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March 18, 2021

Mr. Patrick Wruck
Commission Secretary and Manager
Regulatory Support
British Columbia Utilities Commission
Suite 410, 900 Howe Street
Vancouver, BC V6Z 2N3

Dear Mr. Wruck:

RE: British Columbia Utilities Commission (BCUC or Commission)
British Columbia Hydro and Power Authority (BC Hydro)
Site C Clean Energy Project
Annual Report No. 4 and Quarterly Progress Report No 19
Responses to BCUC Staff Information Request No. 1

In our letters of November 9, 2020, and February 8, 2021, BC Hydro committed to responding to all BCUC staff information requests following the completion of the Province's independent project review by Mr. Peter Milburn.

With the review now complete, we are filing responses to all questions that were sent from the BCUC to BC Hydro. The responses being filed today include information about project activities up to the end of December 2020.

BC Hydro is filing a number of IR responses and/or attachments to responses confidentially with the BCUC. BC Hydro confirms that in each instance, an explanation for the request for confidential treatment is provided in the public version of the IR response. BC Hydro seeks this confidential treatment pursuant to section 42 of the *Administrative Tribunals Act* and Part 4 of the BCUC's Rules of Practice and Procedure.

For further information, please contact the undersigned.

Yours sincerely,

Fred James
Chief Regulatory Officer

fj/ma

Enclosure

1.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Site C Quarterly Progress Report No. 19, Section 1.1.1.1, p. 15
Foundational enhancements

On page 15 of Site C Quarterly Progress Report No. 19 (Quarterly Report No. 19), British Columbia Hydro and Power Authority (BC Hydro) states:

> Geotechnical issues on work fronts other than the left bank diversion tunnels has always been a project risk, and this risk has materialized on the right bank.
>
> At the end of December 2019, investigations and analysis of geological mapping and monitoring activities during construction identified that some foundation enhancements would be required to increase the stability below the powerhouse, spillway and future dam core areas. These investigations and analysis were reported to the Project Assurance Board in early January 2020.
>
> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.1 Please explain when the geotechnical risks were first identified during the project and what specific risk management and mitigation practices were put into effect.

RESPONSE:

This response supports the responses to other BCUC Staff Information Requests.

The Site C Project is designed in accordance with the guidelines of the Canadian Dam Association and international best practices.

The Site C Project identified geotechnical risks during the development of the Project based on investigations and analysis which are an important input into the Project design. The geotechnical risks have continually been monitored and the evolution or changes to the geotechnical risks have been reported to and discussed with the Technical Advisory Board and to the Project Assurance Board (and previous Project Boards) over the Project duration.

For large civil engineering projects, even extensive pre-construction investigations may not uncover all geological details that may impact the design of the project until the construction phase, when actual site conditions become fully evident. When construction commences, the geological model can be integrated with geological mapping of the exposed foundation and the results from geotechnical instrumentation installed to monitor the foundation's response to construction. Only then does the project have sufficient geological information to fully verify the geological model and the project design.

The information below provides additional details on the timelines associated with identifying geotechnical risks, and the related risk mitigation and reporting.

Prior to the start of construction in July 2015 and during the design phase of Site C, geotechnical risks were identified for the Site C Project indicating, among other risks, that there was the potential of instability of the bedrock foundation under the right bank structures. Over the duration of the Project, the geotechnical risks identified for the Project have evolved, been updated and refined, new geotechnical risks identified, and some identified geotechnical risks never materialized and are no longer a risk to the Project.

As expected and confirmed in the earliest geological investigations beginning in the 1970s, the shale bedrock in the foundation at Site C contains bedding planes. The presence of deep bedding planes within the foundation under the right bank powerhouse and spillway structures, and the potential for displacements along the deeper bedding planes, were identified during the design phase of the Project from the 1970s onward. Stability and deformation analysis was completed for a potential failure surface (referring to a continuous surface with the potential for rock movement) along one or more of these deeper bedding planes. As a result of this analysis, the roller-compacted concrete (RCC) buttress on the right bank was included in the design in 2010. The buttress serves to increase the stability of the powerhouse and spillways, referred to as the right bank structures, and to mitigate the various geotechnical risks, including bedding planes.

Figure 1 Spillways RCC Buttress and Continuous Bedding Plane Shears

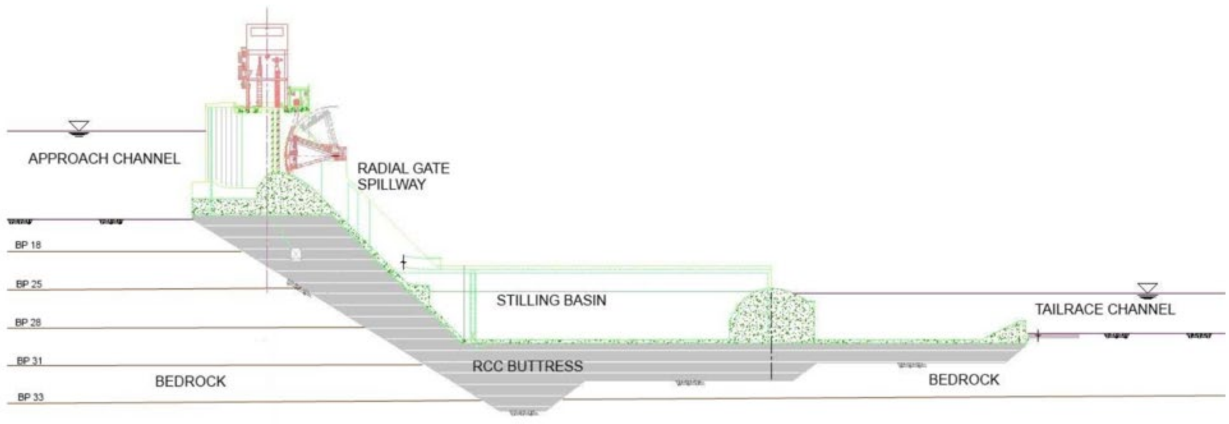

Figure 1 illustrates the spillways RCC buttress and the location of the continuous bedding plane shears that were considered during the implementation phase of the Project, prior to the start of construction.

During construction of the Project, consistent with best practices, instruments were installed to monitor the response of the foundation, and geological mapping was completed during the excavation of the foundations.

In 2018, during the excavation for the spillways buttress, small displacements began to occur on a bedding plane below the bedding plane identified on the diagram as BP33. These small displacements indicated that the shear strength along bedding planes deeper than BP33 may be lower than what was initially assumed in the design basis. These small displacements, other instrument data, and the results of geological mapping led to a re-assessment of the expected strength of the bedrock at this depth that was used in the design.

The re-assessment took place during 2018 and 2019, involved analysis of the interlock of the foundation, strength of the bedding planes below the base of the RCC buttress and other aspects of the foundation rock, as well as the expected water pressures in the foundations resulting from the future reservoir. The focus was to gather and assess additional information on the foundation and determine whether other aspects of the bedrock foundation that contribute to its overall stability, would at least partially compensate for the lower strength of the bedding plane below the base of the RCC buttress. If the re-assessment showed that the stability models could be updated on this basis, then any required mitigation would be relatively modest (e.g. drainage and grouting changes to reduce water pressure acting on the structures). Further analyses and additional data indicated that these other aspects of the foundation did not provide enough resistance to compensate for the lower strength of the bedding plane. By January 2020, it was

concluded that more significant foundation enhancements (i.e., mitigation measures) would be required.

The design team was augmented with external experts to develop alternative solutions and confirm the preferred option. Detailed analyses and conservative parameters have been used. Working with the Technical Advisory Board for the Project, conceptual foundation enhancements have been identified that will address the as-found geological conditions under the powerhouse and spillways and will provide a reliable solution for the stability and long-term operation of the Project.

Our approach to the development of these remediations has involved keeping the Independent Engineer reporting to the British Columbia Water Management Branch informed of the progress and details of the analysis.

The results of recent fieldwork are providing further confidence that the proposed foundation enhancement solution is robust, is in accordance with the guidelines of the Canadian Dam Association and international best practice, and can be optimized further in the final design stage.

The following table provides a chronology of the powerhouse, spillways and dam and core buttresses, including construction activities, instrumentation and geological mapping, and engineering studies related to the right bank foundation enhancements.

Table 1 Chronology for Powerhouse, Spillways and Dam and Core Buttresses

Timeline	Description
Pre-July 2015 Start of Construction	• Engineering Studies completed that formed Design Basis for powerhouse, spillways, and dam and core buttress • Project risks identified and documented, including geotechnical risks
June 2016 – October 2016	• Installation of instruments to monitor excavations
August 2016 – February 2017	• Excavation of approach channel
November 2016	• Technical Advisory Board (TAB) Report #16

Timeline	Description
Powerhouse **Excavation: February 2017 – July 2017** **Start of Powerhouse RCC: September – October 2017**	• **Excavation for the powerhouse** • **Geological mapping of the powerhouse excavation and monitoring of the excavation and excavated slope from time of excavation to placement of roller-compacted concrete powerhouse buttress** • **Movements on bedding planes were distributed on different bedding planes and ranged from fractions of millimeters to tens of millimetres**
June 2017	• **TAB Report #17** • **Completion and presentation of geotechnical engineering studies and analyses of mapping and monitoring activities to date** • **Movements on bedding planes from unloading, blasting and heavy rainfall events**
October 2017	• **Based on inconclusive readings below the base of the RCC buttress in one instrument, the TAB recommended that additional instruments be installed to clarify the nature of displacements**
January 2018	• **TAB Report #18** • **Completion and presentation of geotechnical engineering studies and analyses of mapping and monitoring activities to date** • **Risk of movement caused by lower bedding plane strength below RCC was discussed and presented to the TAB as part of a schedule risk assessment for both the left and right bank**
Spillways **Excavation Phase 1: April 2018 – Aug 2018**	• **Excavation for the spillways** • **Geological mapping of the powerhouse excavation and monitoring of the excavation and excavated slope from time of excavation to placement of roller-compacted concrete powerhouse buttress** • **Similar to powerhouse buttress excavation, movements on bedding planes above the base of the shear key were distributed on different bedding planes and ranged from fractions of millimeters to tens of millimetres** • **Displacement evolving on deep bedding plane (BP33E) in spillways and powerhouse observed in Aug 2018 (up to 5 millimeters)** • **Mapping of spillways foundation continued**

Timeline	Description
Powerhouse **RCC: May 2018 – October 2018**	• **Placement of roller-compacted concrete powerhouse buttress**
October 2018	• **TAB Report #19** • **Completion and presentation of geotechnical engineering studies and analyses of mapping and monitoring activities to date** • **Discussion on new observation of movement on right bank in mid-August 2018 and recommended evaluation for next steps and studies** • **Further displacements on BP33E in response to excavation of spillways (<5 mm measured)** • **The TAB recommended that a 3D stability analysis with the same inputs as used in the conservative 2D analysis be completed and that undisturbed samples of core be obtained to evaluate shear strength on bedding planes**
Spillways Excavation Phase 2: October 2018 – April 2019	• **Geological mapping of the spillways excavation and monitoring** • **Continued analysis of instrumentation data and mapping data and various conference calls with the TAB to provide updates. Presentation by design team of potential areas where the strength of the foundation has been underestimated in the design basis, and a comparison or two-and three-dimensional stability analyses**
January 2019	• **TAB Conference Call** • **The TAB noted that more reliance can be placed on 3D effects provided the design basis be updated and performance doesn’t become worse in the short term**

Timeline	Description
May 2019	• **TAB Report #20** • **Completion and presentation of geotechnical engineering studies and analyses of mapping and monitoring activities to date** • **Recommendations provided in TAB presentations to review the grouting program and drainage measures which were considered modest in scope** • **The TAB indicated that the changes in seepage control were correctly identified by Project to mitigate this risk** • **The TAB recommended that a hydrogeological model be developed to facilitate a re-evaluation of the drainage measures and the effectiveness of the planned grout curtain**
Spillways **RCC: March 2019 – October 2019**	• **Placement of roller-compacted concrete spillways buttress**
Dam and Core **Excavation: April 2019 – October 2019**	• **Excavation for the dam and core buttresses**
September 2019	• **Technical Advisory Board Workshop in Fort St. John** • **Presentation of geotechnical engineering studies and analyses of mapping and monitoring activities to date** • **Work plan presented to TAB with the following items: continued refinement of the geology model, stability analysis during operation, water pressure testing and seepage analysis** • **The potential modifications identified at this point were modest and focused on designing drainage from the existing right bank drainage tunnel and modifications to the grout curtain**

Timeline	Description
January 2020	• **TAB Report #21** • **Completion and presentation of geotechnical engineering studies and analyses of mapping and monitoring activities to date** • **The review of the geological and instrumentation information was completed by the end of 2019, indicating that structural measures were likely required to improve the foundation. These findings were presented to Technical Advisory Board and Project Assurance Board in January 2020. At that time neither the preferred solution nor the magnitude of the forecast costs for the remediation was known and the potential forecast progressively increased after the initial concepts were developed and evaluated** • **The TAB supported the recommendations, indicated that the formulation of the extreme loading case be re-assessed and structural support be evaluated.** • **Proposed design modifications for the dam and core buttress were discussed with the TAB in relation to the interim conclusions on the updated geological model**
February 2020	• **TAB Conference Call** • **The Engineering design Team presented concepts and options for improved drainage and structural stabilizing measures** • **Final design modifications for the core buttress, increased grouting for the earthfill dam abutment and a RCC buttress for the right bank of the earthfill dam were presented to the TAB and issued to the main civil works contractor for comment**
March 2020	• **In response to the increasing escalation of the global COVID-19 pandemic, BC Hydro had to reduce the number of workers in the worker accommodation lodge which means that Project work at site was scaled-back on March 18, 2020 to focus on critical work, including work to meet 2020 river diversion and essential services related to safety and regulatory and environmental requirements. This reduced the work force housed in the worker accommodation camp by about 50 per cent** • **Analysis of potential design modifications continued and a range of options presented to the TAB** • **By March 2020, determined that significant foundation enhancements were required and the cost of those enhancements would be significantly higher than**

Timeline	Description
	previously expected
April 2020	• **TAB Report #21A** • **Completion and presentation of geotechnical engineering studies and analyses of mapping and monitoring activities to date** • **The TAB commented that drainage alone improves stability, but not sufficiently; the need for other structural interventions was confirmed for the post reservoir filling stability of the power buttress and spillways buttress** • **The TAB recommended a structured decision making process to determine the preferred modifications**
June 2020	• **TAB meeting #22** • **Completion and presentation of geotechnical engineering studies and analyses of mapping and monitoring activities to date** • **Several alternative stabilizing measures were evaluated in a structured process which gathered input from the design team, dam safety and environmental personnel, and the constructability and costing staff** • **The two favourable solutions that emerged were large diameter concrete filled steel pipe piles and concrete shear walls. Both solutions would extend the load-carrying capacity of the RCC buttress down to elevation 350 m. The final depth of the shear walls or piles will depend on the findings of the ongoing geological investigations**
May 14, 2020	• **BC Hydro began to safely increase construction activities at the dam site in a gradual phased approach. BC Hydro continues to work with Northern Health to ensure it continues to adhere to provincial guidelines** • **Contractors began the gradual increase in their work activities at the dam site**
July to September 2020	• **A series of conference calls with the TAB to present the recommended conceptual designs for the approach channel (June), spillways buttress (July) and power buttress (August)**
Dam and Core **RCC: August 2020 – October 2020**	• **Started placement of roller-compacted concrete dam and core buttress**

Timeline	Description
October 2020 - November 2020	• **Excavation in foundation of the earthfill dam near the right bank to mitigate potential displacements on bedding plane BP29A and others**
October 2020	• **TAB Report #23** • **TAB supported recommendations for the laterally loaded piles for both the powerhouse buttress and spillways buttress and conceptual modifications to the approach channel** • **Report provided to the Project Assurance Board and meetings held to discuss content and respond to questions** • **Mobilization for full size field trial for large diameter laterally loaded piles underway**
August 2020 to October 2020	• **Project Assurance Board approves recommended mitigation measures to address additional stability requirements for the approach channel, spillways and powerhouse**
Post October 2020	• **Continue to advance the design of the recommended mitigation measures**
October 2020	• **Project Assurance Board retained two experts that are internationally recognized for their breadth and depth of technical knowledge and experience with design of hydroelectric projects around the world.**
December 2020	• **Completed field trials**

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> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.2 Please provide a timeline and overview of geological mapping and monitoring activities that occurred on the powerhouse, spillway and dam core areas.

RESPONSE:

Please see the response to BCUC Staff IR 1.1.1 for additional information, including information regarding the timeline for geological mapping and monitoring.

Geological mapping of all excavated bedrock surfaces was undertaken immediately after excavation and cleaning of the excavated surface. Geological mapping provides information on the bedrock including the description of: the rock; the orientation and extent of any joints in the rock; any bedding planes and the infill in the bedding planes; any shears in the rock and the infill in the shears; any offsets; the presence of water; and other geological features of interest.

Instrumentation to monitor the excavations and the completed structures was installed before the start of each excavation. Instrumentation consisted primarily of inclinometers, extensometers and piezometers. The instruments were intended to monitor sliding on bedding planes (inclinometers), opening of relaxation joints or extension in the rock (extensometers), and water pressures in the rock (piezometers).

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1.1.3 Please provide a timeline and overview of all geotechnical engineering studies and analyses of mapping and monitoring activities which have been completed on the powerhouse, spillway and dam core areas.

RESPONSE:

A timeline and overview of geotechnical engineering studies and analyses of mapping and monitoring activities which have been completed during construction on the powerhouse, spillways and dam core areas are included in the response to BCUC Staff IRs 1.1.1 and 1.1.2. Please also refer to BC Hydro's response to BCUC Staff IRs 1.1.1 and 1.1.4 for additional information regarding associated timelines on the geotechnical engineering studies.

Site investigations at Site C began in 1975. At the time of project approval in 2014, the following is a summary of the key investigations completed on the Project:

- **211 diamond drill holes with a total length of over 13,600 metres;**

- **29 large diameter (0.9 m) drill holes (LDH) with a total length of 1,810 metres. The deepest LDH was 96 metres;**
- **202 percussion drill holes with a total length of over 3,440 metres;**
- **271 rotary holes with a total length of over 18,180 metres;**
- **10 sonic drill holes with a total length of over 610 metres;**
- **10.4-meter wide by 45-meter long test chamber on the left bank;**
- **5 exploratory adits (tunnels) with a combined length of 950 metres. Adits 3 and 5 are on the Right bank;**
- **268 test pits with a total depth of 1,230 metres;**
- **12 exploratory trenches with a total length of 1,220 metres; and**
- **29 seismic lines with a total length of over 13,000 metres.**

Geological mapping of bedrock was performed on natural bedrock exposures, on bedrock exposed in the exploratory trenches, inside the LDH and in the adits. The LDH were large enough for personnel to be lowered down the hole to map the bedrock and extract undisturbed 150-mm-diameter core samples. The adits were large enough for personnel to enter for in-situ rock mechanics testing as well as geologic mapping and bedrock sampling.

A number of methods have been used to assess the rock mass foundation modulus values at the dam site including: plate load tests in Adit 3; Menard pressure meter and Goodman Jack tests; biaxial testing of United States Bureau of Mines (USBM) over-coring samples; seismic tests; and back analyses of the displacement monitoring from test chamber development.

Horizontal core samples containing bedding planes were obtained from LDHs and adits. Laboratory shear box testing was carried out to determine the strengths of the various bedding planes. Larger scale in-situ shear testing was carried out on Bedding Plane 25 (BP25) in one of the adits.

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> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.3 Please provide a timeline and overview of all geotechnical engineering studies and analyses of mapping and monitoring activities which have been completed on the powerhouse, spillway and dam core areas.

1.1.3.1 Please identify the parties responsible for performing each geotechnical study or analysis listed above.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.1.11 for additional information.

BC Hydro was responsible for the design and investigations from the 1970s to 1989 including site investigations, laboratory testing and assessments.

Since 1989, Klohn Crippen Berger Ltd. (KCBL) and SNC Lavalin Inc. (SLI) (or predecessor firms) have been responsible for the investigations, assessments,

design and contract specifications, and they have retained numerous specialists and experts to undertake this work. KCBL and SLI both have extensive experience in the design and construction of hydroelectric projects within Canada and internationally. The Engineers of Record for the various components are employed by KCBL or SLI.

The Engineer of Record is responsible for conducting field reviews in accordance with Engineers and Geoscientists of BC guidelines. The Engineer of Record is also responsible for identifying modifications in the design, if required, that may be needed to address foundation conditions identified during construction.

BC Hydro engineers and other specialist consultants provided additional due diligence and design review.

The Technical Advisory Board retained by BC Hydro also reviews the design for the Site C Project.

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1.1.3 Please provide a timeline and overview of all geotechnical engineering studies and analyses of mapping and monitoring activities which have been completed on the powerhouse, spillway and dam core areas.

1.1.3.2 Please explain the review process that took place for each geotechnical study or analysis listed above.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.1.1 for additional information.

KCBL Berger Inc (KCBL) and SNC Lavalin (SLI) are the Engineering Design Team and are responsible for the design of the main civil works structures of Site C. Both firms have extensive experience in the design and construction of hydroelectric projects within Canada and internationally. KCBL and SLI employ the Engineer of Record for the various components of the Project.

The Engineering Design Team implemented quality system procedures that are consistent with Engineers and Geoscientists BC guidelines for a range of items, including design calculations, checking and reviewing, and independent reviews. BC Hydro engineers and other specialist consultants provide additional due diligence and design review. Independent senior reviews were undertaken by senior personnel of BC Hydro, KCBL and SLI, who were not involved in the project on a day-to-day basis. BC Hydro engineers review and accept design deliverables from the Engineer of Record.

BC Hydro also retained a Technical Advisory Board to review the design for the Site C Project.

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1.1.4 Please discuss which geotechnical studies were used to inform the initial design of the powerhouse, spillway and dam core foundations.

RESPONSE:

The current Site C Project general arrangement was approved in 2014 and designed to minimize geotechnical risk with the foundation. Site investigations carried out from 1975 to 2014 informed the location and design of the Project. These investigations are described in BC Hydro's response to BCUC Staff IR 1.1.3.

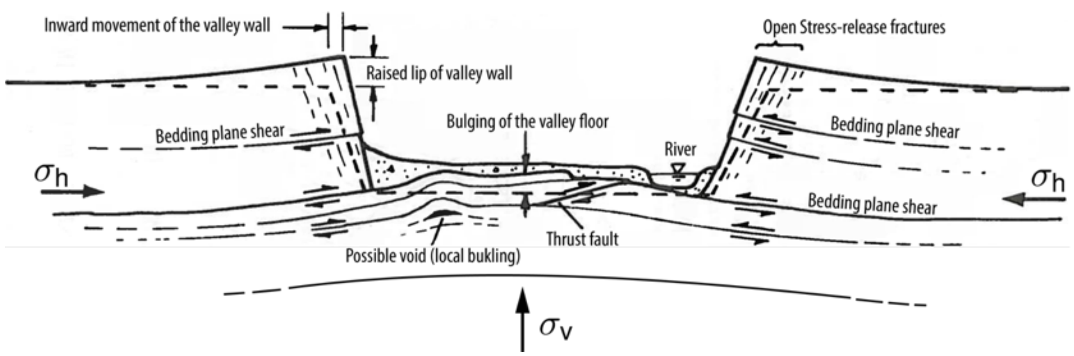
At the time of Project approval in 2014, the site investigations were considered state-of-the-art and extensive. The investigations focused on four main areas: (1) experience with existing dams on clay shale bedrock foundations; (2) site investigations for bedding plane shears; (3) site investigations for sub-vertical fractures; and (4) strength of bedding plane shears.

These studies touched on a wide range of topics. Geotechnical studies for the initial design of the powerhouse, spillways and dam core that relate to the stability of the structures consisted of the following:

1. **Site investigations to characterize the engineering geology of the site. These identified, among other things, geological units, bedding planes, relaxation joints and shears, as described in BC Hydro's response to BCUC Staff IR 1.1.3.**
2. **Laboratory and field strength and stiffness testing of the bedding planes, shale, relaxation joints and shears, as described in BC Hydro's response to BCUC Staff IR 1.1.3.**
3. **Based on the results from the borehole logs, testing and geological mapping, the strengths to be used in the design were determined. In particular, the operational strength of bedding planes were determined.**

A representation of the geology at Site C is shown in the general illustration of Bedding Planes and structural geology shown in Figure 1.

Figure 1 Bedding Plane Shears and Stress Release Fractures Associated with Valley Rebound (Adapted from Patton and Hendron, 1974)



Originally, three alternative designs for earthfill dams were studied, all of which incorporated a spillway on the right bank terrace. An earthfill dam across the river valley was selected as the basis of the site arrangement because of its ductility and ability to provide a wide base with low angle slopes. Earthfill dams are well suited to the foundation conditions at Site C. In contrast, the powerhouse and spillways are generally less tolerant of movements and the response in the foundation rock. The option of locating the power intakes adjacent to the spillways headworks on the right bank terrace and the powerhouse in the river channel next to the right bank was selected for further study. When the Project was deferred in 1983, there were unresolved issues with this design, particularly

the potential for differential rebound of the foundation to negatively impact the concrete structures on the right bank.

