Visit to the Soldiers Pond site.
- Wednesday, November 30, 2016:
  - AM: Travel to Goose Bay from St. John's.
  - AM and PM: Tour of the Dam works, Spillway, Powerhouse and Switchyard at the Muskrat Falls site.
  - PM: Travel from Goose Bay to St John's
- Thursday, December 1:
  - Wrap-up meetings at Nalcor's offices in St. Johns. This included a half hour discussion between the IE geotechnical Expert and the SNC geotechnical engineer to review the cofferdam leakage and repairs.

Principal observations and comments are presented in the following paragraphs. Labeled photographs are presented in Appendix 1.

2. SOLDIERS POND

At the time of the November 29, 2016 site visit the construction work was proceeding well with many activities underway. Photographs taken from this site are presented in Appendix 1, Section A. The following observations were made during the site visit:

- Work on the AC switch yard was at an advanced stage of construction (Photos A.1 and A.2). Most electrical towers, wiring and switching gear have been installed.
- The assembly of the pre-engineered control building was substantially completed (Photo A.3.). Interior BOP electro-mechanical equipment and wiring / cabling installation was in progress (Photo A.4).
- Erection of the Synchronous Condenser (SC) Building is completed (Photo A.5). Work was being carried out on equipment installations inside the building at the time of the site visit (Photo A.6). The SC transformers have been installed and the gantry for the transformers feeders erected (Photos A.7, A.8 and A.9). Concrete footings for excitation transformers were substantially completed (Photo A.10).
- The erection of the Converter Building is completed and work was underway on electrical and mechanical BOP equipment installations in the interior (Photos A.11 and A.12).

- The fire walls and foundations of the converter transformers (Photo A.13) have been completed and final work and grading was being carried out on the footings for the AC and DC filters equipment (Photo A.14).
- The Converter oil/water separator at the southern end of the site was also completed and partially backfilled.

3. MUSKRAT FALLS POWERHOUSE

Work on the Muskrat Falls Power Intake/Powerhouse/Tailrace was ongoing at the time of the IE site visit. This work is on the critical path and directly impacts initial power generation at Muskrat Falls. Photographs taken from this site are presented in Appendix 1, Section B.

Observations made during the November 30, 2016 IE site visit include the following:

- It is reported by Nalcor that about 44.5% of concrete placement has been completed (138,200 m^3 of the required 310,000 m^3 for the powerhouse/intake complex).
- Work is progressing on formwork, reinforcement, and concrete placement of the four units under winterized conditions (Photos B.1, B.2, B.3, B.4 and B.10).
- Remediation work in draft tube of unit 2 is completed and reinforcement and concrete placement is proceeding at higher elevations (Photos B.5, B.6 and B.7).
- Steel superstructure framework of the South Service Bay was finalized with the completion of the final alignment of overhead crane rails, and final bolting, torquing and tie back of steel frames on lines 6 and 7 (Photos B.8 and B.9).
- Concrete placement of upstream and downstream walls of unit 1 is complete and ready (anchor bolts installed) for erection of steel superstructure frames on lines 8 to 12 (Photos B.11, B.12 and B.13).
- The IE observed that the construction works quality is of a high standard.

4. SPILLWAY

At the time of the November 30, 2016 site visit, the spillway was completed and was operational. All five gates were fully open to permit full river flow. The water in the upstream reservoir pond was at approximately el 14.0 m during the IE site visit. Photographs taken during the visit are presented in Section C of Appendix 1.

5. COFFERDAM

5.1. General

Both the upstream and downstream cofferdams of the main dam were completed in early November and the reservoir was raised to the planned el of ~21.5 m to facilitate placement of the ice boom for control of ice formation in the downstream area during the upcoming winter months. The downstream cofferdam performed well but the upstream cofferdam experienced leak-age and internal erosion damage in the vicinity of Sta 0+330 m when the reservoir was raised to el ~21.5 m. The reservoir has been lowered and various remedial works have been carried out and new grouting program is currently underway on the up-stream cofferdam. It is anticipated that repairs will be completed by January - February 2017. Photographs taken from this site are presented in Appendix 1, Section D. A brief description of the situation, as understood by the IE, is presented in the following paragraphs.

5.2. Upstream Cofferdam Description

The Muskrat Falls Upstream cofferdam is a 450 m long embankment structure located upstream of the planned main RCC dam (Photo D.1). As originally designed and constructed it was about 26 m high and consists of lower dumped starter dam topped off by a compacted fill embankment dam, as shown on Figure 5.1 below and on Drawing MFA-SN-CD-2340-CV-SE-0002-01 Rev C2. As shown on the figure and the drawing, the starter dam consisted of two rock fill groins of 5 m to 12 m height, constructed from the riverbed up to el 14 m with a dumped till impervious zone placed in between them. Dumped transition rock fill zones were placed on the groin slopes, upstream and downstream of the impervious zone. Additionally, a granular filter zone will be sandwiched between the downstream impervious and transition zones. A 12 m high conventional center core embankment dam was then constructed on top of the starter dam up to el 26 m. The overall design of the cofferdam is conventional and in line with accepted practice.

