

3.5 DAM SAFETY QUARTERLY REPORT

Executive Summary

The purpose of this report is to update the Capital Projects Committee of the Board of Directors on key dam risk management activities during the period from April 1 to June 30, 2021 and to provide reasonable assurance that the safety of dams operated by BC Hydro continues to be managed to the established guidelines and criteria of the Dam Safety Program. To keep the Committee as fully abreast of the Dam Safety Program as possible, some notable developments that took place after June 30 but before the completion of this report have also been included.

This report has been slightly reformatted at the request of the Capital Projects Committee. In response to feedback from the Committee, the Program Dashboard on page 2 has been restructured to provide a clearer overview of the program and supporting, detailed metrics have been returned to the body of the report.












The key highlights from F2022 Q1 documented in this report are:

- Impacts of the wildfires on dam safety (p. 8) have been minimal to date, but there are potential impacts to the schedules of reservoir slope inspections (p. 13) and some project construction work (p. 17). Site visits for Dam Safety Reviews have been scheduled to later in the year than is typical (p. 11).
- On July 15, 2021, the downstream gate of the navigation lock at Hugh Keenleyside Dam dropped from the raised, fully open position to the sill. The navigation lock remains out of service while the cause is being investigated and repairs are made. While this prevents normal commercial river traffic from navigating past the dam, there are no associated dam safety impacts or risks. See p. 6.
- COVID-19 has continued to have only minor impacts on the Dam Safety Program. Critical dam safety activities, such as surveillance, inspection and spillway gate testing, continued with minimal interruption under safe work protocols. Required rescheduling of some site visits has led to some minor lags in the work program for Operation, Maintenance and Surveillance Manual updates. See pp. 7 and 10 for details.
- There was one new deficiency identified and four deficiencies either closed or re-rated, leading to an overall decrease of 7.74 to the aggregated Vulnerability Index. See pp. 3-5.

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Dam Safety Program Dashboard

The following dashboard provides an overview of the status of the Dam Safety Program. “Traffic lights” provide a qualitative indication of the status of each of five elements of the Program and trend arrows identify whether the status is improving, deteriorating or unchanged. As referenced, these indicators are supported by more detailed metrics and narratives in the report.

Risk Profile and Issues Management		<ul style="list-style-type: none"> • Vulnerability Index (pp. 3-5): The aggregated Vulnerability Index was reduced by 7.74 in F2022 Q1 and is forecast to remain stable or slightly reduced through the fiscal year. • Program Non-Conformances (p. 5): The total number of issues was reduced. • New and Current Issues (pp. 6-8): Recently arisen issues from last quarter’s report are all under active management or closed. Two new issues are both under active management and neither poses a significant dam safety risk.
Regulatory Compliance		<ul style="list-style-type: none"> • Operation, Maintenance and Surveillance Manual Updates (pp. 9-10): Site visits have been delayed by previous COVID-19 travel restrictions. Work on the Ruskin update remains on hold while the project team completes final documentation. An updated schedule will be provided next quarter. • Dam Safety Reviews (pp. 9-10): F2022 work has just commenced. Site visits will be performed later than typical to avoid the height of the wildfire season.
Surveillance		<ul style="list-style-type: none"> • Dam Inspections (pp. 11-12): Formal dam inspections were ahead of plan in Q1. Three routine inspections (out of 411) were missed in the quarter, but these are not deemed to be indicative of a systemic issue. • Instrumentation and Monitoring (p. 11): Quality control and data reviews met targets in Q1. • Reservoir Slopes (p. 12): Reservoir slopes inspections were on plan in Q1.
Maintenance and Testing		<ul style="list-style-type: none"> • Civil Maintenance (p. 13): Condition-based maintenance progressed on plan. Preventative maintenance lagged behind the plan due to incorrect curving of the plan that erroneously increased the number of work orders due in Q1. • Spillway Gates (pp. 14-15): The number of outstanding maintenance issues increased over Q1. Two of 216 scheduled gate tests were missed, and gates failed to operate on demand during three tests. • F2022 maintenance plans for civil and spillway assets are being reviewed and adjusted in response to pressure on maintenance budgets across BC Hydro.
Projects and Investigations		<ul style="list-style-type: none"> • Capital Projects (pp. 16-18): Dam Safety projects have exhibited steady progression. • Deficiency Investigations (p. 18): There were no significant developments or milestones on Deficiency Investigations in F2022 Q1.
Legend:	     	<p>All areas within the Program element are being implemented to a satisfactory level. Minor, isolated issues may exist but are not deemed to be indicative of deteriorating performance.</p> <p>One or more areas within the Program element exhibit or are at risk of underperformance and are being monitored.</p> <p>One or more areas within the Program element exhibit unsatisfactory performance and require correction.</p> <p>Status of the Program element has improved over the quarter.</p> <p>Status of the Program element was unchanged over the quarter.</p> <p>Status of the Program element deteriorated over the quarter.</p>