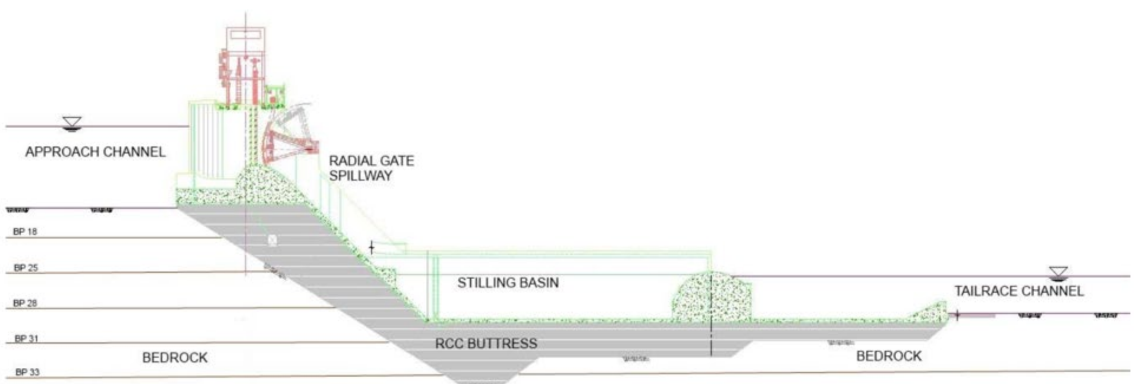
The layout and design of the right bank structures were reviewed and revised in 2010 (Figure 2). The current layout reduced the impact of the bedding plane shears and stress release fractures on the stability of the right bank structures. To accomplish this, the rock containing the open stress release fractures and bedding plane shears was to be excavated and replaced with roller-compacted concrete (RCC), referred to as the RCC buttress. This RCC buttress was intended to prevent sliding movements along the horizontal continuous bedding plane shears and provide a competent concrete foundation for the powerhouse, spillways and headworks structures (Figure 2).

Stability and deformation analyses of the structures were undertaken. These analyses provided an assessment of the stability of the structures based on the adopted strength parameters for the bedding planes, relaxation joints and shears. The method of stability analysis was the U.S. Army Corps of Engineers rigid block analysis, checked with a finite difference deformation model.

Although the design of the right bank buttress foundation assumed that no continuous bedding plane shears existed below El. 375 m (base of RCC buttress), a stability check for the right bank structures was carried out during design. The stability check was to confirm that if a bedding plane was created at a critical depth below El. 375 m during construction, the buttress would remain stable based on the design parameters. Because that bedding plane shear would likely form as a result of the shale's response to excavation, its shear strength was assumed to have a composite friction angle composed of: intact rock shear strength; rock to rock contact with small movements; and a lower bound strength for newly formed bedding plane shears with little displacement. This composite friction angle was estimated along the failure surface according to the anticipated displacement. The buttress satisfied the Project stability criteria with this assumption.

Figure 2 Arrangement of Structures

Figure 3 Spillways RCC Buttress with the Location of the Continuous Bedding Plane Shears Considered during the Implementation Design



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> Geotechnical issues on work fronts other than the left bank diversion tunnels has always been a project risk, and this risk has materialized on the right bank.
>
> At the end of December 2019, investigations and analysis of geological mapping and monitoring activities during construction identified that some foundation enhancements would be required to increase the stability below the powerhouse, spillway and future dam core areas. These investigations and analysis were reported to the Project Assurance Board in early January 2020.
>
> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.5 Please discuss the reasons for any discrepancies between the geotechnical studies or used to inform design of the foundations and subsequent geotechnical studies.

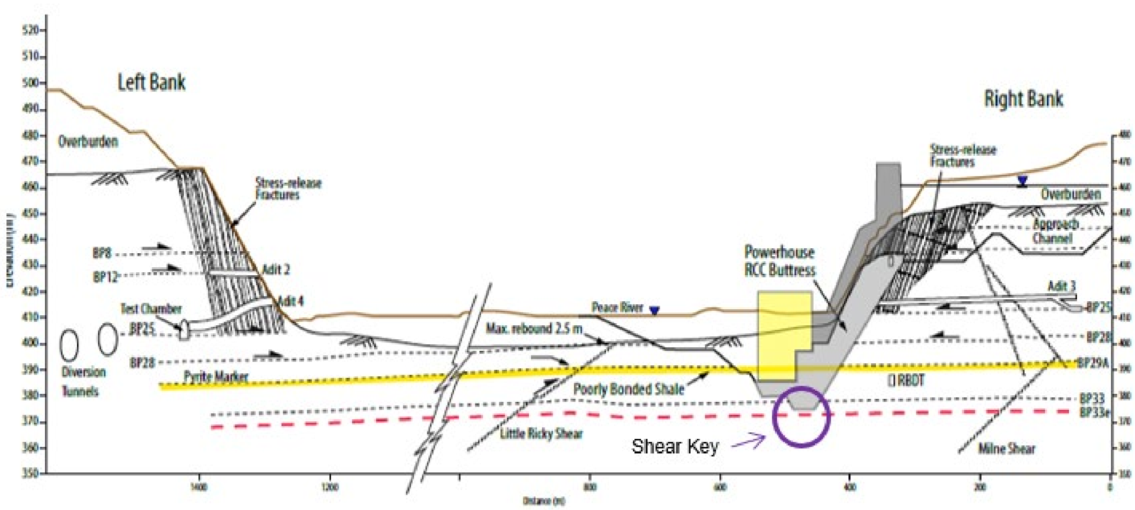
RESPONSE:

The original design of the foundations was based on the studies and analysis completed prior to the start of construction. Please refer to BC Hydro's response to BCUC Staff IR 1.1.4 for details.

During construction of the Project, consistent with best practices, instruments were installed to monitor the response of the foundation, and geological mapping was completed during the excavation of the foundations. The original design of the foundations was then analyzed and updated based on the additional information that was obtained from the instrumentation and mapping during construction.

Before the start of construction, the deepest identified continuous bedding plane shear below the RCC buttress was BP33. As a result, the shear key incorporated into the RCC buttress was designed to a depth below bedding plane shear BP33 (refer to Figure 1). As a result of the additional information that was obtained from the instrumentation and mapping during construction, another continuous bedding plane shear (BP33e – red dashed line in Figure 1) was identified below the base of the buttress shear key. Please note that the cross section in Figure 1 has a 4:1 exaggerated vertical scale.

Figure 1 Simplified Site C Geology for the Right Bank Structures



The original design basis established criteria and strength on bedding planes and the strengths and characteristics of the rock. The original design had estimated the operational strength of bedding planes based on the residual strength obtained in laboratory tests and field investigations.

The formation of a new deep bedding plane as a result of construction movements was also contemplated in the original design. If a deformation analysis indicated that displacements would occur on a weak layer below the deepest identified continuous bedding plane shear, the strength of the bedding plane was adjusted based on the magnitude of the calculated deformation.

During construction, displacements were observed on bedding planes below the base of the RCC buttress. Based on these displacements, the operational strength of the bedding planes under the powerhouse and spillway proved to be less than estimated (Figure 1).

Deformation of the foundation in response to both excavation and water infiltration was also larger than anticipated. Field mapping of extension jointing revealed a greater and more complex distribution of jointing. This reduced the potential benefit that could be attributed to interlocking of the rock mass in the assessment of the stability of the structures.

Mapping of excavated surfaces indicated that shears were more abundant than had been assumed in the design, indicating that the breakout zone provides less resistance to movement.

An integration of the above observations, supported by a range of stability analysis, indicated that additional foundation enhancement measures were required to meet Canadian Dam Association guidelines and international best practices. These guidelines account for uncertainties and address dam safety.

1.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Site C Quarterly Progress Report No. 19, Section 1.1.1.1, p. 15
Foundational enhancements

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>
> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.6 Please discuss to what extent foundation construction activities continued after geotechnical risks materialized on the right bank.

RESPONSE:

All foundation construction activities continued while the investigation, assessment and evaluation of the potential foundation enhancements to address the geotechnical risks were being completed. As part of this assessment, a number of alternative foundation enhancements were evaluated based on various considerations, one of which was minimizing the impact to the construction schedule.

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> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.7 Please identify when the construction schedule on the right bank was first changed due to the materialization of geotechnical risks.

RESPONSE:

The construction schedule on the right bank was first changed due to the materialization of the geotechnical risk in spring 2020. This was when BC Hydro directed the contractor to install anchors in the foundation of the core buttress.

1.0 A. CONSTRUCTION PROGRESS

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> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.8 Please describe how geotechnical risks were factored into the project contingency and project reserve.

RESPONSE:

Geotechnical risks were factored into the project contingency and reserve based on the following assumptions:

- **That the geology of the site would generally be consistent with the extensive geotechnical investigations undertaken of the site and that no significant issues would arise that would affect the means, methods and schedule of the work.**
- **That the identified sources of granular material would be sufficient to complete construction of the dam structure.**
- **That geotechnical conditions would not be significantly worse than contemplated by the design and construction contracts issued to date.**

- **That contingency was not to be included for unusual events or for any significant additional scope of work.**

Based on the above assumptions and exclusions, the Project was re-estimated as part of the currently approved budget. Geotechnical contingencies were included for typical and expected items such as extra support at excavated surfaces, increases in excavation quantities to find suitable bed rock, and minor alterations in the work. No allowance or risk provision for significant additional scope or schedule delays due to unforeseen geotechnical issues were provided for in accordance with the Association for the Advancement of Cost Engineering International (AACEI) recommended practices.

The materialization of significant geotechnical challenges was highlighted at the time as a possible risk that could have material impact on the cost estimate.

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> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.9 Please identify when the Project Assurance Board was first made aware of potential geotechnical issues in the powerhouse, spillway or dam core areas.

RESPONSE:

The Project Assurance Board was formed in January 2018.

On a monthly basis, the Project Assurance Board (PAB) is provided information on the Project including the key project risks. The geotechnical risks associated with the foundation enhancements have been included in these materials every month since September 2018.

All Technical Advisory Board reports are issued to the Project Assurance Board at the time of issue by the Technical Advisory Board (TAB). The first TAB report that specifically discusses the geological risks associated with the right bank

foundation enhancements was in October 2018, and these risks were also discussed in each subsequent TAB report from that point forward.

In a meeting between the TAB and PAB in January 2020, it was recommended that new information on foundation conditions needed to be further analyzed and that this risk and potential mitigation were more significant than earlier reported. This recommendation was provided in TAB report #21. All TAB reports are included in BC Hydro's Annual Progress Reports.

1.0 A. CONSTRUCTION PROGRESS

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Site C Quarterly Progress Report No. 19, Section 1.1.1.1, p. 15
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> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.10 Please provide a timeline for when BC Hydro expects to have a better understanding of the enhancement measures and the resulting cost and schedule impact.

RESPONSE:

BC Hydro worked to select and optimize the design of the enhancement measures throughout 2020. As of February 2021, the feasibility design was completed for the majority of the foundation enhancements. This work contributed to the updated Project cost estimate of $16 billion. Please refer to BC Hydro's response to BCUC Staff IR 1.5.1 for the details on the cost increase attributable to the foundation enhancements. The foundation enhancements are expected to be completed by 2023.

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> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.11 Please explain if BC Hydro has retained the services of independent consultants/experts in dam construction and dam safety to provide assistance on the foundational issues.

RESPONSE:

As described in BC Hydro's response to BCUC Staff IR 1.1.3.1, Klohn Crippen Berger Ltd. (KCBL) and SNC Lavalin Inc. (SLI) (or predecessor firms) have been responsible for the investigations, assessments, design and contract specifications, and both firms have numerous specialists and experts. KCBL and SLI both have extensive experience in the design and construction of hydroelectric projects within Canada and internationally.

BC Hydro has also retained a Technical Advisory Board to review the design for the Site C Project. The Technical Advisory Board is made up of a team of individuals that are internationally recognized for their breadth and depth of technical knowledge and experience with the design of hydroelectric projects around the world. The core area of experience spans hydroelectric projects and

arrangements, geotechnical design, geological and hydrological considerations, hydraulic design of spillways, tunnels and reservoir landslides.

The Project Assurance Board has also retained two experts that are internationally recognized for their breadth and depth of technical knowledge and experience with design of hydroelectric projects around the world.

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1.1.11 Please explain if BC Hydro has retained the services of independent consultants/experts in dam construction and dam safety to provide assistance on the foundational issues.

1.1.11.1 If so, please describe the consultant/expert recommendations.

RESPONSE:

As described in BC Hydro's response to BCUC Staff IR 1.1.3.1, Klohn Crippen Berger Ltd. (KCBL) and SNC Lavalin Inc. (SLI) (or predecessor firms) have been responsible for the investigations, assessments, design and contract specifications, and both firms have numerous specialists and experts. Engineers of Record from both KCBL and SLI make recommendations on the foundational issues on a continuous and on-going basis.

Based on presentations and discussions with the Engineering Design Team, recommendations from the Technical Advisory Board (TAB) to BC Hydro and the Engineers of Record related to the Right Bank foundation enhancements are

contained in TAB Reports #19 through #23 and are provided in the table below. All TAB reports are included in BC Hydro's Annual Progress Reports.

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
TAB Report 19 (dated October 2018)	Meeting with the BC Hydro Board & PAB on October 12, 2018	Pages 6, 7	Section 5.2.1 Spillway Stability Reassessment The stability of the Right Bank structure is controlled by sliding along pre-defined bedding planes of weakness characterized by the extensive site investigations, laboratory tests and analytical studies conducted over many years in the past. Instrumentation is installed in the Right Bank to monitor deformations to validate that movements remain within tolerable limits consistent with the prescribed strength associated with the various active bedding planes and no failure mechanism develops. In general, such movements reduce with placement of the RCC buttress and ultimately stop. The final resistance along bedding planes must be compatible with the Factor of Safety required by the design criteria, or tolerable deformations associated with the MCE (Maximum Credible Earthquake) earthquake loads. During the first phase of spillway excavation, prior to buttress construction, slip along several bedding planes was encountered. This was generally as anticipated except for slip at a depth below the deepest bedding plane (BP 33) that had been considered to be of concern. This slip on its own so far is not consequential. However, if slip along this plane is considered in a stability analysis with conservative design parameters, the design Factor of Safety is violated. Remedial measures are available but are costly and could impact schedule. Therefore, a substantial investigation is warranted to validate the extent of this plane of weakness, improve its strength characterization, and evaluate mitigation measures, if they prove necessary. There is some urgency associated with this undertaking since mitigation, if needed, may be costly and might impact schedule associated with spillway construction. To this end, the TAB recommends the following: 1. Continue with observations as planned during the excavation of the spillway which is assumed to proceed in a top-down manner. 2. Conduct a 3D stability analysis with the same inputs as used in the conservative 2D analysis. 3. Develop a more realistic seepage pattern in the foundation consistent with the drainage boundary conditions. 4. Synthesize past data for borings, televiewer logs and laboratory tests. 5. Obtain undisturbed samples of core over the length of interest to evaluate visual characteristics and shear strength on the

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			bedding plane(s); triple tube coring is likely necessary. **6. Evaluate the spatial variability along the bedding plane by means of all available data.** **7. Review outcomes and evaluate whether design changes are necessary and, if so, what mitigative measures are appropriate.** **The TAB further recommends that following this review, a meeting be convened by teleconference to discuss the results and their implications.**
TAB Report 20 (dated May 2019)	**Meeting with the BC Hydro Board & PAB on May 31, 2019**	**Pages 7, 8**	**Section ii. <u>Right Bank Foundation</u>** **The hazards associated with various ground defects affecting stability have been correctly identified as have risk mitigation efforts based on seepage control and drainage. While the broad strategy is correct, the TAB is of the view that a greater effort is required to explore the implications of this strategy in the short term.** **To this end, the TAB is of the view that it is a high priority to develop a hydrogeological model of the right bank; to calibrate it to existing conditions and to forecast recharge into the right bank following reservoir filling when significant mounding will be expected. This will facilitate a re-evaluation of drainage measures and the effectiveness of the planned grout curtain. The optimal location of the grout curtain should be evaluated together with the drainage requirements essential to maintain stability. The TAB looks forward to an update on this task at its next meeting.** **Another aspect of the Right Bank Foundation is the need to construct a geological model with a focus on this location but that is extendable elsewhere on the site. A considerable effort is being expended in mapping the geology, but the effort will not be fully utilized unless the data is integrated in to a 3D site-wide data retrievable model. To this end, the TAB recommends that a task force be assembled to design this model, structured on the geological units that have been established sometime ago. This can also be regarded as an important contribution to the creation of the as-built record.**
TAB Letter to PAB (dated September 24, 2019)	**Monthly PAB meeting on October 7, 2019**	**Page 2**	**<u>Foundation Performance of the Site</u>** **Regarding ongoing Right Bank rock foundation movements in the Spillway area, it appears that the shear rates on the lower bedding planes are decreasing at multiple instruments. The piezometric levels appear to be responding to rainfall, therefore additional drainage has been designed and is being installed for the dam and core buttress excavation. Regarding movements along the Left Bank core trench excavation, there are slight movements indicated by inclinometers in response to excavations. Some higher**

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			piezometer levels in bedrock have been observed and will be reduced and controlled by installing inclined pumping wells to aid in minimizing movements. **<u>Foundation Model and Workplan for the Right Bank Structures</u>** **A detailed review of all the foundation mapping was presented which confirmed the character and consistency of the various bedding planes throughout the Project and, in particular the Right Bank. The use of the "LeapFrog" Model will continue by incorporating the results of borings, water pressure testing, grout takes and geologic mapping. The use of this model will allow visual and 3D interrelations of the various rock units and bedding features for further design, stability analysis and construction.** **The planned future work regarding geology and structure stability includes:** • **Continued refinement of geology model** • **Stability analysis during operation** • **Water pressure testing from RBDT** • **Seepage analysis** **The advancement of the geological model and stability analyses as proposed is supported. Consideration should be given to automating performance data with prescribed alert levels. The assessment of long-term seepage in the right bank and associated control measures requires an analysis underpinned by a hydrogeological framework and this should be initiated.**
TAB Report 21 (dated January 2020)	**Meeting with the BC Hydro Board & PAB January 10, 2020**	**Pages 2, 3**	**Section 3.1 Response to Question 1 to the TAB** **1. Does the TAB have any comments on the performance, criteria and design assessment for the Right Bank RCC foundation and stability?** **The Project has continued with its practice of validating the design basis to reflect ongoing findings from performance during construction and from an assessment of the significance of any new observations that can be made when the foundations are exposed. From the perspective of ensuring safety, this represents best professional practice. The major concerns so far have focussed on the left and right banks of the Project. In this past year, it has been possible to inspect the geological features of the foundation material in sufficient detail to map the fabric of the rock and identify whether the presence of previously identified weak features are more or less extensive than previously identified. In addition, instrumentation installed in the banks to monitor deformations during excavation have also provided information in the presence or otherwise of the weak features that have been recognized in the design.** **New findings in the right bank arising from this geological /**

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			geomechanical synthesis have raised concerns with respect to satisfying some of the original Design Basis Memorandum (DBM) requirements. These are: **i. A weak bedding plane (BP33e) beneath the spillway has been discovered at a depth deeper than had been anticipated for such features.** **ii. Field mapping of extension jointing has revealed a greater and more complex distribution than revealed during the original site investigations. This facilitates a design re-assessment that can accommodate their influence on stability with greater confidence.** **iii. Local small shear features have been recognized in some zones that indicate that the rock mass strength within some horizons may have been over-estimated.** **Dam design for safety is based on the concept of a Factor of Safety. This defines degrees of resistance in the foundation that are required to be satisfied under various loading assumptions. These loading assumptions or design cases vary from normal operating conditions to more extreme conditions when, for example, the Maximum Design Earthquake occurs or when more conservative assumptions are made with regard to the reliability of prescribed drainage control measures.** **The current assessment recognizes that the new information on foundation conditions indicate that past design criteria will not be satisfied without additional mitigation measures. The TAB and the Engineering Design Team (EDT) engaged in extensive discussions evaluating the new information, the logic of past design assumptions, particularly for the extreme case, the appropriate analyses to be used going forward to analyze the situation in more detail, and a schedule to develop executable mitigation measures which will most likely involve the construction of a shear key tunnel across the BP33e.** **The recommended way forward involves the following steps:** **i. Re-assess the formulation of the Extreme Loading case which, in the past, made assumptions for the calculation of the Factor of Safety that, in the view of the TAB, are excessively conservative.** **ii. Synthesize the available data to reflect the current understanding of the controlling strength properties that enter into the calculation of the Factor of Safety and their uncertainty.** **iii. Calculate the requirements of the mitigative measures that should be implemented to achieve the design Factor of Safety for both Operating and Extreme Loading conditions.**

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			The schedule to address this re-assessment involves the following: **i. TAB update on February 10, 2020 (meeting by Skype).** **ii. Subsequent updates as required.** **iii. The TAB review of final assessment and recommendations the week of June 8, 2020.**
TAB Report 21A (dated April 2020)	**Report provided to the Project Assurance Board and Board of Directors on April 27, 2020 – no "report out" meeting.**	**Pages 4, 5**	**Question 3. Does the [Technical Advisory] Board have any comment on the options for increasing stability by structural stabilization?** **The Board comments on the options presented as follows:** **1. RCC Key Tunnel – Modelling showed that an 8m wide by 11 m high RCC filled Key Trench Tunnel was not alone, sufficient to achieve required stability. Significant displacement yields occurred on bedding plane 33e (at approximately El. +372 m and on two lower planes at +364 and +358 m. Similar bedding planes are thought to exist generally from +372 down to +350 m and so the concept of a key tunnel is not being pursued further. The TAB agrees.** **2. Deep Shear Piles – This option assumes multiple 8' (2.44 m) dia. piles down to El. +350 m. The piles would either be steel, backfilled with concrete, or concrete with internal rebar cages. Installation would be from the surface and it is a well-established technology. However, the way in which groups of such piles would work together in rock may need further clarification. It is considered that, in conjunction with foundation drainage measures, such piling might be required to provide an equivalent shear resistance of 10 MN/m run. The option is practical and so is to be taken further. The TAB agrees but points out that mobilization of deep shear piles may involve significant lateral deformations and these are controlled by the stiffness of the ground which is not readily characterized for the current ground conditions.** **3. Post Tensioned Anchors – This option incorporates well established engineering practice. It has the advantage of applying a positive upstream, active, stabilising load and should thus minimise any significant downstream yield. Short anchors (approximately 56m) are feasible but would require lower galleries to be excavated possibly below El. +350 m as well as upper galleries excavated in the RCC key trenches. The former could usefully serve as a permanent de-watering facility. Other single gallery and non-gallery arrangements are feasible but would require longer (circa 100 m) anchors. The option involving post tensioned anchors is again practical and also flexible. It is to be taken further and the TAB agrees.** **4. Upstream Drag Plate – This is an interesting concept which**

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			takes advantage of the fact that part of the upper, upstream approach channel is now to feature a concrete invert slab and dewatering arrangements. This option takes that concept further by making the works more substantial with regard to relative movement by anchoring them down and then using that as an "anchor block" to restrain the downstream buttresses. However, the arrangement puts the buttresses and the structural concrete works they support into overall tension, including the upper anchor nosing and gallery. To become an acceptable option a structural review of this concept is needed which follows the various load paths to ensure that all parts involved would be structurally adequate. There are limited precedents for this option. It is suggested that this option be put on hold pending structural checks. 5. Upstream Piles and RCC – This option has not been developed to any great extent but would involve excavation, RCC and piling in the upper apron channel immediately upstream of the buttresses. In concept this would extend the theoretical failure path farther upstream and so gain an associated incremental increase in FoS. It may be possible to develop the concept further given that some upstream apron concrete is anyway, now envisaged. However, it needs more work to develop and prove a practical arrangement. The TAB is skeptical that a practical solution will emerge. The Board is content that all practical options are under consideration but reminds the Project that a combination of options may well be appropriated for the different needs of the spillway than the needs of the powerhouse.
TAB Report No. 22 (dated June 2020)	Report provided to the Project Assurance Board and Board of Directors on October 26, 2020 – no "report out" meeting.	Pages 3, 4	1. Is the TAB convinced that based on the available information (instrumentation, mapping of geology, modeling, etc.) that additional stability measures are required? Based on the available information regarding current strength and conditions and the detailed computer modeling conducted, the TAB is convinced that additional stability measures are required. Over the past two years the Engineering Design Team have been monitoring, measuring, studying, and evaluating the reactions of the Right Abutment rock conditions. The detailed monitoring was conducted during excavation as well as measuring movements and reactions associated with the placement and loading of the RCC Buttresses. This has included geologic rock foundation mapping as well as studying instrumentation results from piezometers, inclinometers and survey markers. During recent (2018 to 2019) foundation excavations required for the spillway buttress, there were inclinometer readings indicating movements on several deeper bedding planes that were earlier considered to be stable. Bedding planes BP29A and BP33E are examples that led to a