The rockfill groins of the el 14 m starter dam were placed on the natural riverbed. Approximately 12.5 m wide at the base, the impervious fill zone was placed on the cleaned riverbed between the groins. Since the foundation between the groins could not be dewatered, final cleaning of the rock surface was carried out by backhoes operating from the tops of the groins. The impervious core till material was dumped through the water onto the machine cleaned foundation. No foundation grouting was carried out prior to raising the reservoir upstream of the cofferdam.

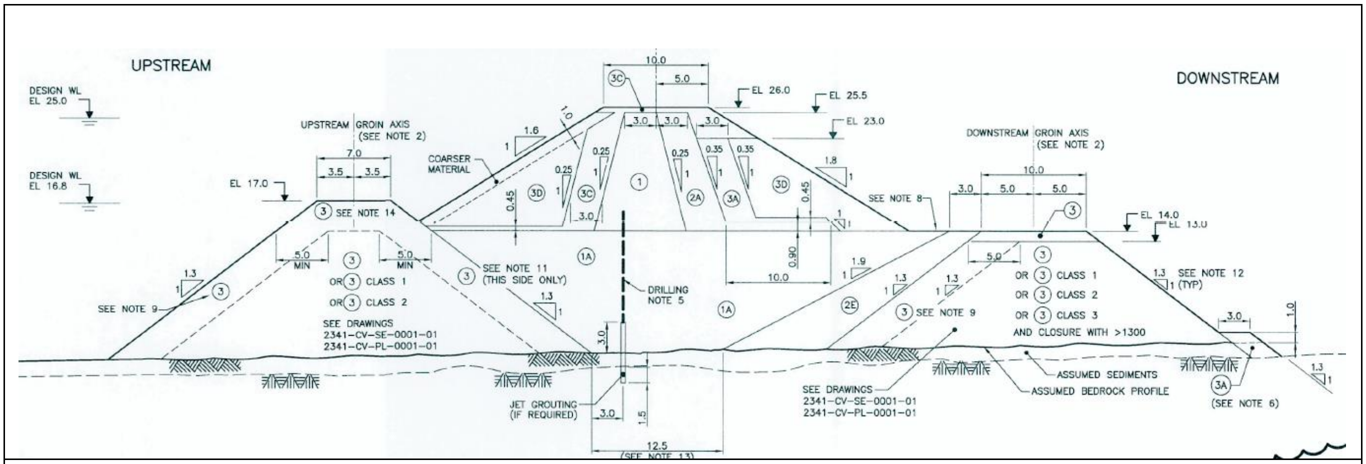

Figure 5.1: Upstream cofferdam zoning

5.3. Leakage and Internal Erosion of the Upstream Cofferdam

Given that the day of the IE visit was less than 2 weeks since the event no reports on the cofferdam leaks were yet available for review. Discussions with Nalcor and SNC engineers indicated that the following sequence of events occurred.

- The upstream river level was at el 14.0 m when the cofferdam closure was achieved on July 15, 2016. It was more or less maintained at this elevation until early November when the gates were partially closed to raise the level.
- Before raising the river level from el 14 m, three small leaks (designated nos. 1, 2 and 3) appeared in the downstream foundation of the cofferdam. Flow ranges were in the order of 3 to 4 m^3/min at no.1, 1 to 2 m^3/min. at no. 2 and very small seepage at no.3. All three leaks were continuously monitored before and during impoundment. Water discharges were clear and it was believed that water flows were through fractures in the upper bedrock, not through cofferdam fill materials. While undesirable, none of these leaks were considered to be problematic and were within the range of expected leakage of a new cofferdam.

- By November 14, 2016, the river level had been raised to el 21.5 m. During the night of November 14/15, a new water discharge developed near the toe of the dam in an area away from the previous leakages. By early morning the flow rate from this new discharge point was estimated to be in excess of the pump capacity of 28 m^3/min. This water was muddy which indicated that internal erosion was occurring. This flow rate continued for a couple of hours before it suddenly declined on its own. A slump in the upstream face of the cofferdam at approximately Sta 0+330 developed at this time (Photo D.2 and Figure 5.2). It is reported that some cracks also appeared in the crest.

- The reservoir level was held at approximately el 21.5 m throughout the day of November 15 and 16 and the behavior of the upstream slump, crest cracks and downstream leakage area was closely monitored. Leakage was fairly low during this period and it appeared that movement of materials within the cofferdam had effected self-healing of the leak.

Figure 5.2: Aerial view of cofferdam showing location of the upstream slope slump at approximate Sta 0+330.

- During the night of November 17, a new leak occurred near the top of the downstream groin at about el 15. It is significant that this leakage was at a higher elevation than the original leak. Water discharge was muddy and flow rates were high, generally believed to be 25 m^3/min or less. It is understood that some minor crest settlement occurred during this time but no data has been made available to support this.

- Early on November 18 the spillway gates were fully opened to reduce the water level. Later the same day the level had fallen to el 17 m and leakage flows had substantially declined. Leakage flows had more or less ceased when the reservoir level was lowered to el 13.6 m during subsequent days. This situation prevailed unchanged up to the time of the IE site visit on November 30.