<table>
<tr><th>TAB Report #</th><th>Date Provided to PAB</th><th>Pages to Reference</th><th>Comments in Document (Excerpts from TAB Reports)</th></tr>
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re-evaluation of the movements and strengths along bedding planes. The following are examples of earlier design assumptions versus the present conditions along bedding planes.
<table>
<tr><th>Design Assumption</th><th>Current Conditions</th></tr>
<tr><td>Movement on BP18</td><td>Minimal Movement Observed</td></tr>
<tr><td>No movement on BP29A, BP33E</td><td>>70 mm movement on BP29A</td></tr>
<tr><td>No significant BPs below BP33</td><td>Back analysis of BP33E yields phi=11</td></tr>
<tr><td>Stress Relief Fractures (SRF) terminate on BPs</td><td>SRFs vertically continuous across BPs</td></tr>
<tr><td>Most SRFs terminate on BP25</td><td>Significant number of SRFs present below BP25</td></tr>
<tr><td>SRFs remaining after excavation will be tight</td><td>Rock has loosened so that remaining SRFs can still be highly conductive</td></tr>
</table>
The re-evaluation of the right abutment has been completed utilizing reduced strength parameters along bedding planes. The Design Basis Memorandum will be updated to incorporate the current strength parameters. A detailed geologic and structural model has been developed and evaluated. The Canadian Dam Association (CDA) requirements regarding standard of care and regarding structural stability factors have been adopted by the project. Additional measures are needed to meet these design criteria.
The observational approach was utilized in the final design of the project, in particular with regards to the right abutment features and foundations for the hydraulic structures. Given the complex nature of the geology and geotechnical features there will be additional stability measures necessary to resist the water loads imposed by the reservoir. Foundation drainage will be a necessary component of the design in order to maintain the required stability. These features are presently being considered by the Engineering Design Team and play a significant role in the consideration and design of the additional stability measures required to meet design criteria.
</td></tr>
<tr><td>TAB Report No. 22 (dated June 2020)</td><td></td><td>Page 5</td><td>
2. Does the TAB have any comment on the process of evaluation and weighting of the structural options for the Right Bank Stability? What in the TABs opinion are the outstanding feasibility questions?
The selection of the best option for improving the stability of the Right Bank Structure is a complex undertaking, involving matters
</td></tr>
</table>

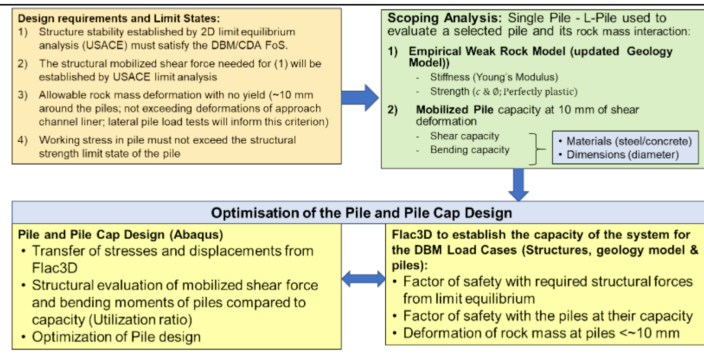
TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			of technical feasibility, constructability and management related issues with some elements lacking precedence. The TAB has been a strong advocate of adopting a structured decision-making process to assist this selection and, in its experience, it has found the MAA procedure to be effective in assessing the variable inputs involved and organizing them into a coherent summary to guide ultimate decision-making. **The MAA is effective in integrating multiple points of view, with flexibility in efficiently doing sensitivity studies by modifying the weightings if there is interest in assessing the robustness of the conclusions. It also provides a valuable record of the decision-making process.** **The TAB has been consulted on the evolution of the MAA as it progressed to its current state. It is content that it has been managed well and, while the TAB has not devoted much time to the weightings, it is also content that they are reasonable. The TAB will look more closely at weightings and their sensitivity when the process has been finalized with respect to the "musts" and the "desirable wants" and all sensible options have been included. With respect to the "musts", the TAB recommends that more detailed scrutiny be paid to the serviceability criteria as laid out in the design. The limitations on dam deformations associated with impounding are onerous. Other serviceability restraints might be designed out of the system. The TAB also places a high value on construction simplicity and the results should rank this as a "desirable want" if not already recognized.** **Feasibility relies on establishing adequate resistance under the prevailing loads, exhibiting tolerable deformations, reliable constructability and provision of an adequate quality assurance program. None of the options have been evaluated to finalize the assessment of these criteria but considerable activity is underway to do so.** **The TAB recommends as part of the assessment, attention be given to hybrid concepts such as anchors (designed to a convenient precedent) plus piles or shear walls.**
TAB Report No. 22 (dated June 2020)		**Pages 5 to 7**	**3. Does the TAB have any comment on the proposed changes to the approach channel, drainage and grouting, including the addition of a grouting gallery extension from the Dam Buttress? Is the TAB supportive of advancing these details to preliminary engineering while the evaluation for structural options for the Right Bank continues?** **Analyses have shown that the biggest factor contributing to the potential instability of the spillway and powerhouse RCC buttresses is water loading within the Right Bank hillside. This was recognized in the tender design with the provision of a Right Bank**

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			Drainage Tunnel and by minimizing the potential for water ingress into the hillside from above by water-proofing the approach channel above the slope. However, the behaviour of the hillside upon excavation has shown an extended potential for relaxation movement and cracking, possibly extending into the approach channel. This has necessitated the robustness of channel waterproofing arrangements to be reviewed as well as the means of generally ensuring the drainage of the hillside. Maximum reliability is essential to achieve the controlling loading requirements in the design. Various arrangements are now being developed by the Engineering Design Team (EDT) all of which the TAB support in principle but with some comments on matters of detail. These are discussed below by individual aspect. **The adoption of a more robust liner and drain in the Approach Channel is also needed to give confidence to lowering the assumed water level in hillside relaxation joints below the Approach Channel from 461.8 m to 432.5 m in the extreme loading case. In terms of stabilising the powerhouse buttress, this is equivalent to a lateral load reduction from 29 MN/m to 15 MN/m in the mechanical stabilization resistance which would otherwise be required.** **It is proposed to provide an enhanced zone of secure waterproofing along the approach channel and immediately upstream of the spillway and power intakes and a dewatered zone immediately beneath it. Details are being developed and at present show reinforced concrete slabbing overlaying a waterproof HDPE or PVC and GCL combined membrane which in turn overlays various zones of drainage fill and an underlying bitumastic membrane. The fill then drains, via drainage pipes, into the upstream gallery systems of the spillway and power intakes.** **The use of HDPE or PVC is a change from the solely bitumastic Coletanche liner currently specified. The TAB acknowledges the advantages this change may have, especially regarding ductility, but would nevertheless urge BC Hydro to review the benefits and disbenefits of the various alternatives with their specialist advisor, Kerry Rowe and pay special attention to long term durability. The TAB would also question the value of the lower GCL membrane.** **The TAB believes that current proposals would benefit from greater simplification by, for example, exploring alternatives to the multiple layers of zoned fill. A single layer of no-fines concrete for example, could be explored as could the use of a geotextile drainage layer. Even more importantly, careful attention must be given to providing a secure water-proof connection between the intakes and spillway headworks and the concrete slabs which is also capable of significant elongation. A geotechnically based option is indicated on current proposals but would seem to be of limited use should significant movements occur. Similar details would be**

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			needed between the slabs and the grout caps and curtains which will surround the limits of the slabs. Mechanical membrane connections to dams and other structures are becoming increasingly common in the industry and the TAB would recommend a review of similar details which have been used successfully elsewhere. The TAB also fully supports the concept of compartmentalizing this enhanced zone of waterproofed concrete slabbing so that, if a leakage does occur, it does not then affect the whole hillside. Compartmentalizing will also help identify the locations of any future leakages and so facilitate remedial action. The zone of hillside immediately under this waterproofed slabbing will be sealed by a triple layer “upstream” grout curtain running lengthways along the channel and which also crosses the channel upstream and downstream. The concept is to produce a sealed and dewatered “box” within the hillside. It is also proposed that the upstream line of grouting incorporates a gallery for monitoring and potentially future grouting. This would enable any future developing relaxation joints to be sealed against ingress from the reservoir upstream. This is a sensible precaution which the TAB supports although clearly the details of the proposed gallery and the associated grout caps to be used elsewhere is still work-in-progress. There are also proposals to extend the grout curtains downstream to flank the powerhouse and spillway and eventually seal across them downstream with a single line of grouting. The TAB would regard the primary benefit of such a single grout line to be more exploratory at this stage. Finally, the TAB note that proposals for the remainder of the approach channel are effectively unchanged in principle from those shown in the tender documents other than perhaps to change the type of waterproofing membrane used from bitumastic Coletanche to either HDPE or PVC. Again, the TAB would urge BC Hydro to review the benefits and disbenefits of the various alternatives with their specialist advisor, Kerry Rowe as part of their decision-making process.
TAB Report No. 22 (dated June 2020)		Pages 7, 8	4. Does the TAB have any comment on the modelling underway for the piles and shear wall options for the Right Bank Stability and the proposed trial excavation? The modelling underway to evaluate the alternate structural solutions to enhance Right Bank stability involves advanced state-of-practice methods that have only relatively recently become practical, at least for three-dimensional analyses. The modelling is particularly complex because different solutions for the spillway and powerhouse appear to be the optimal choice. The TAB is content with the expertise of the team undertaking these analyses and the direction that they are getting. Some additional field work

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			is also being commissioned to reassess some of the critical elements in the model. Ultimately sensitivity studies of response to various inputs will assist in the judgement associated with making the optimal choice. While quantitative forecasts are of value, one must be cautious about over-reliance on predicted numbers, and judgement will need to be exercised. It is most likely that a trial of excavation and in-situ response will be necessary to assist in confirming the final choices. Time is limited to execute such measures and consideration should be given to designing such a trial, that might be applicable to both choices at this time.
TAB Report No. 23 (dated October 2020)	Meeting with the BC Hydro Board & PAB on October 28, 2020	Pages 6, 7	3. Is the TAB satisfied with the project team's recommendation to increase stability of the Power Buttress and Spillway Buttress with large diameter laterally loaded piles? The TAB is satisfied with the Project Team's recommendation to increase the stability of the Power Buttress and Spillway Buttress with large diameter laterally loaded piles. As a result of recent information and understanding of the foundation conditions within the Right Bank, the Site C Design Team has investigated several foundation enhancements options to increase the stability of the right bank powerhouse and spillways buttresses. Since it was and is a very complex condition to analyze both geologically and structurally, an evaluation was conducted using a Multiple Accounts Analysis. This process helps establish an optimal solution to meet the project objectives; dam safety, regulatory, and engineer of record requirements; and achieve owner and operator acceptance. The optimal solution considers construction safety, the long-term quality of the project infrastructure, technical risk, constructability, operability, schedule and cost. The MAA was conducted on both the Powerhouse and Spillway Buttresses and considered several options to increase the stability of the structures. Various options were considered to reduce the driving forces, such as controlling the water load on the structures by introducing drainage facilities and others introduced restraining forces such as anchors and tendons. Still others considered structural foundation features developed within the structures and anchored within the rock foundations, such as shear walls and piles. The TAB was a part of the review team and met on a bi-weekly basis over the past several months to discuss and add experience with the response of the site rock considerations and testing, both analytically and physically. As a result of the detailed analysis (MAA), during several months of study and collaboration, the

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			optimal solution of utilizing large diameter laterally loaded piles was selected – a decision that the TAB fully agrees with.
TAB Report No. 23 (dated October 2020)		**Page 7**	**4. Is the TAB satisfied that the proposed foundation enhancements will achieve design criteria consistent with those recommended by the Canadian Dam Association and other established international practice?** **The design criteria for the dams, both concrete and earth fill, are set out in the Design Basis Memorandum (DBM). This establishes the criteria required by BC Hydro to ensure overall safety and the commitment by the Design Team to meet them. The specific criteria of intent here are the target factors of safety which reflect the reserve resistance of the structures against failure. Different load cases are also specified that must be investigated. The criteria and load cases are consistent with international practice and practice recommended by the Canadian Dam Association.** **It has been a pre-condition that all foundation enhancements that have been considered in any detail must satisfy the design criteria. The evolution of the selected enhancement strategies is documented in a report on the structured decision analyses based on the Multiple Account Analysis methodology. In this procedure, a distinction is made between "musts" and "wants". Not violating the design criteria, as reflected by the DBM, is categorized as a "must".** **Therefore, the TAB is satisfied that the proposed foundation enhancements will achieve design criteria consistent with those recommended by the Canadian Dam Association and other established international practices.**
TAB Report No. 23 (dated October 2020)		**Pages 7, 8**	**5. Is the TAB satisfied with the proposed design process flow for optimization of the pile requirements?** **The proposed design process flow for optimization of the pile requirements is shown in the figure below which is drawn from the presentation received by the TAB. It illustrates the migration of the design from consideration of the geotechnical conditions and pile interaction to one of structural design of the pile group system, optimization of the configuration and considerations of constructability, leading to drawings and specifications.**

TAB Report #	Date Provided to PAB	Pages to Reference	Comments in Document (Excerpts from TAB Reports)
			 **The last element of the geotechnical/pile interaction phase is currently being addressed by the large-scale lateral loading tests, simulating pile behaviour, currently underway. This will allow finalization of representative data to complete the geotechnical/pile interaction-analysis. Results for this phase of concept design can be used as inputs to structural design of the piles and optimization of their design and group layout.** **In the view of the TAB, this is an appropriate design process flow for optimization of the pile requirements. The structural optimization phase can be initiated at this time while the geotechnical/pile interaction phase is being completed. The TAB recommends that a progress report on this next phase of the design and its plans for optimization be presented at the next teleconference meeting of the TAB, scheduled for November 18, 2020.**

1.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Site C Quarterly Progress Report No. 19, Section 1.1.1.1, p. 15
Foundational enhancements

On page 15 of Site C Quarterly Progress Report No. 19 (Quarterly Report No. 19), British Columbia Hydro and Power Authority (BC Hydro) states:

> Geotechnical issues on work fronts other than the left bank diversion tunnels has always been a project risk, and this risk has materialized on the right bank.
>
> At the end of December 2019, investigations and analysis of geological mapping and monitoring activities during construction identified that some foundation enhancements would be required to increase the stability below the powerhouse, spillway and future dam core areas. These investigations and analysis were reported to the Project Assurance Board in early January 2020.
>
> BC Hydro continues to work with the independent Site C Technical Advisory Board and the Project Assurance Board to determine the appropriate enhancement measures. The estimated cost and schedule impacts will be better understood once the enhancement measures are selected in the coming months.

1.1.12 Please describe the extent of the project engineering being performed in-house by BC Hydro versus out-sourcing contracts.

RESPONSE:

Klohn Crippen Berger Ltd. (KCBL) and SNC Lavalin Inc. (SLI) are responsible for the design of the main civil works and the stability of the powerhouse, spillways and dam core areas. BC Hydro provides engineers to the design team under the technical supervision of KCBL/SLI. BC Hydro is responsible for the Owner's technical representatives review and coordinates the Technical Advisory Board.

2.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.1.1.1, p. 17
Conveyor belt system

On page 17 of Quarterly Report No. 19, BC Hydro states:

> The construction of a five-kilometre long electric conveyor belt system, which runs from the 85th Avenue Industrial Lands to the dam site, was completed and commissioned in 2019. The main civil works contractor has proposed plans to upgrade the conveyor system feeders to increase the efficiency.

1.2.1 Please explain who was responsible for the initial design specifications of the conveyor belt system feeders.

RESPONSE:

The public version of this response has been redacted to maintain confidentiality over sensitive information. The un-redacted version of the response is being made available to the BCUC only.

The initial design specification and construction of the till conveyor feeder system was the responsibility of the main civil works contractor. Improving the capacity of the conveyor feeder system was required to provide a reliable consistent flow of till material to site to meet the updated contractual construction schedule accepted by BC Hydro on March 5, 2020. The performance of the original conveyor belt system had a peak rated capacity of 2000 metric Tonnes per hour, which met the original contractor specifications. This peak rated capacity did not meet the anticipated <u>sustained performance capacity</u> of 2000 metric Tonnes per hour needed to complete the work to the updated schedule.

By increasing the efficiency and therefore the reliable capacity of the conveyor feeder system, the risk associated with not meeting the updated schedule is reduced. Modifications to the conveyor feeder system will improve the efficiency of the conveyor system to the required sustained capacity of 2000 metric Tonnes per hour, by introducing separation and segregation in the feeder system. In addition, the modifications will increase reliability, and reduce the schedule impacts of equipment failures.

The improvements to the conveyor feeder system to increase the sustained capacity cost $[redacted] and were agreed to by BC Hydro and the contractor in December 2019. The original contract price for the conveyor system including the

feeder was $[redacted] and included the supply, installation, operation, removal and restoration of the site for the entire conveyor system, including the feeder. To date $[redacted] of the original $[redacted] contract price has been paid to the contractor. The total revised forecast cost, including the $[redacted] for the improvements, is $[redacted].

This response also answers BCUC Staff IRs 1.2.1, 1.2.2, 1.2.3, 1.2.4 and 1.2.5.

2.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.1.1.1, p. 17
Conveyor belt system

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1.2.2 Please explain how the performance of the conveyor belt system compares to that anticipated from the original design.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.2.1 where we explain how the performance of the conveyor belt system compares to the original design.

2.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.1.1.1, p. 17
Conveyor belt system

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1.2.3 Please explain why an increase in efficiency of the conveyor belt system feeders is required.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.2.1.

2.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.1.1.1, p. 17
Conveyor belt system

On page 17 of Quarterly Report No. 19, BC Hydro states:

> The construction of a five-kilometre long electric conveyor belt system, which runs from the 85th Avenue Industrial Lands to the dam site, was completed and commissioned in 2019. The main civil works contractor has proposed plans to upgrade the conveyor system feeders to increase the efficiency.

1.2.4 Please explain how much the conveyor belt system upgrades are expected to cost.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.2.1.

2.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.1.1.1, p. 17
Conveyor belt system

On page 17 of Quarterly Report No. 19, BC Hydro states:

> The construction of a five-kilometre long electric conveyor belt system, which runs from the 85th Avenue Industrial Lands to the dam site, was completed and commissioned in 2019. The main civil works contractor has proposed plans to upgrade the conveyor system feeders to increase the efficiency.

1.2.5 Please provide a comparison of the total forecast conveyor belt system cost to the initial budget estimate, updated February 2018 estimate and expenditures to-date on the conveyor belt system.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.2.1.

3.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.1.1.1, p. 18
Worker accommodation

On page 18 of Quarterly Report No. 19, BC Hydro states:

> In 2018, various scenarios were modelled to forecast expected requirements for bed nights, and these indicated peaks in camp capacity greater than 1,600 beds occurring in 2020, 2021 and 2022 based on forecasted work volumes. In 2019, the first phase of a two-phase expansion was completed which added 150 beds. The Phase 2 camp expansion, which will provide an additional 450 beds, commenced construction in February 2020 and is planned to be completed by the end of May 2020.

1.3.1 Please discuss whether the 2018 scenario modelling was reviewed in the context of COVID-19 pandemic conditions.

RESPONSE:

The 2018 scenario modelling was updated in summer 2020 to reflect the COVID-19 pandemic conditions. Information on peak utilization of the worker accommodations from the updated scenario modelling is shown the in the table below. The table illustrates the impact of COVID-19 on peak utilization.

Worker Accommodation Peak Utilization				
Year	**Peak Capacity Available including ATCO 150 Beds (A)**	**Forecast Peak Capacity Required with COVID-19 (B)**	**Forecast Peak Capacity Required without COVID-19 (C)**	**Variance (B-C)**
2020	**2,350**	**1,900**	**2,400**	**(500)**
2021	**2,350**	**2,500**	**2,400**	**100**
2022	**2,350**	**2,300**	**2,100**	**200**
2023	**1,750**	**1,000**	**1,200**	**(200)**
2024	**1,750**	**1,200**	**500**	**700**
2025	**1,750**	**200**	**-**	**200**

3.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.1.1.1, p. 18
Worker accommodation

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1.3.2 Please discuss how camp bed-night requirements have been affected by the COVID-19 pandemic to-date in 2020.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.3.1.

3.0 A. CONSTRUCTION PROGRESS

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.1.1.1, p. 18
Worker accommodation

On page 18 of Quarterly Report No. 19, BC Hydro states:

> In 2018, various scenarios were modelled to forecast expected requirements for bed nights, and these indicated peaks in camp capacity greater than 1,600 beds occurring in 2020, 2021 and 2022 based on forecasted work volumes. In 2019, the first phase of a two-phase expansion was completed which added 150 beds. The Phase 2 camp expansion, which will provide an additional 450 beds, commenced construction in February 2020 and is planned to be completed by the end of May 2020.

1.3.3 Please discuss whether BC Hydro considers that a COVID-19 related impact to camp bed requirements is likely in 2021 and 2022.

RESPONSE:

Please also refer to BC Hydro's response to BCUC Staff IR 1.3.1.

At this time, BC Hydro is unable to determine if there will be an impact to camp bed requirements in 2021 and 2022 due to the uncertainty associated with the progression of the COVID-19 pandemic. However, the modelling suggests that there will be an increase in the forecast peak capacity required in 2021 and 2022 as a result of the reduction in the forecast peak capacity required in 2020.

4.0 A. CONSTRUCTION PROGRESS

Reference: GENERATING STATION AND SPILLWAYS
Quarterly Report No. 19, Section 1.1.1.2, p. 19
Concrete placements

On page 19 of Quarterly Report No. 19, BC Hydro states,

> During the reporting period, progress on the generating station and spillways advanced on all work fronts prior to the escalation of the COVID-19 pandemic and work being scaled back at the dam site on March 18, 2020. The contractor stopped work on the generating station and spillways on March 18, 2020 and is now performing essential activities to care for the site, including concrete thermal control and water management.

1.4.1 Please discuss whether geotechnical risks played any role in BC Hydro's decisions to suspend or not resume work on any components of the generating station and spillways.

RESPONSE:

Geotechnical risks played no role in the suspension of work on the generating station and spillways. The suspension was due to necessary reductions in workers in the camp accommodation lodge caused by the COVID-19 pandemic. When work was gradually resumed in a phased approach beginning in June 2020 after COVID-19 protocols had been established to allow the safe resumption of work, it was resumed in all areas except for the spillways stilling basins. This is because some foundation enhancement work is planned to be performed in the stilling basins to address the geotechnical risks.

4.0 A. CONSTRUCTION PROGRESS

Reference: GENERATING STATION AND SPILLWAYS
Quarterly Report No. 19, Section 1.1.1.2, p. 19
Concrete placements

On page 19 of Quarterly Report No. 19, BC Hydro states,

> During the reporting period, progress on the generating station and spillways advanced on all work fronts prior to the escalation of the COVID-19 pandemic and work being scaled back at the dam site on March 18, 2020. The contractor stopped work on the generating station and spillways on March 18, 2020 and is now performing essential activities to care for the site, including concrete thermal control and water management.

1.4.2 Please discuss whether BC Hydro has plans to resume work on concrete placements for the generating station and spillways if the current provincial COVID-19 guidelines remain in place.

RESPONSE:

Concrete work has resumed in all generating station and spillways areas except for the spillways stilling basins. The restarting of concrete work in the stilling basins has been postponed as some foundation enhancement work is planned to be performed in the stilling basins.

5.0 A. CONSTRUCTION PROGRESS

Reference: ENGINEERING
Quarterly Report No. 19, Section 1.1.2, p. 31
Foundational enhancements

On page 31 of Quarterly Report No. 19, BC Hydro states:

> Recommended enhancements included design changes for the roller-compacted concrete core buttress to enhance the foundation with anchors, additional grouting for the earthfill dam and a shear key for the right bank of the earthfill dam.
>
> Additional foundation enhancements include improvements to the spillways and powerhouse roller-compacted concrete buttresses. Several options are being evaluated against Project criteria, including improvements to the drainage within the rock and changes in the design of the approach channel.

1.5.1 Please provide further details of the scope of work and estimated budget of the recommended enhancements.

RESPONSE:

The public version of this response has been redacted to maintain confidentiality over commercially sensitive information. The unredacted version of the response is being made available to the BCUC only, to prevent harm or prejudice to procurement processes or negotiations with contractors to resolve commercial issues in the course of construction.

This response answers BCUC Staff IRs 1.5.1 and 1.5.2.

The updated cost estimate for the foundation enhancements is [redacted]. This amount is included in the updated Project cost estimate of $16 billion.

The additional foundation enhancements were evaluated against the Project criteria.

The scope of work of the recommended enhancements are:

1. Spillways and Powerhouse roller-compacted concrete (RCC) Buttresses

The stability of the Spillways and Powerhouse RCC Buttresses must satisfy the factors of safety for the various loading scenarios specified in the Design Basis Memoranda (DBM) for the Project, which are based on Canadian and international dam safety practices. Remedial measures are required to compensate for the lower residual frictional strength of the bedding plane shears below Elevation 375 m. A two-part solution was identified to improve the stability of the right bank structures: extend the foundation deeper into the bedrock and reduce water pressures in the foundation.

The first part of the solution is to improve the strength of the concrete buttresses beneath the right bank structures by anchoring the buttresses deeper into the bedrock below. Vertical piles (large steel pipes filled with concrete) will extend the function of the shear key by drilling through the deeper bedding plane into stronger rock below it. There will be up to 125 piles installed, each up to 2.5 metres in diameter. The piles will extend the foundation 15 to 25 metres into bedrock.

At the Powerhouse Buttress, piles will be installed in the tailrace area. The piles will be embedded in a pile cap, which will be structurally connected to the buttress. At the Spillways Buttress, the piles will be embedded in the RCC in the stilling basin.

The second part of the solution is to reduce water pressures under the buttresses by improving the water tightness of the Approach Channel and improving drainage under the buttresses. The Approach Channel liner will be enhanced, and drainage layers will be added under the liner. Enhancement of the liner will consist of a multi-layer geomembrane liner, a more robust grout curtain, and the addition of a short gallery at the western entrance to the Approach Channel for maintenance of the grout curtain in that area. Granular buttresses will improve the stability of the slopes along the Approach Channel. Additional drains will be drilled from the Right Bank Drainage Tunnel and from the face of both buttresses.

The enhancements will address the conditions that were discovered during construction and will provide a reliable solution for the stability of the Project and long-term operability. The development of the design has involved detailed internal and external review, conservatism in assumptions used in the design process and augmentation of the design team with subject matter experts. The proposed solution will meet Canadian Dam Association (CDA) guidelines and international best practices.

The results of recent fieldwork provide further confidence that the proposed solution is robust.

2. Core RCC Buttress

Enhancements were required to increase the stability of the Core RCC Buttress during the construction phase prior to construction of the earthfill dam. These enhancements were required to address lower strengths on bedding planes under the Core Buttress and involved the installation of large rock anchors in the foundation of the Core Buttress. The Core Buttress is eventually supported by the earthfill dam and the rock anchors serve a temporary requirement to increase stability until the earthfill dam is constructed.

3. Earthfill Dam

Displacements observed during excavation for the buttresses indicated that joints in the rock had opened more and to a greater depth than had been expected in the design of the grout curtain. Assessment of the displacements indicated that the grout curtain at the abutments would need to extend to a greater depth and that additional grout holes would be needed.

At the Right Bank of the Earthfill Dam the existing granular shear key in the foundation of the Earthfill Dam upstream of the powerhouse service bay was deepened locally to increase the stability. The deepening of this granular shear key was to address the lower strength of the bedding planes.

5.0 A. CONSTRUCTION PROGRESS

Reference: ENGINEERING
Quarterly Report No. 19, Section 1.1.2, p. 31
Foundational enhancements

On page 31 of Quarterly Report No. 19, BC Hydro states:

> Recommended enhancements included design changes for the roller-compacted concrete core buttress to enhance the foundation with anchors, additional grouting for the earthfill dam and a shear key for the right bank of the earthfill dam.
>
> Additional foundation enhancements include improvements to the spillways and powerhouse roller-compacted concrete buttresses. Several options are being evaluated against Project criteria, including improvements to the drainage within the rock and changes in the design of the approach channel.

1.5.2 Please discuss the range of estimated budget impacts of the additional foundation enhancements being evaluated against Project criteria.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.5.1.

6.0 B. CONTRACT MANAGEMENT

Reference: HIGHWAY 29 AND HUDSON'S HOPE SHORELINE PROTECTION BERM
Site C Annual Progress Report No. 4, Section 3.2.1.6, p. 34; Quarterly Report No. 19, Section 1.1, p. 9; Section 1.1.1.6, p. 27
Contract management

On page 9 of Quarterly Report No. 19, BC Hydro provides Table 1 Project Status Dashboard. Table 1 is partially reproduced below:

Procurement Overall Project	●	Procurement timelines for the balance of plant contract have been extended to respond to concerns on the impact of the COVID-19 pandemic raised by proponents. The financial submission deadline for balance of plant was extended, which will delay the contract award date past June 2020. All remaining major Highway 29 procurements, including for segments at Cache Creek, Farrell Creek and Lynx Creek, may experience some delay. A direct award contract for the Hudson's Hope Shoreline Protection work was cancelled. A public request for Proposals will be posted in May 2020 with an anticipated award in August 2020.

1.6.1 Please explain why the direct award contract for the Hudson's Hope Shoreline Protection work was cancelled.

RESPONSE:

During the direct award procurement process for Hudson's Hope Shoreline Protection work, BC Hydro could not reach agreement on acceptable contract terms with the First Nations designated business. As a result, a contract was not executed, the direct award procurement process was cancelled, and a public request for proposal was issued.

6.0 B. CONTRACT MANAGEMENT

Reference: HIGHWAY 29 AND HUDSON'S HOPE SHORELINE PROTECTION BERM
Site C Annual Progress Report No. 4, Section 3.2.1.6, p. 34; Quarterly Report No. 19, Section 1.1, p. 9; Section 1.1.1.6, p. 27
Contract management

On page 9 of Quarterly Report No. 19, BC Hydro provides Table 1 Project Status Dashboard. Table 1 is partially reproduced below:

Procurement Overall Project	●	Procurement timelines for the balance of plant contract have been extended to respond to concerns on the impact of the COVID-19 pandemic raised by proponents. The financial submission deadline for balance of plant was extended, which will delay the contract award date past June 2020. All remaining major Highway 29 procurements, including for segments at Cache Creek, Farrell Creek and Lynx Creek, may experience some delay. A direct award contract for the Hudson's Hope Shoreline Protection work was cancelled. A public request for Proposals will be posted in May 2020 with an anticipated award in August 2020.

1.6.1 Please explain why the direct award contract for the Hudson's Hope Shoreline Protection work was cancelled.

1.6.1.1 Please discuss whether BC Hydro was subject to any contractual penalties as a result of the cancellation.

RESPONSE:

BC Hydro was not subject to any penalties as a contract had not been signed.

6.0 B. CONTRACT MANAGEMENT

Reference: HIGHWAY 29 AND HUDSON'S HOPE SHORELINE PROTECTION BERM
Site C Annual Progress Report No. 4, Section 3.2.1.6, p. 34; Quarterly Report No. 19, Section 1.1, p. 9; Section 1.1.1.6, p. 27
Contract management

On Page 34 of Site C Annual Progress Report No. 4 (Annual Report No. 4), BC Hydro states:

> The detailed design for Dry Creek was completed to the 70 per cent level in 2019. Completion of the design is expected in early 2020. Procurement of the grading, paving and bridge construction will be initiated in early 2020.

On page 27 of Quarterly Report No. 19, BC Hydro states:

> A First Nation direct award procurement has been initiated on the Dry Creek grading, paving and bridge construction and is expected to be awarded in July 2020.

1.6.2 Please explain BC Hydro's rationale for direct award procurement of the Dry Creek grading, paving and bridge construction contract.

RESPONSE:

Working together to build relationships that respect Indigenous peoples' interests is important to BC Hydro. One way we are supporting the long-term economic interests of Indigenous peoples in British Columbia is by committing to directed procurement opportunities for the benefit of Indigenous communities in support of our relationship agreements, impact benefit agreements and other arrangements with Indigenous groups.

As part of the procurement strategy developed for Highway 29, BC Hydro identified that the Dry Creek grading, paving and bridge construction represented an opportunity for a First Nation direct award procurement based on the scope and risk profile of the work.

6.0 B. CONTRACT MANAGEMENT

Reference: HIGHWAY 29 AND HUDSON'S HOPE SHORELINE PROTECTION BERM
Site C Annual Progress Report No. 4, Section 3.2.1.6, p. 34; Quarterly Report No. 19, Section 1.1, p. 9; Section 1.1.1.6, p. 27
Contract management

On Page 34 of Site C Annual Progress Report No. 4 (Annual Report No. 4), BC Hydro states:

> The detailed design for Dry Creek was completed to the 70 per cent level in 2019. Completion of the design is expected in early 2020. Procurement of the grading, paving and bridge construction will be initiated in early 2020.

On page 27 of Quarterly Report No. 19, BC Hydro states:

> A First Nation direct award procurement has been initiated on the Dry Creek grading, paving and bridge construction and is expected to be awarded in July 2020.

1.6.3 Please identify which parties BC Hydro made aware of an opportunity for direct award procurement of the Dry Creek grading paving, and bridge construction contract; and explain why these parties were selected.

RESPONSE:

Please also refer to BC Hydro's response to BCUC Staff IR 1.6.2 for an explanation of the selection criteria.

For each First Nation Direct Award procurement opportunity, BC Hydro selects a single First Nation for the procurement opportunity. As a result, one First Nation with a Site C Impact Benefit Agreement was made aware of the Dry Creek direct award procurement opportunity as a benefit related to their agreement. The First Nation identified their designated business who was also made aware of the opportunity.

7.0 B. CONTRACT MANAGEMENT

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.8.13.1, pp. 71–72
Contract management

On pages 71 to 72 of Quarterly Report No. 19, BC Hydro states:

> The main civil works contract is a unit price contract and as such variations in quantities and design are expected over the term of the contract. Since contract award in December 2015, the main civil works contract value has increased by $690 million to reflect approved changes to March 31, 2020.
>
> A contract amendment was executed on March 6, 2020 to the main civil works contract that is retroactive to December 23, 2019 resulting in an increase in the contract value of up to $332 million over the duration of the contract, including investments in equipment to reduce the schedule risk for dam construction and a series of performance-based at-risk incentives for the contractor with the objective of maintaining schedule for diversion and first power.

1.7.1 Please provide an itemized breakdown of the $690 million contract value increase.

RESPONSE:

The public version of this response has been redacted to maintain confidentiality over sensitive information. The un-redacted version of the response is being made available to the BCUC only.

The Main Civil Works (MCW) contract was awarded in December 2015 for $1,748 million. The contract is a unit price contract (i.e., based on quantities) and as such variations in quantities and design are expected over the term of the contract. Between the contract award in December 2015 and March 2020, the MCW external contract value increased by $690 million.

Two key changes to the external contract value include:

- **In 2018, BC Hydro reached an agreement with the main civil works contractor for $330 million that addressed claims associated with the 2017 Left Bank tension cracks, construction environment management plan and relocated surplus excavated materials. The agreement included investments in equipment to reduce the schedule risk for dam construction, and a series of**

performance-based at-risk incentives for the contractor with the objective of maintaining the schedule for river diversion and first power.

- **In 2019, BC Hydro reached an agreement with the main civil works contractor for $332 million that addressed claims to date, and included further investments in equipment to reduce the schedule risk for dam construction, and a further series of performance-based at-risk incentives for the contractor with the objective of maintaining the schedule for river diversion and first power. The incremental increase for this agreement was $[redacted] million as it included $[redacted] million in performance-based at-risk incentives that were recast from the 2018 agreement.**

At a high level, the external contract value changes are summarized in the table below. As of March 31, 2020, the MCW external contract value is $2,438 million. This figure does not include amounts for the schedule delay to the non-critical and non-essential work that was stopped in March 2020 due to the necessary reductions in workers in the camp accommodation lodge caused by the COVID-19 pandemic, nor impacts to the contract because of the right bank foundation enhancements. The external contract value also excludes incentives not yet earned in the amount of $[redacted] million.

Summary Descriptions of Major Contract Changes	**($ million)**
MCW contract value as of December 2015	**1,748**
• ***Change orders – Quantity Variations, Fuel Escalation, Care of Water[1]***	[redacted]
• ***Other change orders – Geotechnical, design changes, winter works, inlet portal agreement***	[redacted]
• ***2016: Agreement for Right Bank Excavation and Acceleration***	[redacted]
• ***2018: Agreement*** • ***Claims($[redacted]), Investments ($[redacted]), Incentives ($[redacted])***	**330**
• ***2019: Agreement*** • ***Claims ($[redacted]), Investments ($[redacted]), Incentives ($[redacted])*** • ***Note: $332 million less incentives recast from the 2018 Agreement***	[redacted]
• ***Less incentives not yet earned and not yet included in the external contract amount.***	[redacted]
MCW contract value as of March 2020	**2,438**

1. **Care of Water is the control of water and removal of water from surface and underground excavations and work areas.**

7.0 B. CONTRACT MANAGEMENT

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.8.13.1, pp. 71–72
Contract management

On pages 71 to 72 of Quarterly Report No. 19, BC Hydro states:

> The main civil works contract is a unit price contract and as such variations in quantities and design are expected over the term of the contract. Since contract award in December 2015, the main civil works contract value has increased by $690 million to reflect approved changes to March 31, 2020.
>
> A contract amendment was executed on March 6, 2020 to the main civil works contract that is retroactive to December 23, 2019 resulting in an increase in the contract value of up to $332 million over the duration of the contract, including investments in equipment to reduce the schedule risk for dam construction and a series of performance-based at-risk incentives for the contractor with the objective of maintaining schedule for diversion and first power.

1.7.2 Please elaborate on the equipment investments and their projected impact on reduction in schedule risk for dam construction.

RESPONSE:

The public version of this response has been redacted to maintain confidentiality over sensitive information. The un-redacted version of the response is being made available to the BCUC only.

In 2019, BC Hydro reached an agreement with the main civil works contractor for $332 million that addressed claims to date, and included further investments in equipment over and above the base contract to reduce the schedule risk for dam construction, and a series of performance-based at-risk incentives for the contractor with the objective of maintaining the schedule for river diversion and first power.

These equipment investments were added to reduce the schedule risk for the dam building seasons by providing either increased capacity or redundancy. These investments build schedule float should equipment break down or if production rates are affected by quality or weather events.

The breakdown of the items addressed in the agreement is shown in Table 1.

Table 1 Agreement Breakdown

Breakdown of Agreement	($ million)
Claims	[redacted]
Incentives	[redacted]
Investments	[redacted]
Recast incentives from 2018 Agreement	[redacted]
Total	332.4

The equipment investments included funding for the main civil works contractor to procure, install and commission additional equipment for the performance of the work as follows:

Table 2 Equipment Investments

Investments	($ million)
Large earth moving equipment	[redacted]
Grouting equipment	[redacted]
Till feeder system	[redacted]
Total	[redacted]

The large earthmoving equipment is to be principally used to construct the main earthfill dam during the 2021, 2022, and 2023 construction seasons. This equipment will be used to construct the main earthfill dam and to enable sustained production of at least 40,000 m3/day with a peak production of 60,000 m3/day in the earthfill dam-building seasons to meet a capacity of at least 6,000,000 m3/year in 2021, 2022, 2023.

The grouting equipment, including related heating and hoarding equipment, is to be principally used to construct the main earthfill dam during the 2021, 2022, and 2023 construction seasons. The grouting equipment is required to enable grouting in cold weather conditions.

The till feeder system is to be principally used to construct the main earthfill dam during the 2021, 2022, and 2023 construction seasons. Modifications to the till feeder system will allow the existing till conveyor system to achieve and sustain the required 2,000 metric tonnes per hour, by introducing separation and segregation in the feeder system. In addition, the modifications will increase reliability and reduce the schedule impacts of equipment issues.

These equipment investments will reduce the schedule risk for the dam building seasons by providing either increased capacity or redundancy.

7.0 B. CONTRACT MANAGEMENT

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.8.13.1, pp. 71–72
Contract management

On pages 71 to 72 of Quarterly Report No. 19, BC Hydro states:

> The main civil works contract is a unit price contract and as such variations in quantities and design are expected over the term of the contract. Since contract award in December 2015, the main civil works contract value has increased by $690 million to reflect approved changes to March 31, 2020.
>
> A contract amendment was executed on March 6, 2020 to the main civil works contract that is retroactive to December 23, 2019 resulting in an increase in the contract value of up to $332 million over the duration of the contract, including investments in equipment to reduce the schedule risk for dam construction and a series of performance-based at-risk incentives for the contractor with the objective of maintaining schedule for diversion and first power.

1.7.3 Please describe the performance-based incentives that were introduced into the contract.

RESPONSE:

The public version of this response has been redacted to maintain confidentiality over sensitive information. The un-redacted version of the response is being made available to the BCUC only.

In 2019, BC Hydro reached an agreement with the main civil works contractor for $332 million that addressed claims to date, and included further investments in equipment to reduce the schedule risk for dam construction, and a series of performance-based at-risk incentives for the contractor with the objective of maintaining the schedule for river diversion and first power. The breakdown of the agreement is detailed in the response to BCUC Staff IR 1.7.2 and included $[redacted] for performance based at-risk incentives. The performance based at-risk incentives that were introduced into the contract are shown in Table 1.

Table 1 Incentives

Incentives	($ million)
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
Total (amounts are rounded to the nearest $0.1 million)	[redacted]

These incentives were added to increase the probability that the key schedule milestones would be achieved, and included accelerating the work in a number of critical areas.

A number of these incentives were targeted at reaching the river diversion milestone (milestone 3.2) and its interim milestones in 2020. These incentives were instrumental in successfully achieving the opening of the two diversion tunnels and full river diversion in October 2020. The remaining incentives are targeted for the main earthfill dam and cofferdam construction to achieve the overall Project in-service date.

These incentives were agreed upon to ensure that the geotechnical issues with tunnelling and inlet and outlet construction that arose in 2019 could be addressed to recover schedule and mitigate risks going forward.

7.0 B. CONTRACT MANAGEMENT

Reference: MAIN CIVIL WORKS
Quarterly Report No. 19, Section 1.8.13.1, pp. 71–72
Contract management

On pages 71 to 72 of Quarterly Report No. 19, BC Hydro states:

> The main civil works contract is a unit price contract and as such variations in quantities and design are expected over the term of the contract. Since contract award in December 2015, the main civil works contract value has increased by $690 million to reflect approved changes to March 31, 2020.
>
> A contract amendment was executed on March 6, 2020 to the main civil works contract that is retroactive to December 23, 2019 resulting in an increase in the contract value of up to $332 million over the duration of the contract, including investments in equipment to reduce the schedule risk for dam construction and a series of performance-based at-risk incentives for the contractor with the objective of maintaining schedule for diversion and first power.

1.7.3 Please describe the performance-based incentives that were introduced into the contract.

1.7.3.1 Please explain why the need for this modification to the contract has been deemed necessary at this point in the project.

RESPONSE:

Please refer to BC Hydro’s response to BCUC Staff IR 1.7.3.

8.0 B. CONTRACT MANAGEMENT

Reference: MAIN CIVIL WORKS
Site C Quarterly Progress Report No. 14, Section 4.2.1.1, p. 12
Contract management

On page 12 of Site C Quarterly Progress Report No. 14, BC Hydro states:

> On June 1, 2018, BC Hydro reached a settlement agreement with the main civil works contractor on an updated contractual schedule. The settlement agreement included:
>
> - A contractual schedule that achieves 2020 river diversion and keeps the project on track to meeting the 2024 project in-service date;
> - Accelerating a number of critical construction activities and purchasing some additional key equipment;
> - At-risk incentive payments to the contractor if and when they meet critical project milestones; and
> - Settlement of past issues that arose prior to May 31, 2018.

1.8.1 Please confirm, or explain otherwise, that the incentive payments, accelerated construction activities and purchase of key equipment included in the June 1, 2018 settlement were insufficient to maintain the schedule for diversion and first power.

RESPONSE:

The June 1, 2018 agreement included investments in equipment to reduce schedule risk, and a series of performance-based at-risk incentives for the contractor to achieve river diversion and maintain the schedule for first power (the in-service date for the first generating unit). The 2018 investments and incentives were successful in maintaining the schedule as set in June 2018, but as work progressed, new geotechnical issues arose in 2019 with respect to tunnelling and the inlet and outlet construction. These geotechnical issues were unforeseen at the time of the June 1, 2018 agreement and resulted in the need for additional investments and incentives to maintain the Project schedule.

8.0 B. CONTRACT MANAGEMENT

Reference: MAIN CIVIL WORKS
Site C Quarterly Progress Report No. 14, Section 4.2.1.1, p. 12
Contract management

On page 12 of Site C Quarterly Progress Report No. 14, BC Hydro states:

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> - A contractual schedule that achieves 2020 river diversion and keeps the project on track to meeting the 2024 project in-service date;
> - Accelerating a number of critical construction activities and purchasing some additional key equipment;
> - At-risk incentive payments to the contractor if and when they meet critical project milestones; and
> - Settlement of past issues that arose prior to May 31, 2018.

1.8.1 Please confirm, or explain otherwise, that the incentive payments, accelerated construction activities and purchase of key equipment included in the June 1, 2018 settlement were insufficient to maintain the schedule for diversion and first power.

1.8.1.1 If confirmed, please explain what issues arose that required changes from the June 1, 2018 settlement.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.8.1.

8.0 B. CONTRACT MANAGEMENT

Reference: MAIN CIVIL WORKS
Site C Quarterly Progress Report No. 14, Section 4.2.1.1, p. 12
Contract management

On page 12 of Site C Quarterly Progress Report No. 14, BC Hydro states:

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> - Accelerating a number of critical construction activities and purchasing some additional key equipment;
> - At-risk incentive payments to the contractor if and when they meet critical project milestones; and
> - Settlement of past issues that arose prior to May 31, 2018.

1.8.2 Please discuss the main civil works contractor's performance as it relates to meeting schedule milestones and receiving incentive payments as outlined in the June 1, 2018 agreement.

RESPONSE:

The public version of this response has been redacted to maintain confidentiality over sensitive information. The un-redacted version of the response is being made available to the BCUC only.

The incentive payments are at-risk payments to align the contractor's schedule risks with BC Hydro's delivery schedule risks. The incentives were identified and structured to accelerate critical work activities for improved schedule certainty to achieve diversion of the Peace River in the fall of 2020 as well as roller-compacted concrete (RCC) construction and dam construction. There have been successes and challenges in achieving the interim incentives and some incentives have been met, some were re-cast to a later date, while others have been missed. Generally, the result of including these incentives in the agreement has been as expected, with critical work progressing on time to achieve river diversion in 2020, and the spillway RCC completion in 2019.

This incentive structure allowed for incremental payments for interim milestones to be achieved leading up to river diversion. These interim milestones provided an opportunity for BC Hydro to review whether the work was being completed as

scheduled. If the interim milestones were not being achieved, BC Hydro could take immediate action to put in place mitigation measures with the contractor to ensure achievement of river diversion in 2020. The structure of the incentives allowed for the contractor to receive all diversion related interim incentives should diversion still be met in 2020. This incentive structure provided commercial tension with the contractor until the diversion milestone was achieved. This proved successful as river diversion was achieved in 2020.

The following table lists all incentives including those paid to date, incentives re-cast to later dates as a result of schedule impacts due to geotechnical or other issues, and incentives that were not re-cast to later dates. The table also summarizes the evolution of the incentive amounts from the original contract, through the June 2018 agreement and the December 2019 agreement (which was executed on March 6, 2020) and subsequent change orders.

Description (Incentives)	Current Status	Amount ($ million)	Paid to Date (October 30, 2020) ($ million)
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]

The above table provides information regarding the December 2019 Agreement and therefore also answers BCUC Staff IR 1.8.3.

8.0 B. CONTRACT MANAGEMENT

Reference: MAIN CIVIL WORKS
Site C Quarterly Progress Report No. 14, Section 4.2.1.1, p. 12
Contract management

On page 12 of Site C Quarterly Progress Report No. 14, BC Hydro states:

> On June 1, 2018, BC Hydro reached a settlement agreement with the main civil works contractor on an updated contractual schedule. The settlement agreement included:
>
> - A contractual schedule that achieves 2020 river diversion and keeps the project on track to meeting the 2024 project in-service date;
> - Accelerating a number of critical construction activities and purchasing some additional key equipment;
> - At-risk incentive payments to the contractor if and when they meet critical project milestones; and
> - Settlement of past issues that arose prior to May 31, 2018.

1.8.3 Please identify how the March 6, 2020 contract amendment affects each incentive payment to the contractor as set out in the June 1, 2018 agreement.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.8.2.

9.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PREAMBLE
Letter from BC Hydro dated July 31, 2020, p. 2
Project re-baseline

In a letter submitted by BC Hydro, dated July 31, 2020, on page 2 it states:

> While we remain on schedule to achieve river diversion in 2020, there is uncertainty with the project's schedule and in-service date. This is primarily due to our ability to re-start and accelerate work that was halted due to the pandemic.
>
> BC Hydro has begun the process to re-baseline the project to determine the impact the COVID-19 pandemic has had on the project's schedule and budget.

And further on page 2:

> In addition to these financial pressures mentioned above, a project risk has materialized on the right bank. Towards the end of December 2019, investigations and analysis of geological mapping and monitoring activities completed during construction identified that some foundation enhancements would be required to increase the stability below the powerhouse, spillway and future dam core areas.
>
> By the end of the March 31 reporting period, we had learned more about these geological challenges. Based on further engineering analysis of the proposed mitigation measures, the foundation enhancement costs are anticipated to be more substantial than initially expected in January.

1.9.1 Please explain how the decision was made to re-baseline the project.

RESPONSE:

As indicated in the Site C 2019 Annual Progress Report No. 4 and the Quarterly Progress Report No. 19, the overall project health indicator was at risk due to the project scope, schedule and cost indicators being at risk. As a result, the decision was made to re-baseline the Project budget and schedule in July 2020. At the same time an independent project review was also launched by Government.

9.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PREAMBLE
Letter from BC Hydro dated July 31, 2020, p. 2
Project re-baseline

In a letter submitted by BC Hydro, dated July 31, 2020, on page 2 it states:

> While we remain on schedule to achieve river diversion in 2020, there is uncertainty with the project's schedule and in-service date. This is primarily due to our ability to re-start and accelerate work that was halted due to the pandemic.
>
> BC Hydro has begun the process to re-baseline the project to determine the impact the COVID-19 pandemic has had on the project's schedule and budget.