The situation has been reviewed by geotechnical experts from SNC and Hatch. As the assessment was ongoing at the time of the visit, no complete consensus on the exact cause of the November 14 -18 leakages has yet been made. However, based on the IE site visit observations, discussions with Nalcor staff and the meeting with SNC, the IE believes that there is general agreement that the following leakage mechanisms governed;

- The small pre-November 14 leakages were most likely flows through open sub horizontal stress relief and steeply inclined primary fractures in the bedrock. Given that the water was clean, it is believed that these caused no significant internal erosion. These types of leaks are normal occurrences for most cofferdams constructed on a natural bedrock surface and, when subject to proper monitoring and control of the leaking water, should not cause serious stability issues with the cofferdam.
- The November 14/15 leakages occurred at the base of the dam along or near the foundation surface. The muddy flow water and subsequent slumping of the upstream slope show that significant internal erosion occurred, probably mostly in the impervious core. It is possible that the leakage flows could have been mostly through near surface open fractures in the bedrock immediately below the rock surface. Water flows through rock fractures which were in contact with the base of the core could have caused the internal erosion of the core.at the base of the dam. A second possibility is that there were pockets of open work debris or granular materials on the bedrock surface which became interconnected and formed the flow paths for most of the leakage. Given the stepped, very irregular shape of the bedrock surface (Photo D.3) and difficulty of completely cleaning the rock surface underwater this is a very realistic scenario. Severe leakage through permeable debris would certainly have triggered erosion of the overlying impervious till.
- The presence of the upstream slump and the rapid decline in leakage flows on November 15 indicate internal movements of the core which likely included a rapid or slow moving collapse that in turn choked water flows. This would have resulted in internal damage to the core in the area above the leakage flow.
- The November 18 leakage occurred well above the base of the dam at el 14 m. This leak must have been through the core, most likely through the damaged area caused by the November 14/15 internal erosion. It has been pointed out by Nalcor staff that this leak occurred near the point where juncture of southward and northward placement of fills occurred during construction. Segregated till may have been present at this juncture and that could have contributed to the leakage flows.

5.4. Remedial Repairs

Remedial repairs began at the time of the leakage and continued through the time of the IE site visit. Nalcor stated that the remedial works had the following objectives:

- Repair the slumped area and add extra material to the upstream slope in the leakage area.
- Prevent further loss of core material.
- Increase the crest height by 1.0 m as protection against any erosion induced settlement of the dam.
- Provide a weighting berm on the downstream slope to increase stability and restrain loss of core material from high level leaks.
- Repair the damaged core and plug the leak channels with grout injections.

The IE concurs with these objectives and believes that they would repair the damage and reduce the risk of future leakage damage. This is a "belt and braces" approach which is appropriately conservative. Remedial works are focusing on the area between Sta 280 to Sta 400. By the time of the IE site visit a number of remedial construction works (shown on Figure 5.3) had been completed:

1) Construction of a weighting berm on the downstream slope in area (Photos D.4, D.5 and D.6). The top of this weighting bench is at el 19 m. A reverse filter and transition zone has been placed along the top of the original slope at the base of the weighting zone (Photos D.5 and D.7) to impede washout of core material.
2) Increased the crest level from el 26 m to el 27 m (Photo D.8).
3) Repaired the upstream slumped area and place additional rock fill above the el 14 m bench (top of the old starter groin) (Photo D.9 and D.10). Some new rockfill has also been placed below the el 14 m berm (Photo D.9).

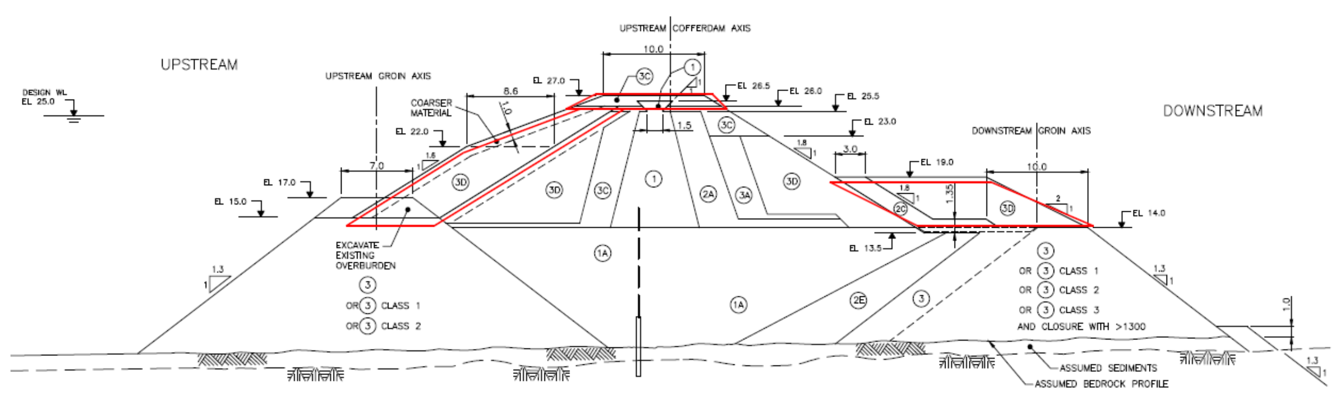

Figure 5.3: Cross-section of the upstream cofferdam. The areas outlined in red show the upstream rockfill addition, the 1.0 m crest raising fill and el 17 m downstream weighting zone above the el 14.0 m downstream groin.