And further on page 2:

> In addition to these financial pressures mentioned above, a project risk has materialized on the right bank. Towards the end of December 2019, investigations and analysis of geological mapping and monitoring activities completed during construction identified that some foundation enhancements would be required to increase the stability below the powerhouse, spillway and future dam core areas.
>
> By the end of the March 31 reporting period, we had learned more about these geological challenges. Based on further engineering analysis of the proposed mitigation measures, the foundation enhancement costs are anticipated to be more substantial than initially expected in January.

1.9.2 Considering the COVID-19 pandemic is still ongoing, please explain how BC Hydro expects to generate reasonable forecasts for the re-baselined project plan.

RESPONSE:

In developing the updated cost estimate of $16 billion, BC Hydro worked with agencies such as Northern Health to ensure that we considered current and future risks associated with the COVID-19 pandemic. The cost estimate factors in the best available information at this time related to the on-going potential impacts from the COVID-19 pandemic, and the numerous safety measures that have been implemented at site have been effective to protect workers such as:

- **changes made at the worker accommodation lodge to increase cleaning and physical distancing (e.g., eliminating self-service stations in the dining room and setting up tables to help workers adhere to physical distancing guidelines);**
- **having workers complete the Ministry of Health self-assessment and confirm results with their employer prior to boarding charter flights to site;**
- **daily screening of every person accessing site, including a temperature scan, at the gate before entering; and**
- **installation of thermal scanners at various exit and entry points of the worker accommodation lodge that are used before workers board crew buses or leave camp to go to various Project work sites.**

BC Hydro began monitoring the emergence of COVID-19 in January 2020 and moved quickly to implement many health and safety measures to protect employees, workers and members of the public. We will continue to closely monitor the development of the pandemic so that we can anticipate any unforeseen risks and implement additional safety measures that may be required.

9.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PREAMBLE
Letter from BC Hydro dated July 31, 2020, p. 2
Project re-baseline

In a letter submitted by BC Hydro, dated July 31, 2020, on page 2 it states:

> While we remain on schedule to achieve river diversion in 2020, there is uncertainty with the project's schedule and in-service date. This is primarily due to our ability to re-start and accelerate work that was halted due to the pandemic.
>
> BC Hydro has begun the process to re-baseline the project to determine the impact the COVID-19 pandemic has had on the project's schedule and budget.

And further on page 2:

> In addition to these financial pressures mentioned above, a project risk has materialized on the right bank. Towards the end of December 2019, investigations and analysis of geological mapping and monitoring activities completed during construction identified that some foundation enhancements would be required to increase the stability below the powerhouse, spillway and future dam core areas.
>
> By the end of the March 31 reporting period, we had learned more about these geological challenges. Based on further engineering analysis of the proposed mitigation measures, the foundation enhancement costs are anticipated to be more substantial than initially expected in January.

1.9.2 Considering the COVID-19 pandemic is still ongoing, please explain how BC Hydro expects to generate reasonable forecasts for the re-baselined project plan.

1.9.2.1 Please indicate when the re-baselined project plan will be complete.

RESPONSE:

On February 26, 2021, Government announced an updated cost estimate for the Project of $16 billion and a new expected in-service date of 2025 as a result of the impacts of the COVID-19 pandemic. We will continue to monitor and assess the schedule and risks associated with the Project and will continue to update Government of any changes.

10.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK
Quarterly Report No. 19, Section 2.2.1, p. 76
Project governance

On page 76 of Quarterly Report No. 19, BC Hydro states:

> Measures to improve Project governance in the reporting period include:
> - EY Canada continued to provide independent oversight for the Project including budget oversight, schedule evaluation and risk assessment analysis. BC Hydro and EY Canada are working collaboratively on enhancements to risk analysis and reporting;
> - BC Hydro completed one cost and schedule risk analysis during the reporting period. As part of these analyses, BC Hydro worked collaboratively with EY Canada and implemented identified enhancements;

1.10.1 Please provide results of the cost and schedule risk analysis completed during the reporting period, including copies of any reports issued.

RESPONSE:

The public version of Attachments 1 to 4 to this response are redacted to maintain confidentiality over commercially sensitive information. The confidential version of Attachments 1 to 4 of this response are being made available to the BCUC only, to prevent harm or prejudice to procurement processes or negotiations with contractors to resolve commercial issues in the course of construction.

The results of the Cost and Schedule Risk Analyses completed during the reporting period are provided as Attachments 1 to 4 to this response. The attached reports were shared with the Project Assurance Board in February 2020.

These analyses have a data date of December 1, 2019.

CONFIDENTIAL ATTACHMENT

FILED WITH BCUC ONLY

10.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK
Quarterly Report No. 19, Section 2.2.1, p. 76
Project governance

On page 76 of Quarterly Report No. 19, BC Hydro states:

> Measures to improve Project governance in the reporting period include:
>
> - EY Canada continued to provide independent oversight for the Project including budget oversight, schedule evaluation and risk assessment analysis. BC Hydro and EY Canada are working collaboratively on enhancements to risk analysis and reporting;
> - BC Hydro completed one cost and schedule risk analysis during the reporting period. As part of these analyses, BC Hydro worked collaboratively with EY Canada and implemented identified enhancements;

1.10.2 Please provide details of the enhancements to risk analysis and reporting that were implemented by BC Hydro and EY Canada.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.10.3.

10.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK
Quarterly Report No. 19, Section 2.2.1, p. 76
Project governance

On page 76 of Quarterly Report No. 19, BC Hydro states:

> Measures to improve Project governance in the reporting period include:
>
> - EY Canada continued to provide independent oversight for the Project including budget oversight, schedule evaluation and risk assessment analysis. BC Hydro and EY Canada are working collaboratively on enhancements to risk analysis and reporting;
> - BC Hydro completed one cost and schedule risk analysis during the reporting period. As part of these analyses, BC Hydro worked collaboratively with EY Canada and implemented identified enhancements;

1.10.3 Please provide details of the cost and schedule enhancements that were implemented by BC Hydro and EY Canada.

RESPONSE:

BC Hydro, working collaboratively with EY Canada, completed the following enhancements to risk analysis, reporting, and the cost and schedule risk analysis processes during the Quarterly Progress Report No. 19 period:

Cost Risk Analysis

- **Enhanced mapping of risks between the Project risk register and the Cost Risk Analysis was implemented. This improvement provided better traceability of risks between the Project risk register and the Cost Risk Analysis.**
- **Improvements to the documentation of the cost estimates that are used as an input to the Cost Risk Analysis. This resulted in more robust documentation to support the Cost Risk Analysis.**
- **Additional and regular oversight reviews with EY Canada were established as part of the Cost Risk Analysis process.**

Schedule Risk Analysis

- **Improvements to the documentation of risks used in the Schedule Risk Analysis. This resulted in more robust documentation to improve traceability and reconciliation of risks between the project risk register and the scheduling model used in the Schedule Risk Analysis.**

10.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK
Quarterly Report No. 19, Section 2.2.1, p. 76
Project governance

On page 76 of Quarterly Report No. 19, BC Hydro states:

> Measures to improve Project governance in the reporting period include:
> - EY Canada continued to provide independent oversight for the Project including budget oversight, schedule evaluation and risk assessment analysis. BC Hydro and EY Canada are working collaboratively on enhancements to risk analysis and reporting;
> - BC Hydro completed one cost and schedule risk analysis during the reporting period. As part of these analyses, BC Hydro worked collaboratively with EY Canada and implemented identified enhancements;

1.10.4 Please provide the frequency at which BC Hydro and EY Canada conduct cost and schedule risk analysis of the Project.

RESPONSE:

BC Hydro prepares the cost risk analysis and schedule risk analysis which are then reviewed by EY Canada.

For the Site C Project, cost risk analysis and schedule risk analysis are generally planned to be conducted twice a year. However, the timing may vary at the request of the Project Assurance Board.

11.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PROJECT GOVERNANCE, COSTS AND FINANCING AND RISK
Quarterly Report No. 19, Section 2.2.2, p. 77
Project budget summary

On page 77 of Quarterly Report No. 19, BC Hydro states:

> The COVID-19 pandemic escalated significantly in British Columbia and has had a material impact on the Project. The Project is experiencing material schedule impacts from the pandemic and these impacts will affect the Project completion dates. As the evolution of the COVID-19 pandemic is uncertain and the date of resolution is unknown, the impact to the Project cost cannot be estimated at this time. Various cost and schedule impact scenarios continue to be assessed;

1.11.1 Please explain the direct impact to date that the COVID-19 pandemic has had on cost and schedule of the Project.

RESPONSE:

As announced on February 26, 2021, the cost estimate for the Project has increased to $16 billion. The one-year delay and other costs associated with the COVID-19 pandemic is the single largest contributor to the cost increase. The other significant cost pressures that have contributed to the increase in the cost estimate include: the requirement for foundation enhancements on the right bank; amendments to the main civil works contract; increases in the Highway 29 work; the need to expand the worker accommodation; increased costs associated with reservoir clearing; and higher interest costs during construction.

11.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PROJECT GOVERNANCE, COSTS AND FINANCING AND RISK
Quarterly Report No. 19, Section 2.2.2, p. 77
Project budget summary

On page 77 of Quarterly Report No. 19, BC Hydro states:

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1.11.2 Please elaborate on the various cost and schedule impact scenarios that are being assessed and refined.

RESPONSE:

The primary variables that impact the cost and schedule outcomes from the various COVID-19 scenarios that have been assessed and refined include:

- **The schedule and cost impacts due to scaling back the workforce in the worker accommodation camp beginning in March 2020 which impacted construction activities at site.**
- **The on-going schedule and cost impacts from the COVID-19 pandemic on the construction activities.**
- **Potential future changes to the impacts from the COVID-19 pandemic on construction activities which are influenced by:**
  - **The performance of the various safety measures implemented at site to protect workers in the worker accommodation and around the work sites. Refer to BC Hydro’s response to BCUC Staff IR 1.9.2 for a full description;**
  - **The evolution of the COVID-19 pandemic within B.C.; and**
  - **Changes in construction activities over the remaining duration of the COVID-19 pandemic.**

The assessment of these various cost and schedule impact scenarios are reflected in the updated schedule with a one-year delay and the cost estimate for the Project of $16 billion.

11.0 C. PROJECT GOVERNANCE, COSTS AND FINANCING, AND RISK

Reference: PROJECT GOVERNANCE, COSTS AND FINANCING AND RISK
Quarterly Report No. 19, Section 2.2.2, p. 77
Project budget summary

On page 77 of Quarterly Report No. 19, BC Hydro states:

> The COVID-19 pandemic escalated significantly in British Columbia and has had a material impact on the Project. The Project is experiencing material schedule impacts from the pandemic and these impacts will affect the Project completion dates. As the evolution of the COVID-19 pandemic is uncertain and the date of resolution is unknown, the impact to the Project cost cannot be estimated at this time. Various cost and schedule impact scenarios continue to be assessed;

1.11.3 Please list and describe the major project milestones and tasks that have been placed at-risk due to the COVID-19 pandemic

RESPONSE:

The COVID-19 pandemic has had a significant impact on the Project schedule and progress of work at site as it caused an extended period of scaled-back work activity through the Project's important summer construction season.

On March 18, 2020, BC Hydro scaled back the workforce in the worker accommodation camp caused by the COVID-19 pandemic, which impacted the construction activities at the dam site, focussing on critical milestones including river diversion, and essential work, such as keeping the site safe and secure and meeting the project's regulatory and environmental commitments. This measure immediately reduced the number of workers staying at the worker accommodation lodge and resulted in fewer workers travelling to and from Fort St. John and the Peace Region.

While BC Hydro began to safely and gradually increase capacity at the worker accommodation camp, which allowed for a resumption of scaled back construction activities at the dam site beginning in May 2020, the Project missed approximately 60 per cent of the important 2020 summer construction season for the dam and core buttress, earthfill dam, and generating station.

The following planned significant work milestones have been placed at risk due to the impacts from the COVID-19 pandemic:

- **The completion of the dam and core roller-compacted concrete buttress. The original planned completion date was October 2020, which has now been delayed to late 2021;**
- **The powerhouse intakes and penstocks;**
- **The spillway headworks; and**
- **The main earthfill dam.**

Despite the impacts from the COVID-19 pandemic, BC Hydro continued to prioritize the work required to meet major Project milestones, including river diversion in fall 2020. The Peace River was successfully diverted around the dam site on October 3, 2020.

The Site C substation was completed and energized ahead of schedule, and the first of two new transmission lines was placed into service in October 2020, ahead of schedule, linking the Site C substation with the Peace Canyon substation.

The off-dam site work includes the realignment of Highway 29 and work on the second transmission line and reservoir. Construction activities were impacted due to the COVID-19 pandemic, but they continued to progress. BC Hydro also continued to secure the appropriate permits, authorizations and leaves to commence construction required for the Project. Work continued to advance in the areas of environmental monitoring and assessment; fish, wildlife, habitat, vegetation management and heritage programs; and Indigenous and community engagement activities.

12.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 37
Safety planning for diversion

On page 37 of Quarterly Report No. 19, BC Hydro states:

> Planning for public and worker safety during river diversion increased in January 2020. Planned safety measures include a public communication campaign, safety embedded in construction planning and operational processes, and diversion focused safety hazard identification and mitigation strategies. The Public Safety and Security diversion plan includes a fulsome signage plan for the Moberly and Peace Rivers, and flashing lights as warning on the final reach of the Peace River (before the first debris boom). The Diversion Safety Plan identifies safety hazards specific to diversion activities and key requirements for contractors' Safety Management Plans for each of the diversion works.

1.12.1 In developing the Public Safety and Security diversion plan and the Diversion Safety Plan (if different), please explain whether BC Hydro consulted or coordinated with government bodies and/or other regulatory agencies.

RESPONSE:

This response answers BCUC Staff IRs 1.12.1, 1.12.1.1 and 1.12.1.1.1.

Public Safety and Security Diversion Plan

The BC Hydro Public Safety department applies the Canadian Dam Association (CDA) guidelines for *Public Safety Around Dams* in evaluating public safety risks at all our dams and generating facilities. These nationally accepted guidelines provide a consistent approach for assessing and mitigating public safety risks. This CDA methodology was used to develop the Public Safety and Security Diversion Plan for Site C.

Transport Canada specifies minimum requirements for reasonable public safety risk controls related to river access and closures, including Signage and Lighting requirements. BC Hydro's Signage and Lighting Plan for diversion was reviewed and accepted by Transport Canada under our relevant Canadian Navigable Waters Act approvals.

BC Hydro in fact exceeded Transport Canada requirements with a more extensive deployment of signage on the Moberly and Peace Rivers, and at the Halfway River and Taylor boat launches.

BC Hydro's Site C Safety and Security team ensures a public safety inspection is performed every six months. The most recent inspection was done in late October, with the inspection report provided on November 6, 2020. Due to often changing conditions on the rivers, inspection of the public safety controls implemented for river diversion is critical.

The Public Safety and Security Diversion Plan for Site C is a specific component of a broader Public Safety Management Plan for the Project, which is a shared responsibility between the BC Hydro Public Safety department and the Project. This Public Safety Management Plan is updated and approved every six months.

Diversion Safety Plan

At the start of construction, a comprehensive Site C Construction Safety Management Plan (CSMP) was developed. This CSMP covers all activities required for construction of the Project and is updated annually. The CSMP guides all BC Hydro employees and contractors on safety requirements for construction and provides contractors with a basis for their development of Contractor Safety Management Plans prior to the start of their work.

The Diversion Safety Plan was developed as a separate component of the Site C CSMP, specifically to document safety management expectations for BC Hydro and contractors related to the completion of diversion works. The scope of diversion works included:

- **Moberly River – BC Hydro's River Debris Retention Structure;**
- **Moberly River – Peace River Hydro Partners Debris Boom;**
- **Peace River – Upstream Debris Boom;**
- **Peace River – Downstream Debris Boom;**
- **Peace River – Stage 1 Inlet and Outlet Cofferdams;**
- **Peace River – Stage 2 Upstream and Downstream Cofferdams;**
- **Diversion Tunnels; and**
- **Temporary Upstream Fishway.**

Unlike the Public Safety & Security Diversion Plan which required the river Signage and Lighting Plan to be approved by Transport Canada, there is no regulatory requirement or framework for BC Hydro to consult with a regulatory agency on the Diversion Safety Plan. BC Hydro worked with WorkSafeBC on worker safety considerations, and the Water Controller on overall safety aspects, including public safety.

Further, BC Hydro consulted with experienced independent advisors to the Site C Technical Advisory Board, as well as reviewing other representative major dam construction projects in North America.

Some examples of specific safety hazards identified from these sources and captured in the Diversion Safety Plan are listed below:

- **Working in or near fast moving water and strong currents**
- **Unexpected fluctuations in river flows;**
- **Rapid, unexpected build-up of ice and ice jams;**
- **Access and egress methods to and from the river;**
- **Specialized safety equipment for the diversion works construction;**
- **Operational readiness of trucks, equipment, boats and water rescue tools; and**
- **Increased volume and congestion of heavy vehicles and equipment in and around the water.**

All hazards required documented safe work procedures, which were reviewed and approved by the BC Hydro Safety team.

12.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 37
Safety planning for diversion

On page 37 of Quarterly Report No. 19, BC Hydro states:

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1.12.1 In developing the Public Safety and Security diversion plan and the Diversion Safety Plan (if different), please explain whether BC Hydro consulted or coordinated with government bodies and/or other regulatory agencies.

1.12.1.1 If so, please detail the parties involved in the development of the plan(s).

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.12.1.

12.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 37
Safety planning for diversion

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1.12.1 In developing the Public Safety and Security diversion plan and the Diversion Safety Plan (if different), please explain whether BC Hydro consulted or coordinated with government bodies and/or other regulatory agencies.

1.12.1.1 If so, please detail the parties involved in the development of the plan(s).

1.12.1.1.1 Please discuss whether the plan(s) are subject to ongoing review and refinement.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.12.1.

12.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 37
Safety planning for diversion

On page 37 of Quarterly Report No. 19, BC Hydro states:

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1.12.2 Please explain whether the plan(s) require approval.

RESPONSE:

This response answers BCUC Staff IRs 1.12.2 and 1.12.2.1.

The signage and lighting component of the Public Safety and Security Diversion Plan required review and approval from Transport Canada. Transport Canada approval was received. In addition, the Public Safety and Security Diversion Plan was reviewed and approved by BC Hydro's corporate Security and Public Safety functional groups.

Both the Public Safety and Security Diversion Plan and the Diversion Safety Plan also required approval from several BC Hydro Site C functional groups including:

- **Safety and Security;**
- **Construction Management; and**
- **Regulatory and Environment.**

Finally, all of the Project diversion management plans, including the two referenced in the preamble to the question, were reviewed and approved by the BC Hydro Project Director for Main Civil Works and the BC Hydro VP, On-Dam Site Construction.

12.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 37
Safety planning for diversion

On page 37 of Quarterly Report No. 19, BC Hydro states:

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1.12.2 Please explain whether the plan(s) require approval.

1.12.2.1 If so, please identify the part responsible for approving the plan(s).

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.12.2.

13.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 43
Safety performance frequency metrics

On page 43 of Quarterly Report No. 19, BC Hydro writes:

> Comparing the rolling 12-month average Q4 results from Fiscal 2019 to 2020 shows serious incident frequency and all-injury frequency metrics (adjusted for work hours) have increased over the past year, while lost time injury results have decreased.
>
> The serious incident frequency for the 12-month period ending March 2020 is 0.53, which remained the same as in Q3, but significantly increased compared to the 12-month period ending March 2019. Similarly, the all-injury frequency is 1.92 for Q4, a 14 per cent increase over Q3 and a 90 per cent increase from March 2019. These safety frequency results reflect, at least in part, that construction work on the Project did not slow down for the winter months of 2019/2020.
>
> The lost time injury frequency is 0.20 for this reporting period, which is higher than the prior quarter reflecting increased safety incidents from information working in deep winter conditions; however, it is lower than the 12-month period ending March 2019.

1.13.1 Please elaborate on the relationship, as stated, between the increase in all-injury rate and the completion rate of the project.

RESPONSE:

This response answers BCUC Staff IRs 1.13.1, 1.13.1.1 and 1.13.1.2.

To assess project safety over time, key safety metrics are reported as a frequency (i.e., a rate) to account for variances in hours worked. The more hours worked, the more likely there will be an increased number of incidents and injuries. A frequency measure provides a more meaningful metric to show trends over time.

Safety incidents are typically higher in the spring and summer construction season. There are more active work fronts, more workers, and more trucks and equipment operating during this time. This activity results in increased tool use, overhead loads, working at heights, worker / equipment interfaces, and congestion hazards. As the Project did not slow down for the winter of 2019/2020, these active construction hazards continued to exist in the winter, as well as

further specific winter condition hazards that existed. Winter conditions introduce ice, snow, and extreme cold hazards to the construction work, typically resulting in more slips, trips and falls.

These impacts resulted in the higher all-injury rates reported in Quarterly Progress Report No. 19 and anticipates a possible increase in all-injury rates as the Project continues a heavy construction schedule across many work fronts.

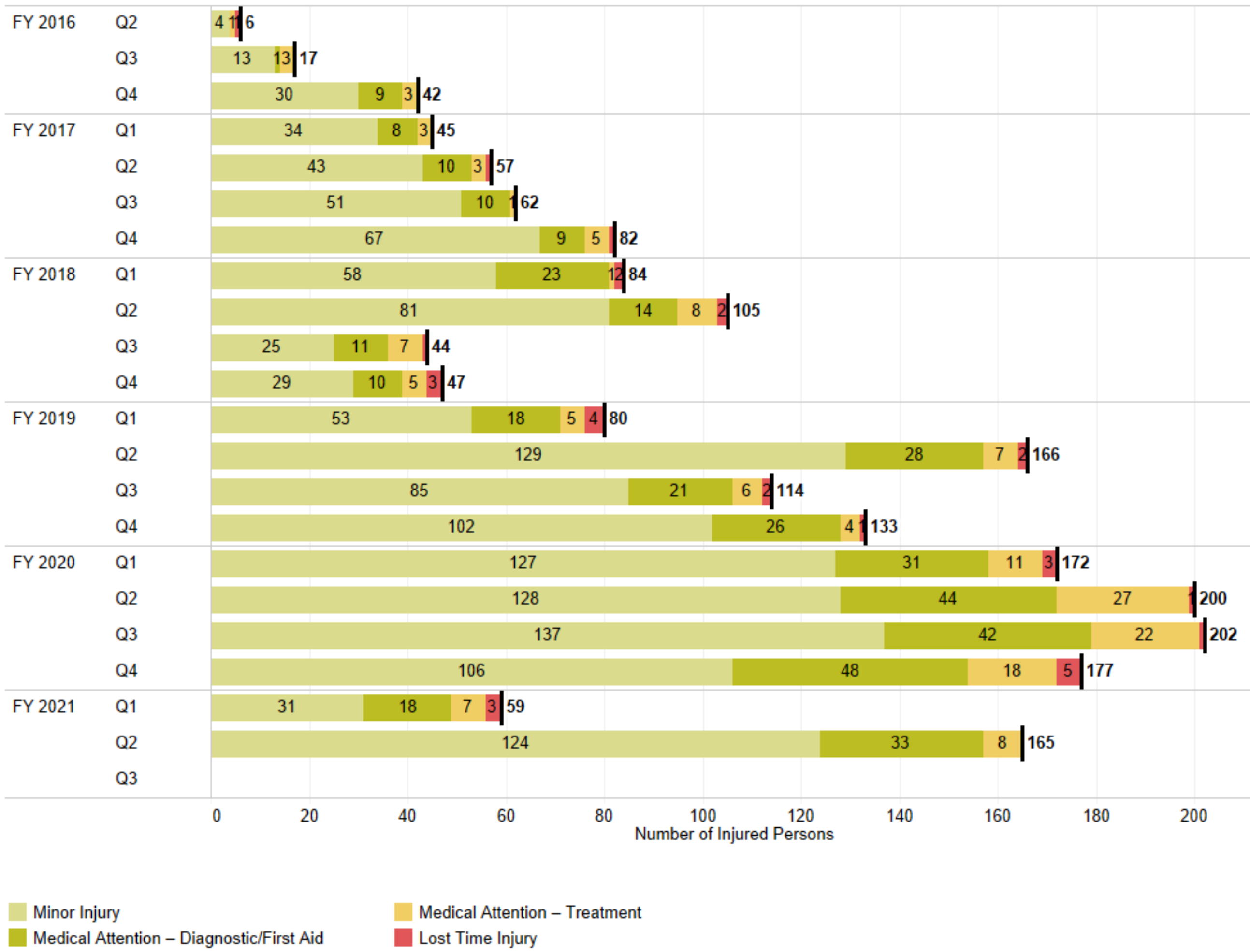
Injury Types

Table 1 summarizes the types of injuries recorded on the Project, organized by injury category. Of the 2,059 injuries, 91 per cent were either a diagnostic, first aid or minor injury. A graphic representation of the data is provided in Figure 1.