At the time of the IE site visit, the project engineers were finalizing details of the grouting repairs to the core and foundation. A contract had been let and a drill/grout rig was enroute to the Muskrat Falls site. Planned grouting works were being designed to; (a) repair the damaged core, (b) inject grout into possibly permeable zone at the base of the fill, i.e. at the top of the bedrock, and (c) inject grout into open fractures in the upper bedrock zone. These three grouting objectives require different grout mixes and techniques. The planned grouting program will deal with this in the following way:

1) **Permeation grouting** of the upper zone of bedrock using a GIN type stable grout mix suitable for bedrock grouting.
2) **Permeation grouting** in the foundation zone of the impervious fill to infill any open work rock debris or granular material that may be on top of the bedrock. This will use a high mobility grout mix suitable for permeation grouting of soils. Special care will be taken to limit injection pressures to avoid hydraulic fracturing of the core.
3) **Compaction Grouting** in the impervious core**.** This consists of the placement of bulbs of high viscosity grout with a low cement content into the core from the end of borehole casing. The grout will displace and compress disturbed till fill effecting reinforcement and compaction of the impervious zone. It is unlikely that the compaction grout bulbs from adjacent boreholes will replace all of the material between the holes, therefore this method will not form a continuous

cut-off. Grouting will be carried from 6 inch cased boreholes drilled with primary spacing of 6 m followed by split spaced secondary and, if necessary, tertiary holes.

The IE concurs that the planned grouting will repair defects in the core, foundation contact zone and upper bedrock. The IE suggested in the SNC meeting on December 1 that additional downstream holes be drilled to form local cells in localized spots where there are high grout takes. The IE also notes that compaction grouting may not seal washed granular zones in the core that were created by the November leakages. Some permeation grouting with plastic-low strength mixes may be beneficial in the core. Similar permeation grouting was used to repair damaged impervious till cores of the Upper Churchill dykes in the late 1970's and the Long Pond Dam in Bay D'Espoir in the late 1980's.

5.5. Effects of Delayed Impoundment on Downstream Ice Dam Formation and Impact on Powerhouse Cofferdam

Historically, a large ice bridge has formed in the open water immediately downstream of the Muskrat Falls rapids on an annual basis. This feature causes the river level rise and often drowns the lower reach of the rapids. The formation and size of the ice bridge are controlled by the amount of frazil ice and drift ice which passes through the rapids to the open water.

Studies have shown that with a headwater at el. 25 m a solid sheet of ice would form. This would insulate the waters of the head pond, preventing the formation of frazil ice. Additionally, the erection of an ice boom above the rapids would restrain drift ice from passing downstream. These combined works would eliminate most of the downstream ice bridge and result in reduced water levels downstream of the falls. This prevents flooding of the lower rapids and powerhouse area.

Nalcor's original plan for the 2016 / 2017 winter was to raise the head water to el. 25 m and to install an ice boom to retain drift ice. This work was to have been done by mid-November, however with the protest activities, cofferdam leakage problems and subsequent lowering of the headpond, this activity was not achieved. Due to higher flow velocity and floating ice formations on the upstream river pond it is now not possible to install the ice boom until the headwater level is back to el.21.5 m. It appears that raising of the headwater pond can't be done until January. This will prevent the formation of continuous ice cover above the rapids and facilitate the formation of frazil ice in the river until that time.

The combined effect of unplanned frazil ice generation (due to lack of solid river ice cover) and lack of an ice boom will contribute to the formation of an ice dam downstream of the rapids. Water levels will be higher than assumed for the current crest elevation of the cofferdam at the powerhouse tailrace area. The original powerhouse cofferdam could be overtopped by the higher water levels and Nalcor must heighten this structure by a few meters to prevent this. Plans and schedule for raising the powerhouse tailrace cofferdam to el 21m were still being developed at the time of the IE site visit and no details were available for review. This will be done in the near future and the cofferdam raising work must commence as soon as possible.

6. NORTH SPUR

Construction work on the slope stabilization measures was substantially completed by the time of the November 30 IE site visit (photos E.1 and E.2). Gilbert (the contractor) had substantially demobilized for the season and very little work was underway at the time of the site visit. Final demobilization is expected by December 20, 2016. There is some outstanding work that could not be done in 2016 before the onset of winter conditions because of the work disruptions caused by the civil demonstrations in October. Despite this event, Gilbert are not behind and in fact remain ahead of their contractual schedule. Outstanding work consists primarily of regrading waste dumps/stockpiles and various other work items to comply with environmental requirements together. This will be done in the spring and summer of 2017 together with work originally planned for 2017.

Photographs of the completed upstream and downstream slopes taken during the IE visit are presented in Section E of Appendix 1.

7. MUSKRAT FALLS SWITCHYARD

The following observations were made during the November 30, 2016 site visit to the Muskrat Falls Switchyard (photographs of this site are presented in Appendix 1-Section F):

- The Converter Station building was completed including roofing. Interior works on HVAC and other electromechanical BOP activities were ongoing (Photos F.1, F.2 and F.3). All transformer pads with containment pits and fire walls are completed (Photo F.8).
- Work on the concrete foundations for DC and AC filters equipment was ongoing (Photos F.4, F.5, F.6 and F.7).
- GIS building was completed with overhead crane fully installed and commissioned. The building was ready for commencement of GIS equipment installation. (Photos F.9 and F.10).
- The neighbouring Control building was completed. Work on HVAC and other BOP installation was underway along with wiring / cabling in progress. (Photo F.11).

8. SOBI CROSSING

Progress on the submarine/landfall cables was reported by Nalcor during the initial project briefing on November 29, 2016. The SOBI crossing scope of work is 95% complete.

- All three cables are installed.
- The rock berms have been placed. The berm height was reduced from 1.5 m to 0.4 m which reduced the amount of work needed.
- An 800 m length of cable # 2 suffered from water ingress and had to be replaced. The cost of this is being covered by an insurance claim. The 800 m of damaged cable was replaced with a section of the 2200 m long spare cable. This cable will be replaced with a new one from the original factory in Japan.
- Outstanding work includes the final testing of the cables and the installation of the surge arrestors at the transition compounds.

9. CONCLUSIONS AND COMMENTS

- At the time of the November 29 site visit construction work at Soldiers Pond was at an advanced stage.
- The spillway was operational. The gates were open to pass the entire river flow and maintain the headpond at el 14 m. This structure and related works are of acceptable quality and in compliance with current schedules.

- Powerhouse construction was at an advanced state at the time of the IE site visit. However, while construction rates have been significantly improving during the past year, the work disruptions caused by the civil demonstrations have contributed to a loss of schedule.

- Both the upstream and downstream cofferdams of the main dam were completed in early November and the reservoir was raised to el. 21.5 m by mid-November. The downstream cofferdam performed well but the upstream cofferdam experienced leakage and internal erosion damage in the vicinity of Sta 0+330 m during November 14 to 18. The reservoir was lowered to el. 14 m to facilitate various repairs and remedial works. A grouting program is currently underway to repair the damaged core and seal the leakage paths in the fill and foundation. It is anticipated that the grouting program repairs will be completed by January-February 2017 and the head pond can be raised at that time.

- Because of the cofferdam leakage and the work disruptions caused by the civil demonstrations, the headpond above the Muskrat Falls rapids cannot be raised until sometime in January instead of mid-November as planned. This interferes with frazil ice control and the installation of the ice boom. These items were needed to minimize the size of the annual ice build-up in the river downstream of the rapids to maintain a lower water level for that section of the river. Tailwater levels below the rapids are now expected to be higher than assumed and the powerhouse cofferdam must be raised several meters to protect against flooding. Details of the planned powerhouse cofferdam raise were not available for IE review at the time of the site visit.

- Construction of the North Spur slope stabilization measures was substantially completed by the time of the November 30 IE site visit. The contractor is expected to be demobilized by December 20, 2016. There is some outstanding work that could not be done in 2016 before the onset of winter conditions because of the work disruptions caused by the civil demonstrations in October. Despite this event, the contractor's work progress remains ahead of the contractual schedule. Outstanding work consists primarily of regrading waste dumps/stockpiles and various other work items to comply with environmental requirements. This work will be done in the spring and summer of 2017.

- Work on the South Dam was suspended for the winter months.

- Work at Soldier's Pond and Muskrat Falls switchyard is proceeding on schedule. Current work is focusing on construction of the facilities.

- The construction works viewed during the site visit were of good quality and in compliance with accepted standards.

Appendix 1

Site Photographs

Photo A.1: AC switchyard. (November 29, 2016)

Photo A.2: AC switchyard. (November 29, 2016)

Photo A.3: AC switchyard control building. (November 29, 2016)

Photo A.4: Interior of switchyard control building – BOP work in progress. (November 29, 2016)

Photo A.5: Synchronous condenser building and transformers. (November 29, 2016)

Photo A.6 Interior of synchronous condenser building. (November 29, 2016)

Photo A.7: Main synchronous condenser transformers - fully installed. (November 29, 2016)

Photo A.8: Spare transformer near the synchronous condenser building. (November 29, 2016)

Photo A.9: Gantry for 230kV feeders to SC transformers. (November 29, 2016)

Photo A.10: Containment pits and foundation pads of excitation transformers. (November 29, 2016)

Photo A.11: Converter station building. (November 29, 2016)

Photo A.12: Interior of the converter building. (November 29, 2016)