Table 1 Injury Types by Injury Category from July 2015 to September 2020

Injury Type	Injury Category				
	Lost Time Injury	Medical Attention – Treatment	Medical Attention – Diagnostic/First Aid	Minor Injury	Grand Total
Sprains/Strains	10	13	145	493	**661**
Contusion, Compression, Bruise	7	25	99	359	**490**
Cut, Laceration, Puncture		58	39	280	**377**
Scratches/Abrasions (Superficial Wounds)		3	9	118	**130**
Scratches/Abrasions in Eye	1	16	37	59	**113**
Inflammation or Irritation of Joints/Muscles			21	62	**83**
Fracture	12	19	10	3	**44**
Chemical exposure / ventilation		6	18	13	**37**
Dermatitis		2	6	13	**21**
Concrete / shotcrete contact		2	11	7	**20**
Burn or Scald (Heat)		2	3	14	**19**
Heat Stroke, Sunstroke - High Temperature			1	16	**17**
Insect Bites		1	2	6	**9**
Dislocation		7	1		**8**
Electrical contact			3	4	**7**
Eye injury		1	3	2	**6**
Concussion	3		1	1	**5**
Allergic Reaction			1	3	**4**
Freezing, Frostbite - Low Temperature			1	2	**3**
Hernia, Rupture			2	1	**3**
Hearing Loss or Impairment			1	1	**2**
Total Injuries	33 (1.6%)	155 (7.5%)	414 (20.1%)	1,457 (70.8%)	2,059 (100%)

Figure 1 Injury Types by Injury Category from July 2015 to September 2020



Tables 2 and 3 summarize the main root cause themes causing safety incidents (injuries and near misses), by quarter for Fiscal 2020 and then by fiscal year since the start of construction.

Table 2 Injury/Near Miss Themes by Quarter for Fiscal 2020

Fiscal 2020			
Q1 (Apr - Jun 2019)	**Q2 (Jul - Sep 2019)**	**Q3 (Oct - Dec 2019)**	**Q4 (Jan - Mar 2020)**
• **Slip/trip/fall due to poor housekeeping as work areas start up, continued icy conditions** • **Musculoskeletal injuries due to repetitive rebar work, lifting heavy objects** • **Cuts and lacerations while using hand tools or working around machinery** • **Tools and objects dropping from height (scaffolding, work platforms)** • **Dust in eye injuries**	• **Slip/trip/fall working with rebar** • **Musculoskeletal injuries (especially rebar)** • **Cuts and lacerations using hand tools, machinery** • **Tools and objects falling from height** • **Vehicle contacts / incidents, poor road conditions** • **Concrete and shotcrete contacts** • **Tunnel shotcrete incidents** • **Tower Crane erection and operation incidents** • **Working in high heat conditions**	• **Slip/trip/fall working around rebar and scaffolding** • **Slip/trip/fall due to snow and ice conditions, poor housekeeping** • **Musculoskeletal injuries due to overexertion, repetitive tasks** • **Cuts and lacerations using hand tools** • **Lockout compliance with equipment** • **Tools and objects falling from height**	• **Slip/trip/fall due to icy conditions from melting and freezing** • **Slip/trip/fall while working around rebar, poor walkways** • **Cuts and lacerations using hand tools or working around machinery** • **Eye injuries caused by welding flashes, and grouting (including in hoarded areas)** • **Concrete and shotcrete contacts**

Table 3 Injury/Near Miss Themes by Fiscal Year Since Start of Construction

Project Inception - July 27, 2015 to March 31, 2019			
Fiscal 2016 (partial) (Aug 2015 - Mar 2016)	**Fiscal 2017 (Apr 2016 - Mar 2017)**	**Fiscal 2018 (Apr 2017 - Mar 2018)**	**Fiscal 2019 (Apr 2018 - Mar 2019)**
• Slip/trip/fall on uneven surfaces • Musculoskeletal injuries due to lifting heavy objects • Foreign objects in eyes	• Slip/trip/fall due to wet and icy conditions, uneven surfaces and poor housekeeping in work areas • Cuts and lacerations while using hand tools or working around machinery • Silica dust management	• Slip/trip/fall due to wet and icy conditions, uneven surfaces and poor housekeeping • Foreign objects in eyes • Musculoskeletal injuries due to lifting heavy objects • Cuts and lacerations while using hand tools or working around machinery • Construction power contact incidents	• Slip/trip/fall due to uneven and icy surfaces and poor housekeeping • Foreign objects in eyes due to improper use of safety glasses • Cuts and lacerations while using hand tools or working around machinery • Shotcrete and concrete burns • Ventilation / exposure to Contaminants • Lockout compliance on equipment

13.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 43
Safety performance frequency metrics

On page 43 of Quarterly Report No. 19, BC Hydro writes:

> Comparing the rolling 12-month average Q4 results from Fiscal 2019 to 2020 shows serious incident frequency and all-injury frequency metrics (adjusted for work hours) have increased over the past year, while lost time injury results have decreased.
>
> The serious incident frequency for the 12-month period ending March 2020 is 0.53, which remained the same as in Q3, but significantly increased compared to the 12-month period ending March 2019. Similarly, the all-injury frequency is 1.92 for Q4, a 14 per cent increase over Q3 and a 90 per cent increase from March 2019. These safety frequency results reflect, at least in part, that construction work on the Project did not slow down for the winter months of 2019/2020.
>
> The lost time injury frequency is 0.20 for this reporting period, which is higher than the prior quarter reflecting increased safety incidents from information working in deep winter conditions; however, it is lower than the 12-month period ending March 2019.

1.13.1 Please elaborate on the relationship, as stated, between the increase in all-injury rate and the completion rate of the project.

1.13.1.1 Does BC Hydro expect an increasing all-injury rate as project completion progresses?

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.13.1.

13.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 43
Safety performance frequency metrics

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> The lost time injury frequency is 0.20 for this reporting period, which is higher than the prior quarter reflecting increased safety incidents from information working in deep winter conditions; however, it is lower than the 12-month period ending March 2019.

1.13.1 Please elaborate on the relationship, as stated, between the increase in all-injury rate and the completion rate of the project.

1.13.1.2 Please provide data on the types of injuries sustained over the reporting quarter and over the life of the project.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.13.1.

13.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
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Safety performance frequency metrics

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>
> The lost time injury frequency is 0.20 for this reporting period, which is higher than the prior quarter reflecting increased safety incidents from information working in deep winter conditions; however, it is lower than the 12-month period ending March 2019.

1.13.2 Please explain the difference in all injury rate from Q3 to Q4 2020, versus the decrease in rate for from Q3 to Q4 2019, given that both periods cover the winter season.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.13.1 for a more fulsome discussion of seasonal construction hazards.

On page 43 of Quarterly Progress Report No. 19, BC Hydro provided the key safety frequencies by quarter for a rolling 12-month average. This data is reproduced in Table 1 below.

Table 1 Site C Safety Performance for Fiscal 2019 and 2020

	Fiscal 2019 April 2018 – March 2019 (Rolling 12-month Average)				Fiscal 2020 April 2019 – March 2020 (Rolling 12-month Average)			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Serious Incident Frequency	0.95	0.56	0.44	0.36	0.43	0.39	0.53	0.53
Lost Time Injury Frequency	0.48	0.43	0.40	0.29	0.23	0.18	0.14	0.22
All Injury Frequency	1.67	1.47	1.25	1.01	1.03	1.44	1.68	1.94

As noted, the difference in all injury rate for Q3 to Q4 in F2020 is an increase, and for Q3 to Q4 in F2019 is a decrease. BC Hydro's review indicates there are different factors influencing each of these F2019 and F2020 safety metrics.

Fiscal 2019 – Q3 to Q4

Construction projects including Site C, generally see a reduction in the number of safety incidents in the late fall through December (Q3). Then, as work restarts after the holidays, with the return of seasonal layoffs, and into spring (Q4), the pattern is an increase in the number of safety incidents.

As illustrated in Table 3 below, the F2019 Q4 reduction in all injury frequency does not follow this pattern – the safety measure does not increase, instead it declines from F2018 Q4 results.

Table 2 Comparing Quarter 3 and Quarter 4 Safety Metrics across Fiscal 2018, 2019 and 2020

	Fiscal 2018		Fiscal 2019		Fiscal 2020	
	Q3	Q4	Q3	Q4	Q3	Q4
Serious Incident Frequency	0.85	0.98	0.44	0.36	0.53	0.53
Lost Time Injury Frequency	0.27	0.37	0.40	0.29	0.14	0.22
All Injury Frequency	1.21	1.36	1.25	1.01	1.68	1.94

The reduction in all injury frequency for F2019 Q4 is correlated to the February 2019 shutdown of work in both diversion tunnels, due to a serious electrical contact incident involving roadheader heavy equipment. This work stoppage resulted in reduced work hours in February, affecting the Q4 period.

During the same Q4 period, there was a proportionally greater reduction in safety injuries, due in part to reduced high hazard work (e.g. heavy equipment operation, underground excavation, shotcrete application) associated with the tunnels.

Fiscal 2020 – Q3 to Q4

In F2020, the Project's all injury frequency increased over the same Q3 and Q4 periods in the prior year. BC Hydro's review indicates this was due to significant increases in both worker hours and safety incidents at that time.

Table 3 below shows a 48 per cent increase (2.96 million hours) in total worker hours over F2019; specifically, a 41.7 per cent increase in Q3 worker hours and 48.6 per cent in Q4 worker hours. Two main factors in this increase were (1) the generating station and spillways civic works contractor was scaling up substantially during this fiscal year; and (2) construction work on the Project did not slow down for the winter months, in part to achieve river diversion.

Table 3 Summary of Worker Hours and Safety Incidents in Fiscal 2019 and 2020

	Total Worker Hours	Q3 Worker Hours	Q4 Workers Hours	Safety Incidents	All-Injury Frequency
F2019	6,115,596	1,607,698	1,522,261	31	1.01
F2020	9,073,057	2,277,957	2,262,817	88	1.94

The Project uses safety frequency metrics (annualized safety incidents / worker hours) to account as much as possible for work hours. However, when the number of safety incidents increases at a higher rate than work hours, safety frequencies will increase. In F2020, Q3 safety incidents were over three times higher than the prior year, and over four times higher in Q4. During these periods, there were more active work fronts at the Project, more workers, more trucks and equipment operating, as well as winter ice, snow and extreme cold hazards.

13.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 43
Safety performance frequency metrics

On page 43 of Quarterly Report No. 19, BC Hydro writes:

> Comparing the rolling 12-month average Q4 results from Fiscal 2019 to 2020 shows serious incident frequency and all-injury frequency metrics (adjusted for work hours) have increased over the past year, while lost time injury results have decreased.
>
> The serious incident frequency for the 12-month period ending March 2020 is 0.53, which remained the same as in Q3, but significantly increased compared to the 12-month period ending March 2019. Similarly, the all-injury frequency is 1.92 for Q4, a 14 per cent increase over Q3 and a 90 per cent increase from March 2019. These safety frequency results reflect, at least in part, that construction work on the Project did not slow down for the winter months of 2019/2020.
>
> The lost time injury frequency is 0.20 for this reporting period, which is higher than the prior quarter reflecting increased safety incidents from information working in deep winter conditions; however, it is lower than the 12-month period ending March 2019.

1.13.3 Please explain how BC Hydro is ensuring a safe work environment on the Site C project for both its employees and contract workers.

RESPONSE:

BC Hydro Employees

BC Hydro undertakes numerous health and safety initiatives to ensure our employees and direct contractors complete their work safely.

For example:

<u>Prime Contractor Worker Orientation</u> – all new employees to site are required to attend Peace River Hydro Partners (PRHP) and ATCO Two Rivers Lodge new worker orientation sessions. PRHP has prime contractor responsibility for many shared areas of the site, such as roads and portions of the Peace River. ATCO is

the prime contractor for camp facilities and the BC Hydro main construction office. Successful completion of these sessions is required for an employee / direct contractor to receive a site access card.

<u>Employee Orientation</u> – once oriented to site, all employees are required to attend a further BC Hydro orientation, which covers respiratory protection, silica awareness, working in and around the river, and a review of key safety hazards and safety procedures.

<u>Entry-Level Workers (Engineers-in-Training, Coop Program)</u> – to ensure the safety of entry-level employees, BC Hydro has a specific orientation program for people joining our workforce, including those assigned to Site C. This program provides safety training such as Life Saving Rules, Job Site Safety Awareness, Drug & Alcohol Policy, Fatigue Awareness, Confined Space, Working from Heights, Wildlife Safety, Driving Hazards and Laws, Emergency Response, Ergonomics, and more.

Entry-level employees are paired with a mentor, who they work alongside for several weeks to support development of a strong safety culture. Mentors train entry-level employees to identify safety hazards and apply hazard mitigations in their daily duties. Entry-level workers are also required to train for and pass an on-site driver assessment, prior to being permitted to drive on site.

Additionally, all of the major Site C contractors have operational Apprenticeship Programs for new workers, which include a focus on construction site safety.

<u>Winter Driving Training</u> – many employees / direct contractors at Site C are not experienced with driving on construction sites or in serious winter conditions. BC Hydro arranges winter driver training on construction site roads, to ensure safe driving across the site.

<u>Annual Safety Plan</u> – starting this year, each sub-project management team (main civil works, transmission, clearing, etc.) completed an individualized Annual Safety Plan for their sub-project. This process includes an updated safety hazard identification and risk assessment, which is then used to identify safety training requirements. The Site C Safety and Security team also has their own Annual Safety Plan. Each team reviews their safety plan and initiatives monthly.

<u>Mandatory Safety Training</u> – Project specific safety training on specific site safety hazards is provided for employees and direct contractors. Several are developed by the onsite BC Hydro safety team to be very targeted to the work environment. Examples of this safety training include confined space, fall protection, wildlife awareness, respiratory protection, and silica awareness.

<u>Joint Occupational Health and Safety Committee</u> – Site C has a Joint Occupational Health and Safety Committee where employees suggest improvements to site policies and conditions, participate in incident investigations, and voice any safety concerns.

<u>Vaccinations</u> – BC Hydro sponsors an annual flu vaccination program to support employee and direct contractor health. This year, BC Hydro opened the program to all contractors and workers involved with Site C.

BC Hydro Contractors

BC Hydro requires all Site C contractors to have a Safety Management Plan for their work scopes, which complies with requirements detailed in our overall Construction Safety Management Plan.

Additionally, BC Hydro has several roles in ensuring our contractors effectively manage identified safety risks, based on our contractual relationship, as follows:

<u>Prime contractor</u> – for contractors who are the designated prime contractor for safety area responsibilities in a specific work area, BC Hydro's role as owner is to seek assurance and evidence that the prime contractor has a safety management system in place to ensure they, their sub-contractors, other employers (including BC Hydro), and other employer sub-contractors working in that safety area are effectively identifying and managing safety risks, and resolving safety issues.

<u>BC Hydro as prime contractor</u> – when BC Hydro acts as prime contractor for a safety area, BC Hydro ensures our own safety management system is in place to ensure contractors, sub-contractors, and other employers are identifying and managing safety risks and resolving safety issues.

<u>Direct contractor</u> – for contractors with whom BC Hydro has a direct relationship, BC Hydro's role is to work directly with that contractor to identify and manage safety risks, as well as help resolve safety issues.

In all contractor engagement models, BC Hydro uses our comprehensive Contractor Safety Program to manage and coordinate safety performance. For Site C, contractual terms with each provider specify BC Hydro's expectations for full regulatory compliance, as well as other safety requirements such as Alcohol & Drug Policies and Certificate of Recognition requirements. BC Hydro mandates that all contracted work must be planned and performed in compliance with:

1. ***B.C. Workers Compensation Act* and the Occupational Health and Safety Regulation of British Columbia;**
2. **Other Occupational Health and Safety legislation in B.C. and Canada; and**

3. BC Hydro policies, standards, practices, and internal regulation.

On the ground, BC Hydro has a safety team dedicated to Site C. This team regularly inspects all on-site work to observe safety practices, communicates unsafe conditions to the contractor for resolution, and follows up to ensure resolution. More specifically, the safety team's responsibilities are to:

1. **Identify, and regularly update safety hazards and risks for Site C, including new work fronts (e.g. diversion of the Peace River);**
2. **Review work plans, site schedules, site activities, and safety documentation, including safe work procedures;**
3. **Verify contractors' implemented systems are effectively managing health and safety requirements;**
4. **Perform formal safety verifications and audits of all work sites, and review evidence of contractor self-verifications and audits;**
5. **Monitor and analyze WorkSafeBC Inspection Reports and Orders issued to the Project – BC Hydro and contractors;**
6. **Participate in safety incident response and investigations; and**
7. **Provide safety reporting and analysis.**

14.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 40
Summary of Site C safety and regulatory metrics

On page 40 of Quarterly Report No. 19, BC Hydro includes the following table:

Table 3 – Summary of Site C Safety and Regulatory Metrics

	Reported January 1, 2020 to March 31, 2020[2]	Reported Since Inception (July 27, 2015 to March 31, 2020)
Fatality[3]	0	0
Permanently Disabling Injury[4]	0	1[5]
Serious Incidents[6]	6	61
Lost Time Injuries[7]	4	30
All-Injury Incidents[8] (Lost Time Injuries[7] and Medical Attention requiring Treatment[9])	22	174

1.14.1 Please provide the data on a quarterly basis since inception of the Project.

RESPONSE:

This response answers BCUC Staff IRs 1.14.1, 1.14.1.1 and 1.14.2.

Table 1 provides updated Site C safety performance metrics through F2021 Q3 (December 31, 2020). This data includes a new confirmed lost time injury from F2020 Q4 (January 2020), as well as three lost time injury claims made in F2020 Q1.

Table 1 Total of Site C Safety Incident Metrics Since Project Inception (Updated)

	Incidents Since Inception July 27, 2015 to December 31, 2020
Fatality	**0**
Permanently Disabling Injury	**1**
Serious Incidents	**75**
Lost Time Injuries	**33**
All-Injury Incidents	**204**

Table 2 shows the number of serious incidents, lost time injuries and all injury incidents, by quarter, since the start of construction in July 2015. Serious incidents include injuries and near misses.

Note these metrics report different results and should be read independently as there is some duplication of injuries between the different metrics. For example, *injuries* from serious incidents and lost time are included in all injury metrics.

Following the data tables is some discussion on the trends and outliners in the data, followed by a graphic representation of the data as requested.

Table 2 Site C Safety Metrics by Quarter for Each Fiscal Year Since Start of Construction

	Fiscal 2016 April 2015 – March 2016				Fiscal 2017 April 2016 – March 2017				Fiscal 2018 April 2017 – March 2018			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Fatality	-	-	-	-	-	-	-	-	-	-	-	-
Permanently Disabling Injury	-	-	-	-	-	-	-	-	-	1	-	-
Serious Incidents	-	-	-	1	-	-	-	3	2	10	4	5
Lost Time Injuries	-	1	-	-	-	1	-	1	2	2	1	3
All Injury Incidents	-	2	3	3	3	4	1	6	3	10	8	8

	Fiscal 2019 April 2018 – March 2019				Fiscal 2020 April 2019 – March 2020				Fiscal 2021 April 2020 – March 2021			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Fatality	-	-	-	-	-	-	-	-	-	-	-	
Permanently Disabling Injury	-	-	-	-	-	-	-	-	-	-	-	
Serious Incidents	1	3	3	4	5	3	10	6	5	6	4	
Lost Time Injuries	4	2	2	1	3	1	1	5	3	-	1	
All-Injury Incidents	9	9	8	5	14	28	23	23	10	8	17	

<u>Trends and Outliers</u>

The following information is provided in response to BCUC Staff IR 1.14.2.

<u>Disabling Injury</u> – In June 2018, a worker received a permanent partial disability award from WorkSafeBC due to an incident in August 2017. The worker was attempting to unload a light tower from a flatbed truck. The worker stepped on the outrigger to reach the lifting attachment, lost their balance and fell about 7.5 feet. The worker fractured their elbow, permanently losing some strength in their arm.

<u>Serious Incidents</u> – Fiscal 2018, 2019, and 2020 have seen the most significant construction activity on the Project. On average during this period, the Project experienced 4.67 serious incidents per quarter, 59 per cent of which were near misses.

The F2018 Q2 outlier in serious incidents (10) correlates to the Main Civil Works contractor's mobilization of craft workers to site in the summer of 2016.

The F2020 Q3 outlier in serious incidents (10) relates to the multiple active work fronts and significant work hours on the two diversion tunnels, with a notable increase in safety incidents in December 2020.

<u>All Injury Incidents</u> – All Injury Incidents start increasing in late spring 2020 (F2020 Q1). At this time, the Main Civil Works contractor had a peak number of worker hours (focused on diversion activities), and the Generating Station & Spillways contractor was scaling up their workforce to support four major work segments (powerhouse, spillways, intakes and headworks).

The drop in all injury incidents starting in April 2020 (Q1 F21) is primarily due to the scaling back of the project to critical river diversion and essential work only, due to the necessary reductions in workers in the camp accommodation lodge caused by the COVID-19 pandemic.

<u>Lost Time Injuries</u> – there are two outlier periods in lost time injuries since the start of construction:

- **F2018 Q4 and F2019 Q1 – there were seven lost time injuries between February 28 and June 9, 2018.**
- **F2020 Q4 and F2021 Q1 – there were eight lost time injuries between January 11 and April 5, 2020.**

These lost time injuries correspond with the late winter, spring start up of the construction season during the last two seasons of high construction activity.

Graphic Representation of the Data

The following information is provided in response to BCUC Staff IR 1.14.1.1, which requested safety data in a graphic format.