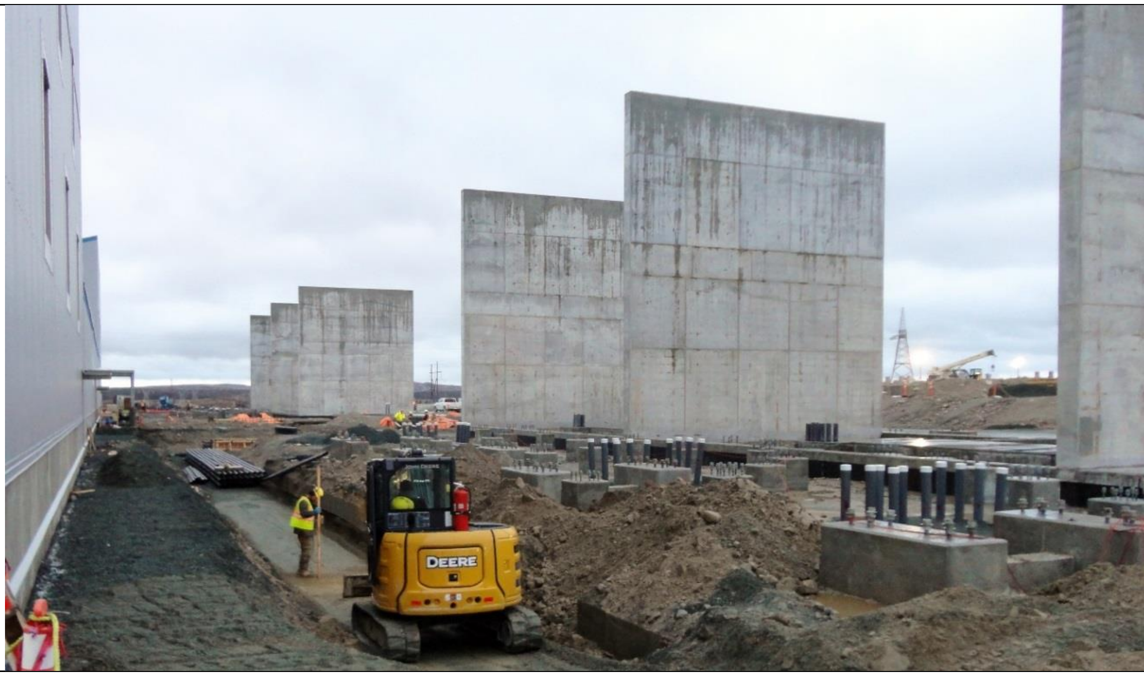

Photo A.13: Transformer blast walls at the converter site. (November 29, 2016)

Photo A.14: Converter station - footings for DC (filters) yard in the foreground. (November 29, 2016)

Photo B.1: Looking upstream at the powerhouse; structures of Units 2, 3 and 4 are visible. (November 30, 2016)

Photo B.2: Looking upstream at the powerhouse; service bay steel framework and concrete structures of Units 1 and 2 are visible. (November 30, 2016)

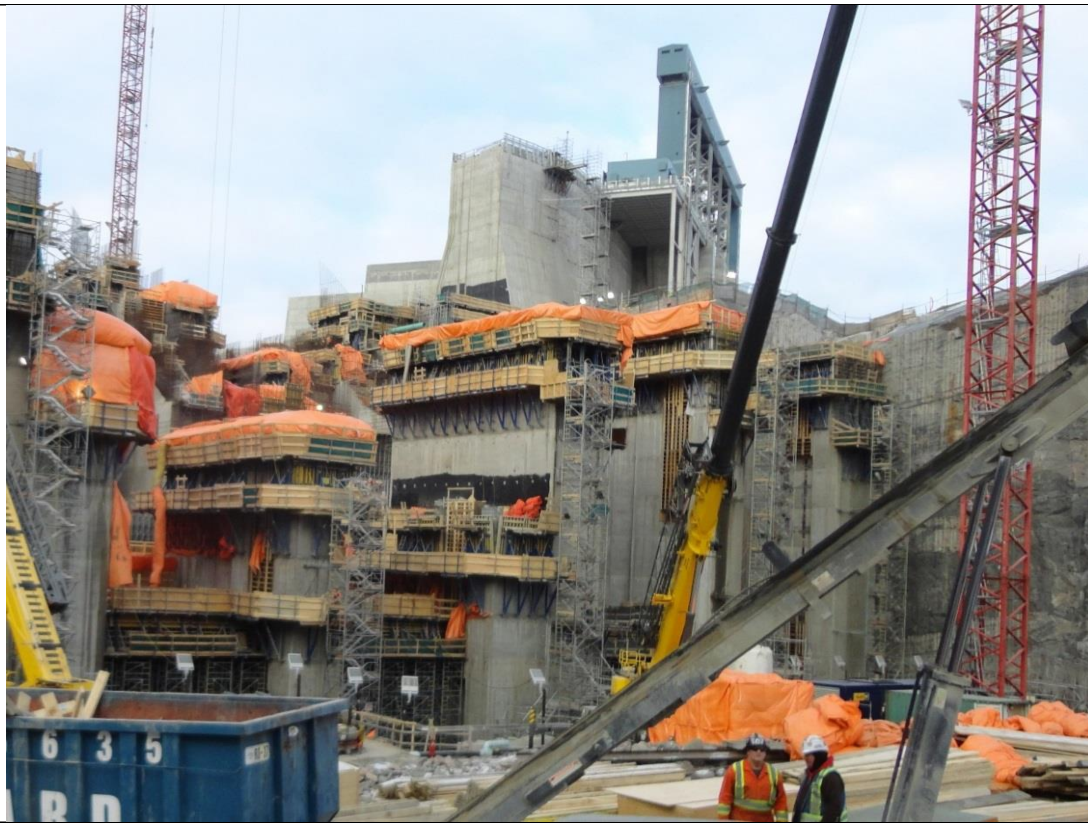

Photo B.3: Looking upstream at the powerhouse; Units 3 and 4 are visible with the Central transition dam and Spillway in the background. (November 30, 2016)