Figure 1 Serious Incidents by Quarter Since Start of Construction

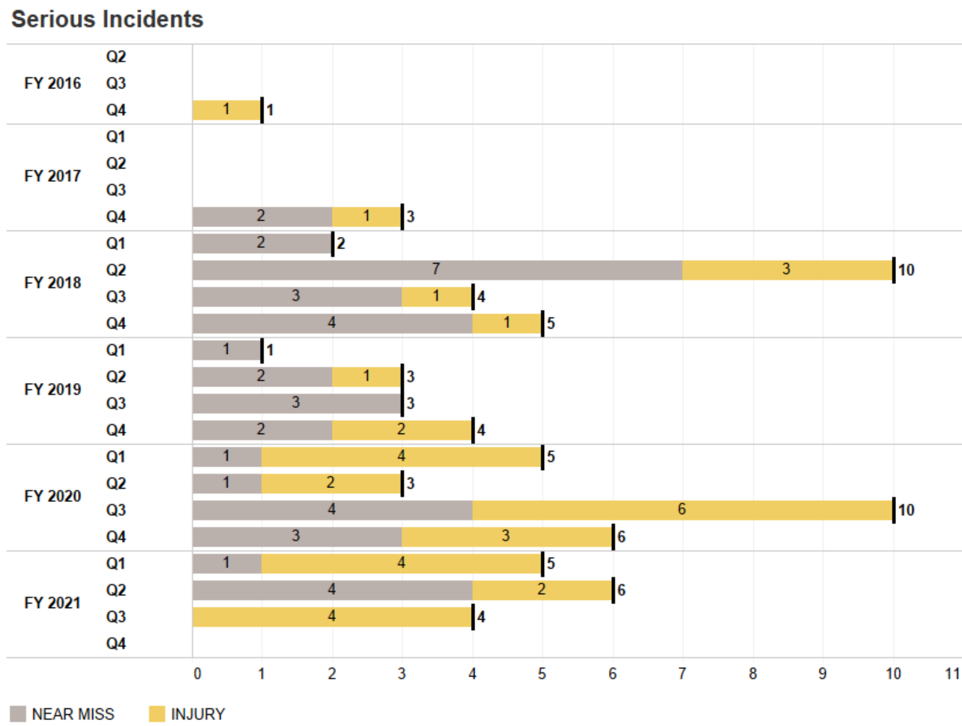


Figure 2 Lost Time Incidents by Quarter Since Start of Construction

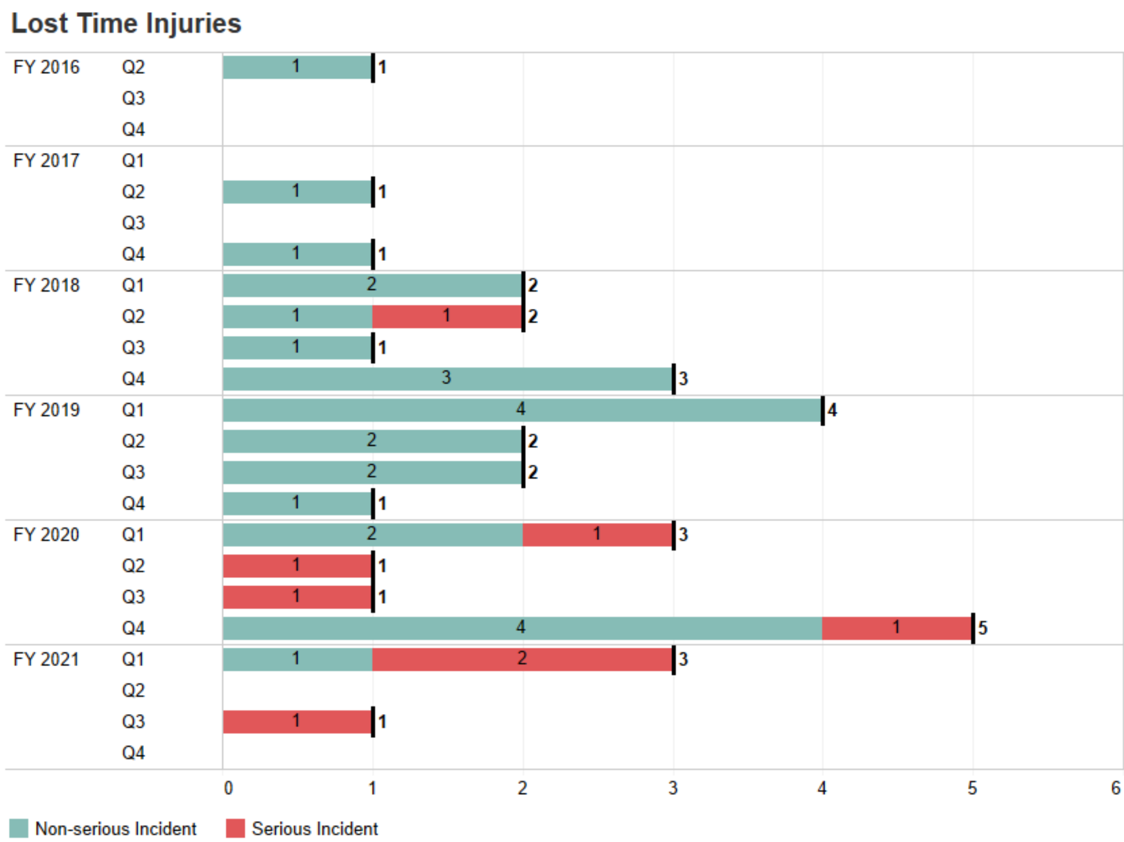
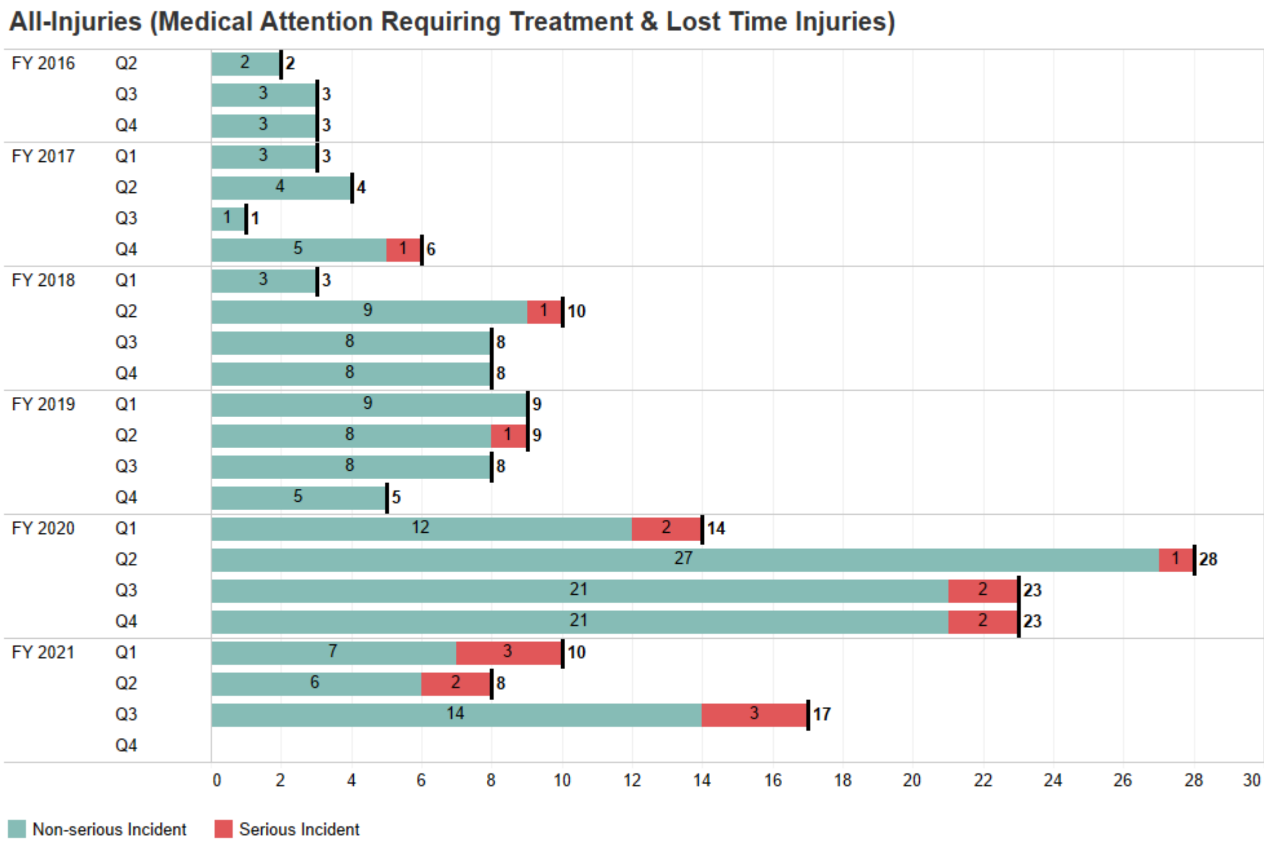


Figure 3 All Injury Frequency by Quarter Since Start of Construction



14.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 40
Summary of Site C safety and regulatory metrics

On page 40 of Quarterly Report No. 19, BC Hydro includes the following table:

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All-Injury Incidents[8] (Lost Time Injuries[7] and Medical Attention requiring Treatment[9])	22	174

1.14.1 Please provide the data on a quarterly basis since inception of the Project.

1.14.1.1 Please provide the data in graph format.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.14.1.

14.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, p. 40
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All-Injury Incidents[8] (Lost Time Injuries[7] and Medical Attention requiring Treatment[9])	22	174

1.14.2 Please identify and explain any trends or outliers that emerge from the data.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.14.1.

15.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, pp. 44–45
Safety regulatory inspections and orders

On page 44 of Quarterly Report No. 19, BC Hydro states:

> In early March 2020, the main civil works contractor received an administrative penalty from WorkSafeBC for the maximum allowed under regulation. This penalty was related to violations of Occupational Health and Safety Regulations identified in three WorkSafeBC inspections from January to August 2019. This is the third time this contractor has received an administrative penalty from WorkSafeBC. The penalty has been posted to WorkSafeBC's website.

1.15.1 Please explain what actions BC Hydro has taken in order to improve its contractors' adherence to safety regulations.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.13.3 for a summary of BC Hydro's actions to ensure a safe work environment for all Site C contractors.

Additionally, BC Hydro's concerns with respect to the contractor's safety performance, and adherence to regulations and expectations, were raised with the contractor's senior executive representatives.

The contractor undertook a systematic review of all high-risk work activities and worked on several safety management improvements, including:

1. **Hiring of additional Health and Safety resources to increase the focus on safety compliance in the field.**
2. **Delivering additional supervisor training for all frontline leaders and supervisors. Specifically, the contractor customized the BC Construction Safety Alliance (BCCSA) 'Leadership for Safety Excellence' training program to fit the scale and complexities of their work on the Project. BCCSA endorsed this customized training.**
3. **Making improvements to the contractor's safety programs (e.g., Electrical Safety, Energy Isolation, Excavation Safety). Safety Programs are now measured with leading performance indicators such as safety inspections by supervisors, field hazard assessments, etc.**

There has been a noticeable improvement in the contractor's safety performance metrics, with a decrease in the number and severity of safety incidents. On the WorkSafeBC compliance front, this contractor has achieved an 83 per cent 'clean sheet' rate on regulatory inspections for F2021 to date. A 'clean sheet' indicates WorkSafeBC Inspection Reports with no orders.

15.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, pp. 44–45
Safety regulatory inspections and orders

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1.15.2 Please describe the contractual requirements related to safety by which BC Hydro contractors are bound.

RESPONSE:

Please refer to BC Hydro's response to BCUC Staff IR 1.13.3 for a summary of contractor engagement models on the Project.

BC Hydro uses our Contractor Safety Program as a comprehensive system to manage and coordinate safety performance by contractors. Under this program, contract terms set with each contractor specify BC Hydro's requirement for full compliance with the B.C. Workers Compensation Act and WorkSafeBC Occupational Health and Safety Regulations, other Occupational Health and Safety legislation (provincial and federal), and BC Hydro policies, standards, practices and reporting.

BC Hydro safety requirements are typically documented in Schedule 10 of every executed contract for the Project. Schedule 10 includes, but is not limited to:

- **General Occupational Health and Safety Requirements – including safety areas, site safety coordination, construction safety officers, safety certification requirements, and more;**
- **Site Safety Management Plan – including safe work procedures, safety practice regulations, WorkSafeBC requirements, and more;**
- **Safety Requirements – including emergency response plan, first aid responsibilities, safety training, failure to comply;**

- **Safety Meetings – including compliance, attendance and documentation;**
- **Audits and Inspections – including access to contractor's work area, personnel and records, workplace safety audits, response to safety deficiencies, and more;**
- **Accidents and Incidents – including contractor reporting of safety incidents, regulatory orders and corrective actions;**
- **Public Safety – including Public Safety Management Plan;**
- **Hazardous Substances and Dangerous Goods – including site hazardous substances, contractor hazardous substances, hazardous substances procedures, dangerous goods, and respirable crystalline silica dust;**
- **Storage and Handling of Materials – including storage and containment facilities, workplace hazardous materials information system, combustible materials, flammable liquids, flammable and combustible gases, and more;**
- **Fire Safety – including fire safety program, annual fire risk management audit, fire prevention, wildfire prevention, hot work operations, fire protection, inspection and testing of fire protection and life safety systems, fire response and rescue services; and**
- **Specific to the Contractor and/or Work Requirements – specific safety considerations and requirements as identified during procurement.**

15.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, pp. 44–45
Safety regulatory inspections and orders

On page 44 of Quarterly Report No. 19, BC Hydro states:

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1.15.3 Please list the different worksites within the Project and identify the prime contractor for each.

RESPONSE:

The public version of this response has been redacted to maintain confidentiality over sensitive information. The un-redacted version of the response is being made available to the BCUC only.

WorkSafeBC Regulations require a designated Prime Contractor for each safety area. Major Project worksites and Prime Contractor responsibilities (on dam-site and off dam-site) as of November 30, 2020 include:

- **Reservoir Clearing Left Bank – [redacted];**
- **Reservoir Clearing Right Bank – [redacted];**
- **Reservoir Clearing Halfway River Drainage – [redacted];**
- **Hudson Hope Shoreline Protection – Cantex Okanagan Construction Ltd.;**
- **Security Perimeter, Joint Use Warehouse, and Peace River Debris Booms – BC Hydro;**
- **Transmission Lines (500kV and 138kV) – Allteck Line Contractors Inc.;**
- **Southbank Substation – BC Hydro (complete and operational);**
- **Worker Accommodation – ATCO Two Rivers Lodging Group LP;**

- **Main Civil Works: Overall 'On Dam-Site' Footprint including roadworks and river crossings – Peace River Hydro Partners (PRHP);**
- **Main Civil Works: Diversion and drainage tunnels/adits, generating unit approach channel, Moberly River debris boom, Peace River downstream debris boom, aggregate and conventional concrete production (crusher sites), excavation work sites, dam construction site, roller-compacted buttress, and care of water activities – PRHP;**
- **Generating Station & Spillway Civil Works: Moberly River debris piles, fabrication shop, aggregate and conventional concrete production (crusher sites) – Aecon-Flatiron-Dragados-EBC Partnership (AFDE);**
- **Right Bank Cofferdam Area (RBCA): Powerhouse, Powerhouse Intakes, Spillways, Headworks, Right Bank Foundation, access routes into the RBCA, offices and laydown areas for powerhouse contactors – BC Hydro; and**
- **Peace River Upstream Boom – BC Hydro.**

Where safety oversight is subject to the *Mines Act*, the regulation calls for a mine manager role, not a prime contractor role. The three quarries used by the Project fall under this mandate and mine manager accountabilities are as follows:

- **West Pine Quarry and Wuthrich Quarry – PRHP; and**
- **Portage Mountain Quarry – [redacted].**

The Highway 29 Realignment construction work packages are all managed by the Ministry of Transportation and Infrastructure, with various safety areas assigned to Eiffage/Infracon, Kingston, Flatiron, Thompson Brothers, and Formula.

15.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, pp. 44–45
Safety regulatory inspections and orders

On page 44 of Quarterly Report No. 19, BC Hydro states:

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1.15.4 Since the commencement of the Project, please detail all administrative penalties issued, both for safety and non-safety related instances, and identify the party responsible for penalty.

RESPONSE:

To date, there have been three administrative penalties issued by WorkSafeBC related to work on the Project. All have been issued to the main civil works contractor and are as follows:

1. **May 2017 – penalty of $310,340 issued for not having a complete exposure control plan in place to appropriately protect workers from exposure to crystalline silica, prior to initiation of tunneling work on the diversion tunnels.**
2. **August 2019 – penalty of $662,102 issued for failure to effectively isolate and control hazardous energy sources, which had resulted in an electrical contact incident.**
3. **March 2020 – penalty of $662,102 issued for multiple orders resulting from three WorkSafeBC inspections from January to August 2019. These orders covered construction road berms, inadequate ventilation, and labeling/storage of hazardous chemicals.**

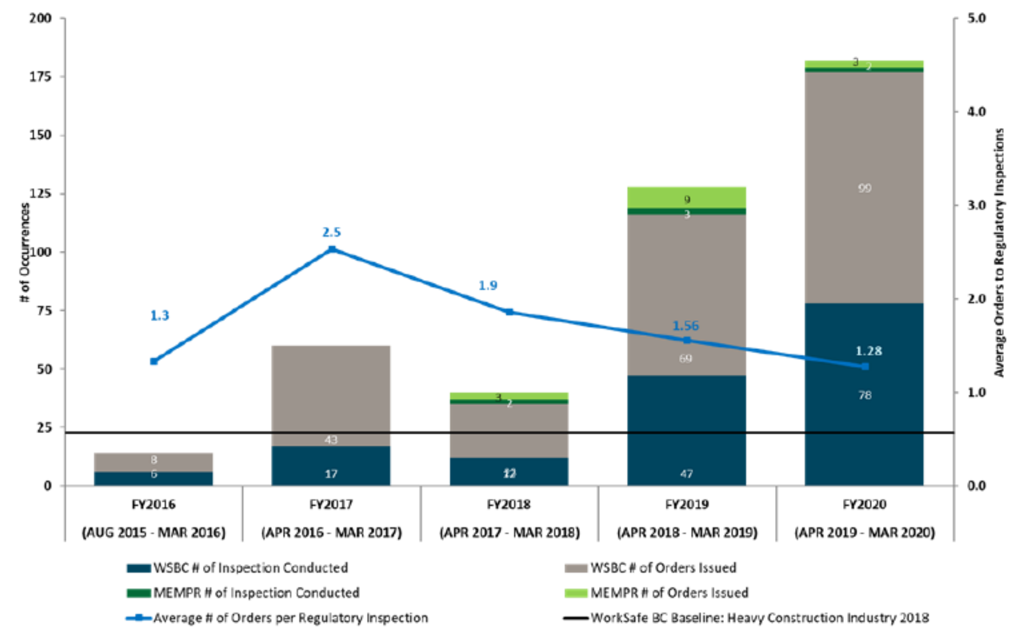
BC Hydro is not aware of any other administrative penalties on the Site C Project.

15.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Quarterly Report No. 19, Section 1.2, pp. 44–45
Safety regulatory inspections and orders

On page 45, BC Hydro provides Figure 2, Number of Orders to Regulatory Inspections, 2015 to 2018. Figure 2 is reproduced below.

Figure 2 Number of Orders to Regulatory Inspections, 2015 to 2018



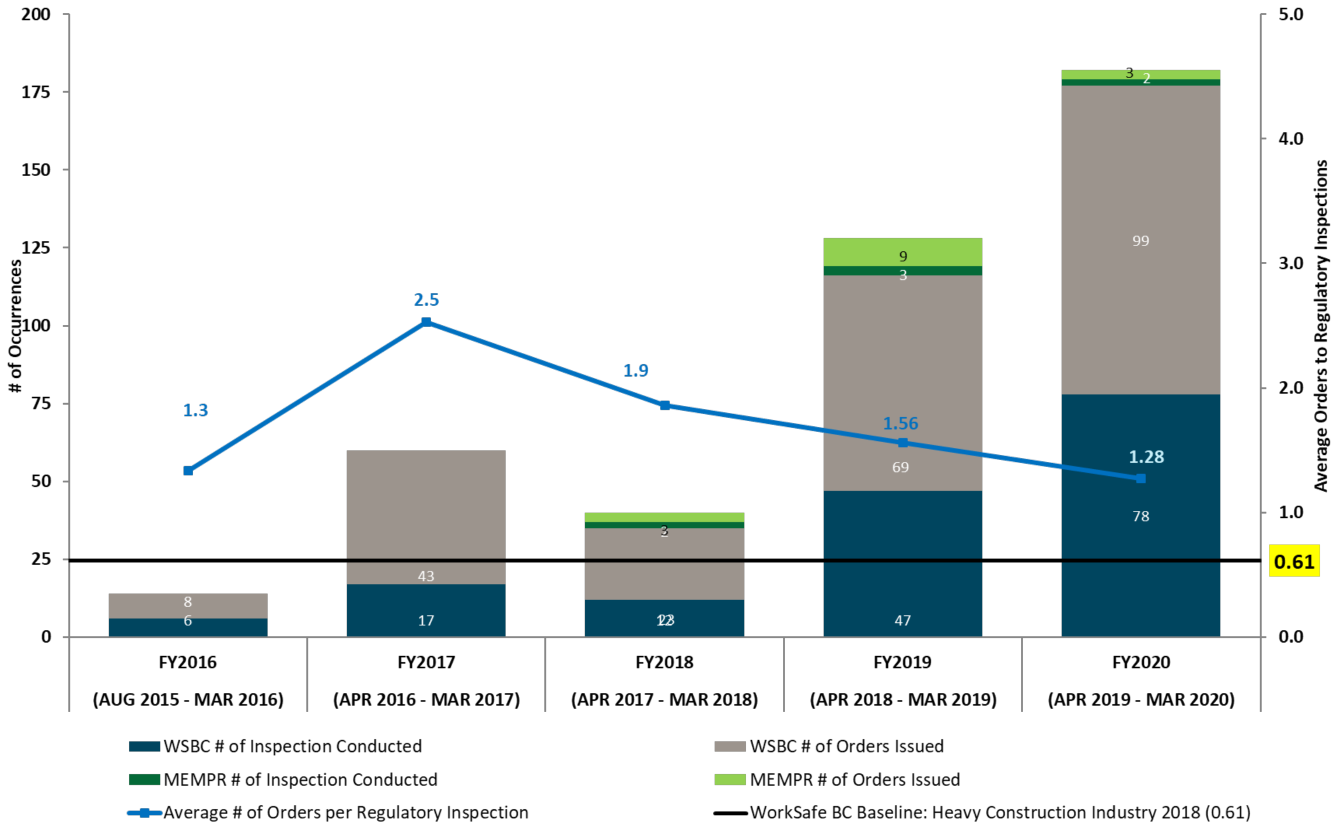
1.15.5 Please provide a reference for the WorkSafeBC Baseline: Heavy Construction Industry 2018 data.

RESPONSE:

BC Hydro's use of WorkSafeBC (WSBC) province-wide safety statistics to derive relevant safety comparators is described in the response to BCUC Staff IR 1.16.1.

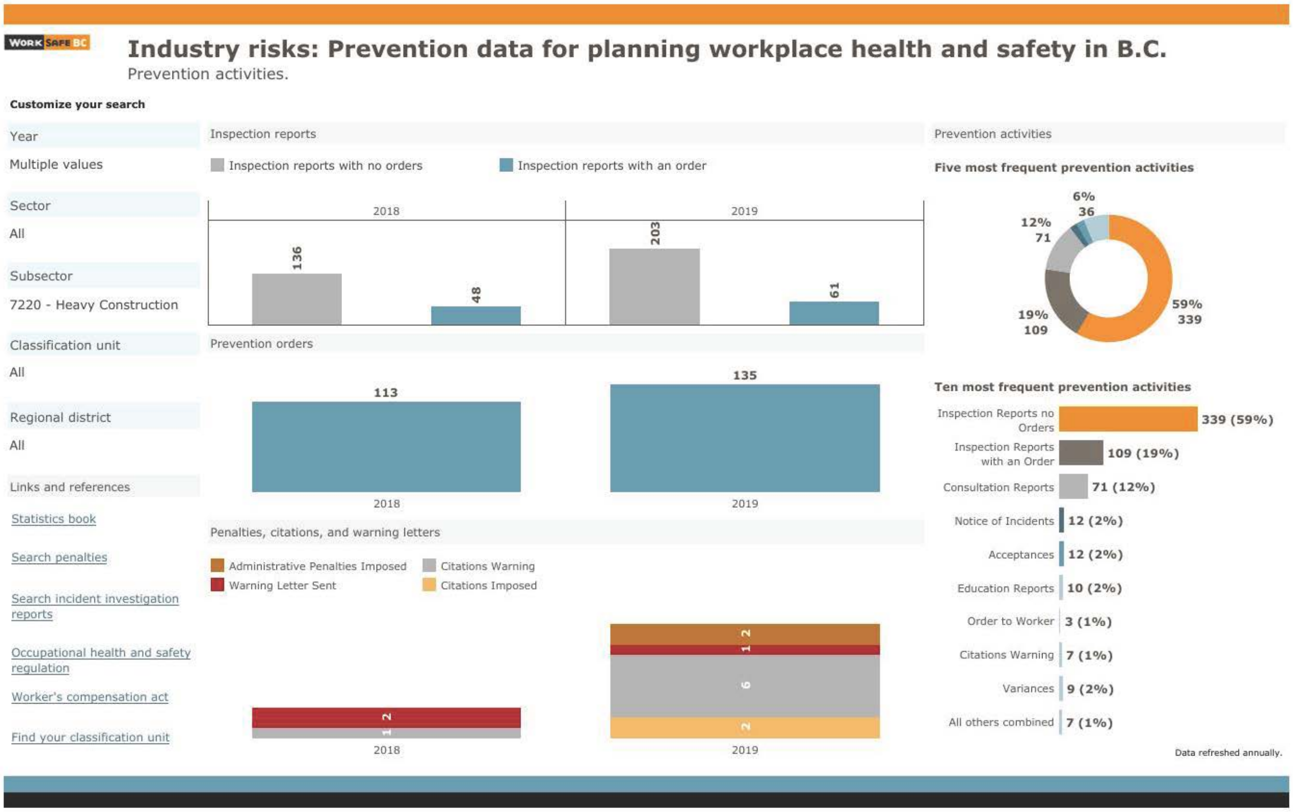
BC Hydro created the WorkSafeBC Baseline: Heavy Construction Industry 2018 reference line in the chart as a comparator representing *WorkSafeBC Number of Orders per Regulatory Inspection* from applicable statistical data. The metric is used by BC Hydro to assess the ongoing regulatory performance of the Project.

The value for this WSBC baseline metric was inadvertently left off Figure 2; it is 0.61 for Heavy Construction in 2018 and is shown in the graph below.



As shown in the graphic below, WSBC publishes their data regarding regulatory inspection reports and orders on their website at [WorkSafeBC Industry Risk: Prevention Data for planning workplace health and safety in B.C](). From this main page, access the tab titled "Prevention activities". Then go to the "Subsector" field in "Customize your search" and select Heavy Construction Industry to view the data.

In 2018, WSBC issued 184 inspection reports (136 with no orders and 48 with orders) and a total of 113 regulatory orders for the Heavy Construction subsector. The calculation of regulatory orders divided by inspection reports results in the 0.61 WSBC baseline result.



Industry risks: Prevention data for planning workplace health and safety in B.C.
Prevention activities.
Customize your search
Year
Multiple values
Sector
All
Subsector
7220 - Heavy Construction
Classification unit
All
Regional district
All
Links and references
Statistics book
Search penalties
Search incident investigation reports
Occupational health and safety regulation
Worker's compensation act
Find your classification unit
Inspection reports
Inspection reports with no orders
Inspection reports with an order
2018
2019
136
48
203
61
Prevention orders
113
135
2018
2019
Penalties, citations, and warning letters
Administrative Penalties Imposed
Citations Warning
Warning Letter Sent
Citations Imposed
2018
2019
Prevention activities
Five most frequent prevention activities
6% 36
12% 71
19% 109
59% 339
Ten most frequent prevention activities
Inspection Reports no Orders 339 (59%)
Inspection Reports with an Order 109 (19%)
Consultation Reports 71 (12%)
Notice of Incidents 12 (2%)
Acceptances 12 (2%)
Education Reports 10 (2%)
Order to Worker 3 (1%)
Citations Warning 7 (1%)
Variances 9 (2%)
All others combined 7 (1%)
Data refreshed annually.