Photo B.4: Looking downstream at the powerhouse intake structures. (November 30, 2016)

Photo B.5: Unit 2 draft tube water passage. (November 30, 2016)

Photo B.6: Preparation of the bedrock foundation above Unit 2 draft tube area. (November 30, 2016)

Photo B.7: Unit 2 formwork construction. (November 30, 2016)

Photo B.8: Structural steel framework erected at South Service Bay. (November 30, 2016)

Photo B.9: Interior of the South Service Bay. (November 30, 2016)

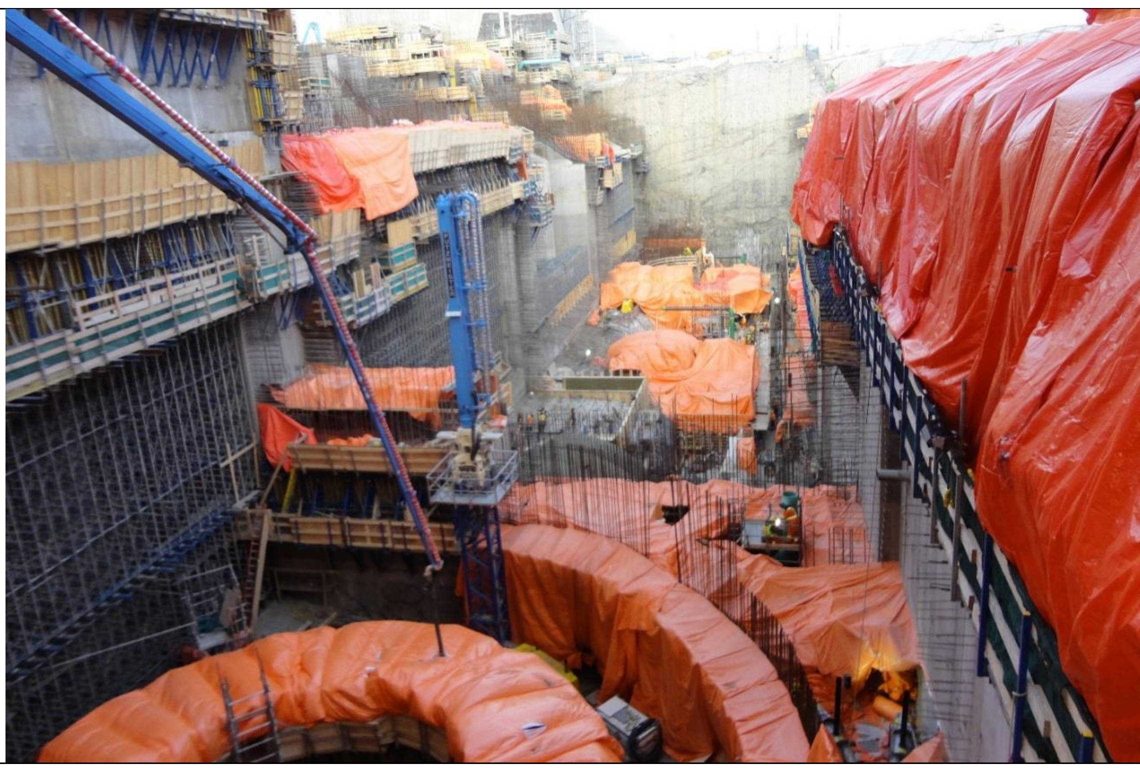

Photo B.10: View looking north from the South Service Bay. Units 1, 2, 3 and 4 are visible. (November 30, 2016)


Photo B.11: Unit 1 formwork and weather protection hoarding. (November 30, 2016)


Photo B.12: Unit 1 – upstream wall to the right. (November 30, 2016)

Photo B.13: Unit 1 – top of downstream wall with anchor bolts installed and ready for steel frames erection. (November 30, 2016).

Photo C.1: Upstream view of Spillway. (November 30, 2016)

Photo C.2: Spillway – upstream approach channel. (November 30, 2016)

Photo C.3: Upstream pond and spillway approach channel to the right. (November 30, 2016)

Photo C.4: Closer view of the Spillway approach channel and upstream temporary bridge. (November 30, 2016)

Photo C.5: Spillway intake channel looking upstream from the deck of the temporary bridge.