16.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Annual Report No. 4, Section 3.3, p. 46
Safety and regulatory metrics

On page 46 of Annual Report No. 4, BC Hydro provides the following table:

Table 3 Summary of Site C Safety and Regulatory Metrics

	Reported for Quarter October 1, 2018 to December 31, 2018[1]	Reported for Quarter October 1, 2019 to December 31, 2019[1]	Reported for 2018 (January to December)[1]	Reported for 2019 (January to December)[1]	Reported Since Inception (July 27, 2015 to December 31, 2019)[1]
Fatality[2]	0	0	0	0	0
Permanently Disabling Injury[3]	0	0	0	0	1[4]
Serious Incidents[5]	3	10	12	22	54
Lost Time Injuries[6]	2	1	11	6	25
All-Injury Incidents[7] (Lost Time Injuries[6] and Medical Attention requiring Treatment[8])	8	23	34	70	147
Regulatory Inspections	12	15	41	84	156
Regulatory Orders	16	26	65	125	250

Reference: Safety and Security
Annual Report No. 4, Section 3.3, pp. 47–48
Safety performance frequency metrics

On page 47 of Annual Report No. 4, BC Hydro provides a summary of safety performance frequency metrics:

Table 4 Summary of Safety Performance Frequency Metrics

	Fiscal 2019 April 2018 – March 2019 (Rolling 12-Month Average)				Fiscal 2020 April 2019 – March 2020 (Rolling 12-Month Average)			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Serious Incident Frequency	0.95	0.56	0.44	0.36	0.43	0.39	0.53	n/a
Lost Time Injury Frequency	0.48	0.43	0.40	0.29	0.23	0.18	0.14	n/a
All Injury Frequency	1.67	1.47	1.25	1.01	1.03	1.43	1.68	n/a

Fiscal 2020 Q4 will be updated when information is available.

Further on pages 47 to 48, BC Hydro states:

> WorkSafeBC, under the authority of the *Worker's Compensation Act*, is the primary regulator with jurisdiction over safety for the Project. WorkSafeBC oversees all worker safety (employee and contractor) for the Project, both on the dam site and off the dam site. The Ministry of Energy, Mines and Petroleum Resources is the regulatory authority for worker safety on any work fronts subject to the *Mines Act*, specifically West Pine Quarry, Portage Mountain Quarry, and Wuthrich Quarry.

On page 47 of Annual Report No. 4, BC Hydro states:

> Although the Project has seen some decline in safety performance measures in 2019, Project results continue to significantly outperform WorkSafeBC's safety performance comparators in the heavy construction and forestry industries.

1.16.1 Please provide WorkSafeBC's safety performance comparators in the heavy construction and forestry industries. Please provide a reference for all comparators.

RESPONSE:

The safety performance comparators, as referenced in Annual Report No. 4, are derived from statistical data available from WorkSafeBC (WSBC) on workplace injuries under the category of Construction and specific to the Forestry and Heavy Construction Industries. As WSBC does not compile data in a way that directly maps to BC Hydro's standard safety metrics, BC Hydro uses WSBC statistical information, in consultation with WSBC's Statistical Services, Business Intelligence & Analytics Department, to create applicable WSBC safety performance comparators for the Site C Project.

For example, to benchmark BC Hydro's All Injury Frequency (AIF) metric, a comparator was derived using WSBC's statistics for health-care only claims, time-lost claims and number of person years data.

BC Hydro updates comparators for the Project when new WSBC statistical information is made available and depending on the nature of the work at that time. Comparators were last updated in 2019, using WSBC's Heavy Construction statistics as the most relevant baseline for monitoring Site C safety trends.

WSBC publishes information regarding time-loss claims and injury management trends, patterns and statistics on their Provincial Overview interactive website. From this Provincial Overview page, access the tab titled "CU profile", then go to the "Subsector" search field in "Customize your search" and select Heavy Construction to view the data.

‹ WorkSafeBC - Profile ☆ Favorite

Did you know? | Insurance | Injury rate | Injury management | Counts | Costs | CU profile | Industry claims analysis: Counts | Industry claims analysis: Costs | Definitions

WORK SAFE BC

Provincial overview

An interactive tool that lets you view time-loss claims and injury management trends, patterns and statistics to improve workplace health and safety.

Key statistics, 2010 to 2019

2.3 injury rate (average)

0.3 serious injury rate (average)

56 complete duration days (average)

23% high duration claims

81% return to work in less than 26 weeks

1,413 accepted work-related deaths

2,502,117 work days lost in a year (average)

$954,802,160 claim costs paid in a year (average)

This solution gets refreshed on monthly basis

Data as of: November 30, 2020

WORK SAFE BC

CU profile (2010 to 2019)

Customize your search

Year

All

Selection

Industry classification

Subsector

Subsector

7220 - Heavy Constru..

Employer size

All

Selection
Subsector: 7220 - Heavy Construction
Employer size: All

Year: All

Injury prevention

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
# Time-loss claims	91	97	105	110	101	80	86	89	95	95
# Person years*	2,655	2,760	2,923	3,267	3,066	2,721	2,762	2,766	3,096	4,242
Injury rate	3.4	3.5	3.6	3.4	3.3	2.9	3.1	3.2	3.1	2.2
# Inspection reports	398	364	269	311	312	249	197	164	164	232
# Other contacts	112	109	104	116	66	64	39	35	46	56
# Orders	321	274	192	171	150	117	102	114	102	114
# Net penalties imposed	2	0	0	1	1	1	3	0	0	1
# Warning letters sent	3	7	2	2	1	1	1	2	0	0

Injury recovery

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Six-month truncated duration	36.46	52.41	46.14	44.64	38.52	48.41	31.42	42.83	47.53	46.88
# RTW (<= 4 weeks)**		48.00	54.00	55.00	54.00	43.00	55.00	44.00	48.00	39.00
# RTW (<= 26 weeks)**		78.00	82.00	88.00	91.00	68.00	85.00	80.00	82.00	78.00
# RTW (26+ weeks)**		13.00	19.00	18.00	29.00	11.00	14.00	14.00	14.00	14.00

Claim summary

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
# Time-loss claims	91	97	105	110	101	80	86	89	95	95
# Work-related deaths	1			1	1	1	1	3	1	2
# First-paid LTD claims	30	26	39	31	31	19	31	17	25	17
# Serious injury claims	21	23	29	21	22	22	18	30	20	25
% Serious injury claims	23%	24%	28%	19%	22%	28%	21%	34%	21%	26%
Serious injury rate	0.8	0.8	1.0	0.6	0.7	0.8	0.7	1.1	0.6	0.6
# Sprains and strains claims	42	47	47	52	49	32	33	26	43	40
# Long recovery sprains and strains claims	10	16	21	16	17	5	5	8	16	14
% of sprains and strains (SS) that are long recovery	24%	34%	45%	31%	35%	16%	15%	31%	37%	35%
Long recovery sprains and strains rate	0.4	0.6	0.7	0.5	0.6	0.2	0.2	0.3	0.5	0.3
# STD/LTD/Fatal claims	111	104	114	117	108	85	103	89	100	99
# Young worker claims	16	17	11	12	13	13	15	15	13	15
# Mature worker claims	15	10	27	19	17	10	20	9	24	26
# Ergonomic claims	30	28	30	33	29	31	18	13	24	29
# MVI claims	0	0	0	0	0	0	0	0	0	0
Average complete duration	166	94	107	85	78	80	102	101	95	109
% High duration claims	43%	31%	39%	29%	24%	20%	33%	35%	22%	38%
Total work days lost	8,705	8,392	7,532	7,666	7,156	4,845	6,395	5,760	6,159	7,728
Claim costs paid	$4,421,255	$6,990,031	$6,900,365	$5,819,285	$6,664,842	$4,232,707	$4,178,730	$4,929,756	$5,320,583	$5,445,806

Insurance

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
# Employer-CUs	228	231	238	266	265	282	282	293	301	331
Assessable payroll	$136M	$155M	$154M	$181M	$177M	$159M	$160M	$165M	$184M	$249M
Assessment amount	$8M	$10M	$9M	$11M	$10M	$9M	$9M	$9M	$9M	$11M

*For fishing subsector, # Person years will not be displayed. **Return-to-work data prior to 2011 is not measured.

Table 1 below shows Project safety metrics for both 2018 and 2019 in reference to applicable comparators derived from WSBC's statistics for Heavy Construction.

Table 1 WorkSafeBC (Heavy Construction) and Project Safety Metrics for 2018 and 2019

	Calendar Year 2018		Calendar Year 2019	
	WorkSafeBC Heavy Construction	Site C	WorkSafeBC Heavy Construction	Site C
Serious Incident Frequency	N/A	0.44	N/A	0.53
Lost Time Injury Frequency	3.1	0.40	2.2	0.14
All Injury Frequency	8.5	1.25	6.9	1.68

Note: Key safety metrics are reported as a frequency to account for variances in labour hours worked.

Although the Project has seen some decline in safety performance measures in 2019, the safety results continue to outperform WorkSafeBC derived comparators.

For the metric Serious Incident Frequency, BC Hydro could not derive an applicable comparator from WorkSafeBC statistical data. The 'serious injury rate' shown on WorkSafeBC's Provincial Overview page reflects only lost time injury claims related to serious injuries. BC Hydro's Serious Incident Frequency metric includes all serious injuries and serious near misses regardless of whether there was a lost time claim.

16.0 D. SAFETY AND SECURITY

Reference: SAFETY AND SECURITY
Annual Report No. 4, Section 3.3, p. 46
Safety and regulatory metrics

On page 46 of Annual Report No. 4, BC Hydro provides the following table:

Table 3 Summary of Site C Safety and Regulatory Metrics

	Reported for Quarter October 1, 2018 to December 31, 2018[1]	Reported for Quarter October 1, 2019 to December 31, 2019[1]	Reported for 2018 (January to December)[1]	Reported for 2019 (January to December)[1]	Reported Since Inception (July 27, 2015 to December 31, 2019)[1]
Fatality[2]	0	0	0	0	0
Permanently Disabling Injury[3]	0	0	0	0	1[4]
Serious Incidents[5]	3	10	12	22	54
Lost Time Injuries[6]	2	1	11	6	25
All-Injury Incidents[7] (Lost Time Injuries[6] and Medical Attention requiring Treatment[8])	8	23	34	70	147
Regulatory Inspections	12	15	41	84	156
Regulatory Orders	16	26	65	125	250

Reference: Safety and Security
Annual Report No. 4, Section 3.3, pp. 47–48
Safety performance frequency metrics

On page 47 of Annual Report No. 4, BC Hydro provides a summary of safety performance frequency metrics:

Table 4 Summary of Safety Performance Frequency Metrics

	Fiscal 2019 April 2018 – March 2019 (Rolling 12-Month Average)				Fiscal 2020 April 2019 – March 2020 (Rolling 12-Month Average)			
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Serious Incident Frequency	0.95	0.56	0.44	0.36	0.43	0.39	0.53	n/a
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All Injury Frequency	1.67	1.47	1.25	1.01	1.03	1.43	1.68	n/a

Fiscal 2020 Q4 will be updated when information is available.

Further on pages 47 to 48, BC Hydro states:

> WorkSafeBC, under the authority of the *Worker's Compensation Act*, is the primary regulator with jurisdiction over safety for the Project. WorkSafeBC

> oversees all worker safety (employee and contractor) for the Project, both on the dam site and off the dam site. The Ministry of Energy, Mines and Petroleum Resources is the regulatory authority for worker safety on any work fronts subject to the *Mines Act*, specifically West Pine Quarry, Portage Mountain Quarry, and Wuthrich Quarry.

On page 47 of Annual Report No. 4, BC Hydro states:

> Although the Project has seen some decline in safety performance measures in 2019, Project results continue to significantly outperform WorkSafeBC's safety performance comparators in the heavy construction and forestry industries.

1.16.2 Please compare the safety performance measures for the West Pine Quarry, Portage Mountain Quarry and the Wuthrich Quarry against any safety performance comparators provided by the Ministry of Energy, Mines and Petroleum Resources. Please provide a reference for all comparators.

RESPONSE:

All 2018 and 2019 key safety performance metrics (Serious Incident Frequency, Lost Time Injury Frequency and All Injury Frequency) are at 0.0 for the West Pine, Wuthrich, and Portage Mountain Quarries. Given this strong safety performance, BC Hydro has not investigated safety performance comparators that would be available from the Ministry of Energy, Mines and Petroleum Resources.

The Ministry of Energy, Mines and Petroleum Resources published injury rates for quarries and mines in their Annual Report of the Chief Inspector of Mines 2018. Below is an excerpt from this report (page 13).

> The table in Figure 2 outlines the injury rates for the mining industry over the past 10 years; the unit for injury rates is the number of claims per 100 person-years of employment. Note that rates may be adjusted on an ongoing basis to match new and ongoing claims data.

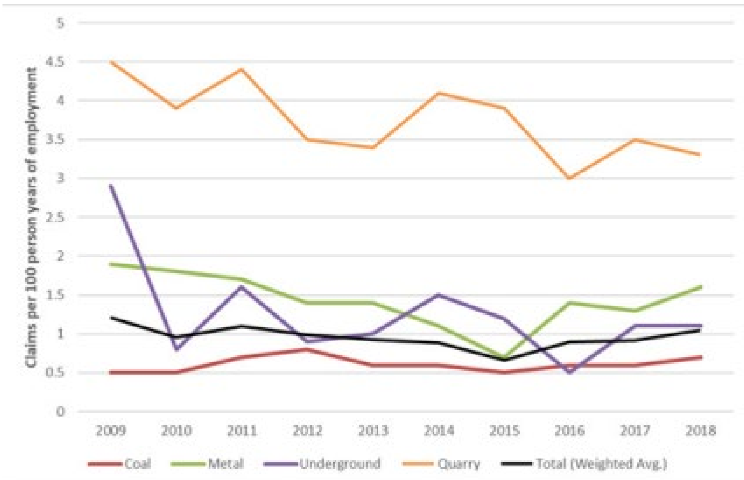


Figure 2: Injury Rates for Quarries, Open-Pit Coal, Open-Pit Metal, and Underground Mines in British Columbia, 2009–2018

17.0 E. QUALITY MANAGEMENT

Reference: QUALITY MANAGEMENT
Quarterly Report No. 19, Section 1.1.3, pp. 36, 40; Annual Report No. 4, Section 3.2.3, pp. 38–39
Nonconformity report Metrics

On page 40 of Quarterly Report No. 19, BC Hydro attaches the following table:

Table 2 Quality Management Nonconformity Report Metrics Reporting Period – January 2019 to December 2019

Contract	Reported October 1, 2019 to December 31, 2019	Closed October 1, 2019 to December 31, 2019	Reported January 1, 2019 to December 31, 2019	Closed January 1, 2019 to December 31, 2019	Reported to Date	Closed to Date	Open as of December 31, 2019
Main Civil Works	227	93	405	256	1,481	1300	181
Turbines and Generators	37	19	98	55	126	67	59
Generating Station and Spillways Civil Works	64	38	255	207	308	257	51
Large Cranes	6	6	8	8	17	17	0
Hydromechanical Equipment	6	6	8	8	8	8	0
Transmission	6	4	35	24	102	88	14

On pages 38 to 39 of Annual Report No. 4, BC Hydro states:

> The Project has a quality management plan that outlines activities to ensure materials, equipment and the constructed works meet contract quality requirements…
>
> Following BC Hydro's internal assessment of quality practices across the Project in 2018, the Project team embarked on several key activities in 2019 to support the recommendations in the internal assessment report including: 1) updating the Project Quality Plan and its supporting plans; 2) re-establishing the quality audit program for site works; 3) hiring of a deputy quality manager dedicated to the generating station and civil works; 4) provision of training to site personnel on the Project's quality management system; and 5) continuing with monthly Quality Performance Indicator assessments for the engineering, manufacturing and construction activities across each sub-project.

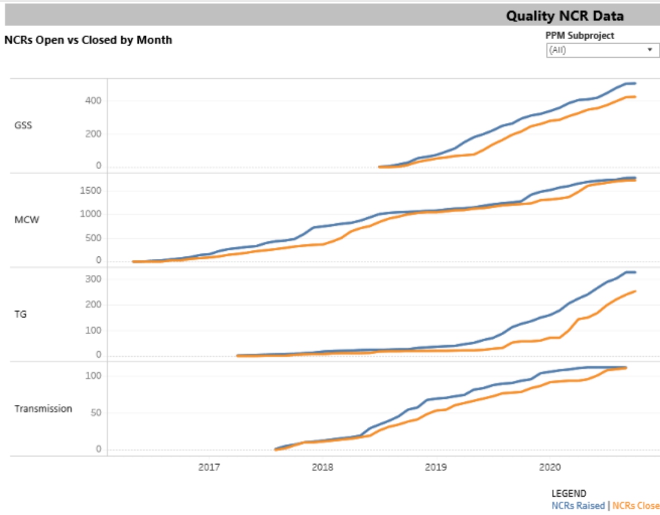
1.17.1 Please discuss the impact the implementation of the key activities identified in the preamble above has had on the number of quality management nonconformity instances in 2019 and 2020, compared to 2015 to 2018. Please provide data to support your response.

RESPONSE:

The number of nonconformity instances between the 2015 to 2018 and 2019 to 2020 time periods is not comparable as there was an increase in the number of contractors, work fronts and complexity of activities between the two time periods.

BC Hydro views a reported nonconformity as an opportunity: 1) for affected parties to learn from; and 2) to formally document a deficiency and track it until the disposition for corrective action is agreed upon. To facilitate this, the Project team actively encourages the reporting of nonconformities during the course of the work. While the total number of nonconformities is an important indicator, BC Hydro is more concerned about the nature of each nonconformity and the frequency of occurrence of nonconformities within specific work fronts, as these are good indicators of whether the Project's quality objectives are at risk.

Quality NCR Data



	Total NCRs to Date	Open NCRs	Closed NCRs	% Closed NCRs	New NCRs Previous Month	Data Last Refreshed
GSS	502	81	421	84%	25	October 7, 2020
MCW	1,775	51	1,722	97%	34	October 9, 2020
TG	325	73	252	78%	24	October 8, 2020
Transmission	111	1	110	99%	0	September 16, 2020

The figure above illustrates the cumulative number of nonconformity reports (NCRs) raised on each major contract since the start of construction and manufacturing. BC Hydro believes that the data supports the conclusion that the implementation of the key activities described in the question has been beneficial.

For example, on the Main Civil Works contract during the 2017 to 2018 time period, there was a significant gap in the number of NCRs raised versus the number of NCRs closed. Following implementation of the key activities, the team was able to catch up and significantly decrease the number of open NCRs. During 2019 to 2020, when a significant number of NCRs were raised during the diversion tunnel construction, the resources were in place to close them out in a timely manner. On the Generating Station and Spillways (GSS) contract, as the

number of work fronts and complexity of work increased during the 2019 to 2020 time period, implementation of the key activities has ensured that BC Hydro has the appropriate number of trained and qualified people in place to identify nonconformities as the work progresses and to close them out once the disposition has been accepted and the corrective action implemented. Note that due to the complexity of the GSS civil works and the complexity of some of the NCRs, it can sometimes take significant periods of time (months) before an agreement is reached on the corrective action and then for the contractor to actually implement it. Hence the gap that appears in the GSS graph above between NCRs raised and NCRs closed.

17.0 E. QUALITY MANAGEMENT

Reference: QUALITY MANAGEMENT
Quarterly Report No. 19, Section 1.1.3, pp. 36, 40; Annual Report No. 4, Section 3.2.3, pp. 38–39
Nonconformity report Metrics

On page 36 of Quarterly Report No. 19, BC Hydro states:

> As a consequence of the COVID-19 pandemic, BC Hydro's ability to travel nationally and internationally to participate in equipment inspections and final acceptance tests has been restricted. BC Hydro is meeting with equipment suppliers and quality assurance partners on a weekly basis to plan upcoming inspections and to coordinate local third-party representation to ensure quality requirements are satisfied prior to components being shipped.

1.17.2 Please discuss whether BC Hydro has seen an increase in instances of nonconformances with respect to components manufactured nationally and internationally since travel was suspended.

RESPONSE:

BC Hydro has not seen an increase in the instances of nonconformances that are attributable to our inability to travel nationally and internationally.

The increase in the instances of nonconformances is attributable to the progression of manufacturing work and the multitude of equipment being manufactured across the major contracts (Turbines and Generators, Hydromechanical Equipment, Large Cranes). Working with our local quality assurance inspectors from Englobe and SGS Canada, and our manufacturing contractors, we continue our standard process of identifying, raising and disposing of nonconformities.

For specialised tests and inspections requiring direct BC Hydro input, we work with Englobe, SGS Canada and our contractors to leverage technology to facilitate 'virtual' participation in these interventions.

17.0 E. QUALITY MANAGEMENT

Reference: QUALITY MANAGEMENT
Quarterly Report No. 19, Section 1.1.3, pp. 36, 40; Annual Report No. 4, Section 3.2.3, pp. 38–39
Nonconformity report Metrics

Further on page 40 of Quarterly Report No. 19, BC Hydro stated the following:

> During 2019, the quality of the roller-compacted concrete placed by the main civil works contractor on the right bank was good. On the left bank, the contractor raised a series of nonconformity reports to address the field observations made on the diversion tunnel concrete linings during the summer and fall of 2019. BC Hydro and the contractor will be collaborating to close these nonconformity reports in 2020. BC Hydro and the contractor continue to meet weekly to discuss and resolve open nonconformity reports, and quality steering committee meetings continue to be held to discuss broader topics related to the contractor's quality performance. BC Hydro will be working with the contractor in 2020 to assess operational readiness of its on-site materials testing laboratory in advance of the commencement of materials processing for the main dam.

1.17.3 Please explain the difference in the number of non-conformity reports for the Main Civil Works for this quarter, from the previous quarter, as reported in the Site C Quarterly Progress Report No. 17.

RESPONSE:

The increase in the number of nonconformity reports between those reported in Quarterly Progress Report No. 17 (71) and those reported in Quarterly Progress Report No. 18 (227) is attributable to the approach taken to place the concrete linings in the two diversion tunnels. In accordance with standard practice for this work, the linings were placed segment-by-segment over the length of each tunnel. Once the concrete for a segment section had set, the slip form was moved progressively downstream in the tunnel so that production could continue. As the slip form was moved progressively downstream in the tunnel, this provided space for a concrete patch/repair crew to follow and implement repairs to the completed segments as required.

BC Hydro used a strict approach for tracking nonconformities on each lining segment, of which there were approximately 120 segments in total. Nonconformities were resolved and closed-out with the Professional of Record prior to the tunnels being put into service.

17.0 E. QUALITY MANAGEMENT

Reference: QUALITY MANAGEMENT
Quarterly Report No. 19, Section 1.1.3, pp. 36, 40; Annual Report No. 4, Section 3.2.3, pp. 38–39
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1.17.4 Please describe the nonconformities on the concrete linings of the diversion tunnel and explain their causes.

RESPONSE:

The nonconformities in the concrete liners were mostly related to cracks in the concrete, roughened surface finish, and areas of low reinforcing bar coverage.

As described in the response to BCUC Staff IR 1.17.3, the linings were placed segment-by-segment. Once the concrete for a segment section had set, the slip form was moved progressively downstream in the tunnel. The slip form is a complex, moveable, cylindrical structure (~12 m length x ~10.5 m diameter). Making concrete placements and advancing the formwork to maintain production is a challenging process and contributed to the occurrence of the nonconformities. The cracks were caused by the cooling process in the concrete. The roughened surfaces were related to the consistency of the concrete and the challenging access to the vibrating ports on the slip form. The areas of low reinforcing bar coverage would have been caused by small movements (either laterally or vertically) of the slip form in the excavated tunnel during the placement of a concrete segment.

The nonconformities were resolved prior to the tunnels being put into service.

17.0 E. QUALITY MANAGEMENT

Reference: QUALITY MANAGEMENT
Quarterly Report No. 19, Section 1.1.3, pp. 36, 40; Annual Report No. 4, Section 3.2.3, pp. 38–39
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1.17.5 Please elaborate on the contractor issues that have contributed the increase in non-conformity reports for the main civil works

RESPONSE:

Please also refer to BC Hydro's response to BCUC Staff IRs 1.17.3 and 1.17.4 for further details.

The increase in nonconformity reports for the main civil works was related to the diversion tunnel construction.

17.0 E. QUALITY MANAGEMENT

Reference: QUALITY MANAGEMENT
Quarterly Report No. 19, Section 1.1.3, pp. 36, 40; Annual Report No. 4, Section 3.2.3, pp. 38–39
Nonconformity report Metrics

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1.17.5 Please elaborate on the contractor issues that have contributed the increase in non-conformity reports for the main civil works

1.17.5.1 Please explain what remedial actions are being taken with the contractor to reduce future non-conformities.

RESPONSE:

With the start of cofferdam construction in 2020 and main dam construction in 2021, there will be a significant amount of contractor activity related to processing, placement and testing of earth fill dam materials. To reduce future nonconformities, the contractor has:

1. **Obtained Canadian Council of Independent Laboratories re-certification of its onsite materials testing laboratory;**
2. **Allowed BC Hydro to audit its onsite materials testing laboratory to assess their processes and operational readiness; and**
3. **Collaborated with BC Hydro to perform independent testing of materials placed in the cofferdam to compare field-testing methods and results.**

In addition to the above, the contractor performs an ongoing assessment of its quality assurance and quality control resources to align its workforce with the number of activities underway. The contractor's quality management team continues to meet with BC Hydro on a weekly basis to discuss quality topics and resolve quality issues.