Photo D.1: Upstream face of the cofferdam. (November 30, 2016)

Photo D.2: Slumped area in the upstream face. (Nalcor photo taken shortly after November 15, 2016)

Photo D.3: View of the bedrock surface of the permanent dam. Note the stepped, very irregular bedrock surface topography which is the result of differential breakage and erosion along inclined foliation planes. (November 30, 2016)

Photo D.4: Downstream slope of the cofferdam. The el 19 stabilizing berm can be seen. (November 30, 2016)

Photo D.5: Downstream el 19 m berm, looking north. The graded transition zone and granular inverse filter can be seen in the left centre and left side of the berm. (November 30, 2016)

Photo D.6: Downstream el 19 berm, looking south. (November 30, 2016)

Photo D.7: Downstream el 19 m berm, looking south. View looking south along the granular inverse filter (brown compacted surface in centre) and graded transition zone (fine rockfill on the left). (November 30, 2016)

Photo D.8: Raised to el 27 m crest of cofferdam, looking south. (November 30, 2016)

Photo D.9: Upstream face of the cofferdam. The original upstream el 14 m berm is visible along the toe of the dam. The new rockfill paced over the north end of the cofferdam is visible in the far end of the slope. Some new rock ill has also been placed on the upstream slope of below the el 14 m berm. (November 30, 2016)

Photo D.10: Rock fill cover (brownish material) placed on the upstream face of the dam in the area of the leakage. (November 30, 2016)

Photo E.1: Upstream face of the North Spur. (November 30, 2016)

Photo E.2: Downstream face of the North Spur. (November 30, 2016)

Photo F.1: AC/DC Converter Building, view from the south. (November 30, 2016)

Photo F.2: AC/DC Converter Building, view from the north. (November 30, 2016)

Photo F.3: AC/DC Converter Building - valve hall interior. (November 30, 2016)

Photo F.4: Foundation preparation works for DC switchyard next to AC/DC converter building. (November 30, 2016)

Photo F.5: Prefabricated concrete footings for switchyard equipment foundations. (November 30, 2016)

Photo F.6: Foundation preparation works for DC switchyard next to AC/DC converter building. (November 30, 2016)

Photo F.7: Foundation works for AC filters equipment next to AC/DC converter building. (November 30, 2016)

Photo F.8: Blast walls between the converter transformers containment pits at the AC/DC converter building. (November 30, 2016)

Photo F.9: Overhead crane in the GIS building. (November 30, 2016)

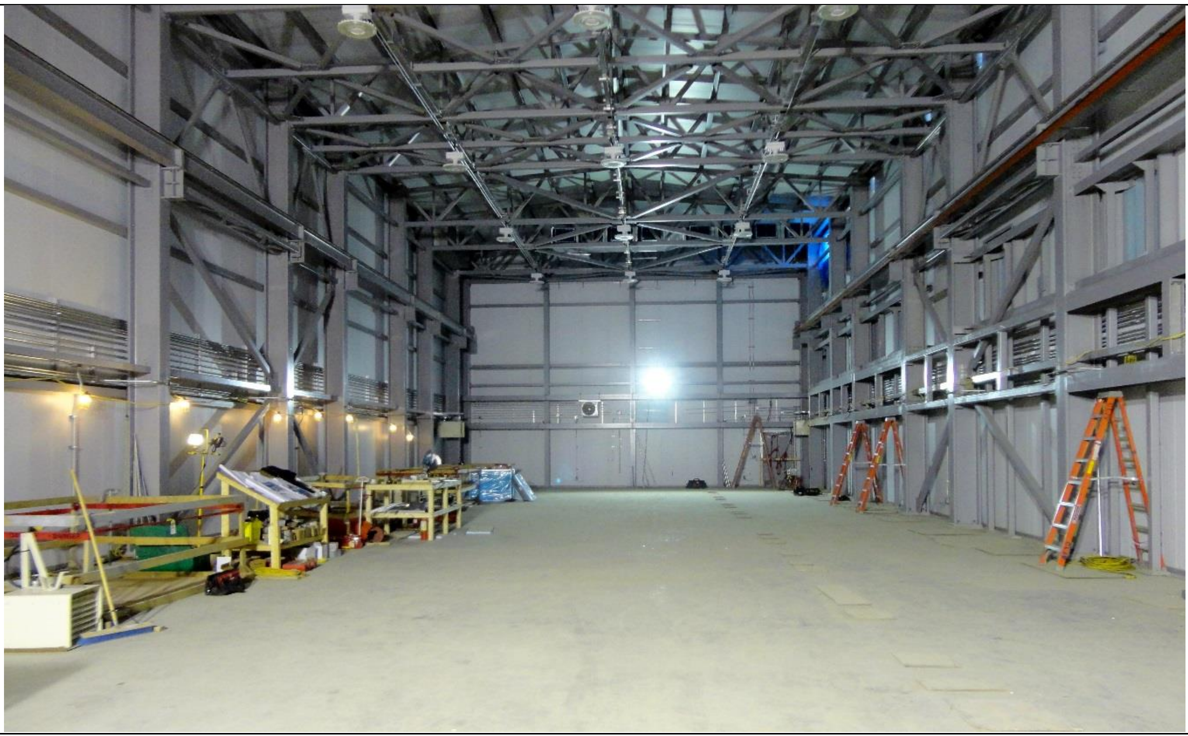

Photo F.10: Interior view of the GIS building. (November 30, 2016)

Photo F.11: .AC switchyard control building – interior BOP work underway. (November 30, 2016)

Photo F.12: Installed transformers for future power supply to Goose Bay, (November 30, 2016)