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Risk Profile of BC Hydro's Dams

Dam Safety Contribution to Enterprise Risk

Dam Safety is assigned a high “risk priority” within BC Hydro’s Enterprise Risk report. Please refer to that report for additional details.

Vulnerability Index Update

Identified physical deficiencies in BC Hydro’s dams and the degree of concern that exists with respect to their impact on the integrity and performance of the dam are characterized by the Vulnerability Index. The higher the value of the Vulnerability Index (scale of 0-10), the higher the likelihood of that deficiency leading to poor performance. The Vulnerability Index for each currently identified issue at each dam site is shown in Figure 1. Dams are sequenced from left to right in order of increasing downstream consequences, per the BC Dam Safety Regulation. Changes in Vulnerability Index for actual and potential deficiencies (including those related to spillway reliability) aggregated across the entire fleet of dams, are tracked on a quarterly basis and shown in Figure 2.

Notable changes in Vulnerability Index in F2022 Q1 are described below and identified in Figure 1.

- 1** An **addition** of 1.9 (Actual Unusual deficiency) at **Sugar Lake Dam**.
The right abutment training wall and protective rip-rap do not adequately protect the right abutment and embankment fills from overtopping erosion under high spillway discharges.
- 2** A **reduction** of 2.24 (Potential Unusual deficiency) at **Whatshan Dam**.
The Whatshan Dam has a zone of granular material in the foundation that was identified as having a potential for internal erosion. Based on good historical and continuing performance, this issue has been reassessed and recharacterized from an Actual Unusual deficiency to a Potential Unusual deficiency.
- 3** A **reduction** of 2.48 (two Actual Unusual deficiencies) at **Wilsey Dam**.
With completion of the Dam Safety Investigation described in last quarter’s (F2021 Q4) report, the dam’s stability under applicable load cases for accumulated sediment on the upstream face and under seismic loading has been found to be adequate and the existing database issues have been completed.
- 4** A **reduction** of 4.92 (Spillway Reliability deficiency) at **Ruskin Dam**.
With the Ruskin Dam and Powerhouse Upgrade project in service, the operational reliability of the spillway gates system has been reassessed and the Vulnerability Index re-evaluated using a newly developed and implemented methodology, described below.

The new methodology for evaluating the Vulnerability Index for operational reliability of spillway gate systems makes direct use of monthly gate testing results. The “Magnitude of the Gap” is the difference between the “Actual Rate of Gate Failure on Demand” and the “Target Rate of Gate Failure on Demand” of 1 failure per 10,000 demands, which is based on BC Hydro’s “Reliability Principles for Flood Discharge Gate Systems”. If, for example, a gate at a facility fails to operate once in every 50 tests, then the “Magnitude of the Gap” is $1/50 - 1/10,000 = 0.0199$ and the calculated Vulnerability Index is 2.71. This new methodology is simple, repeatable, and reflects the common condition that newly commissioned gate systems are initially less reliable than more mature (well-exercised) systems, often described by the so-called “bathtub curve”.

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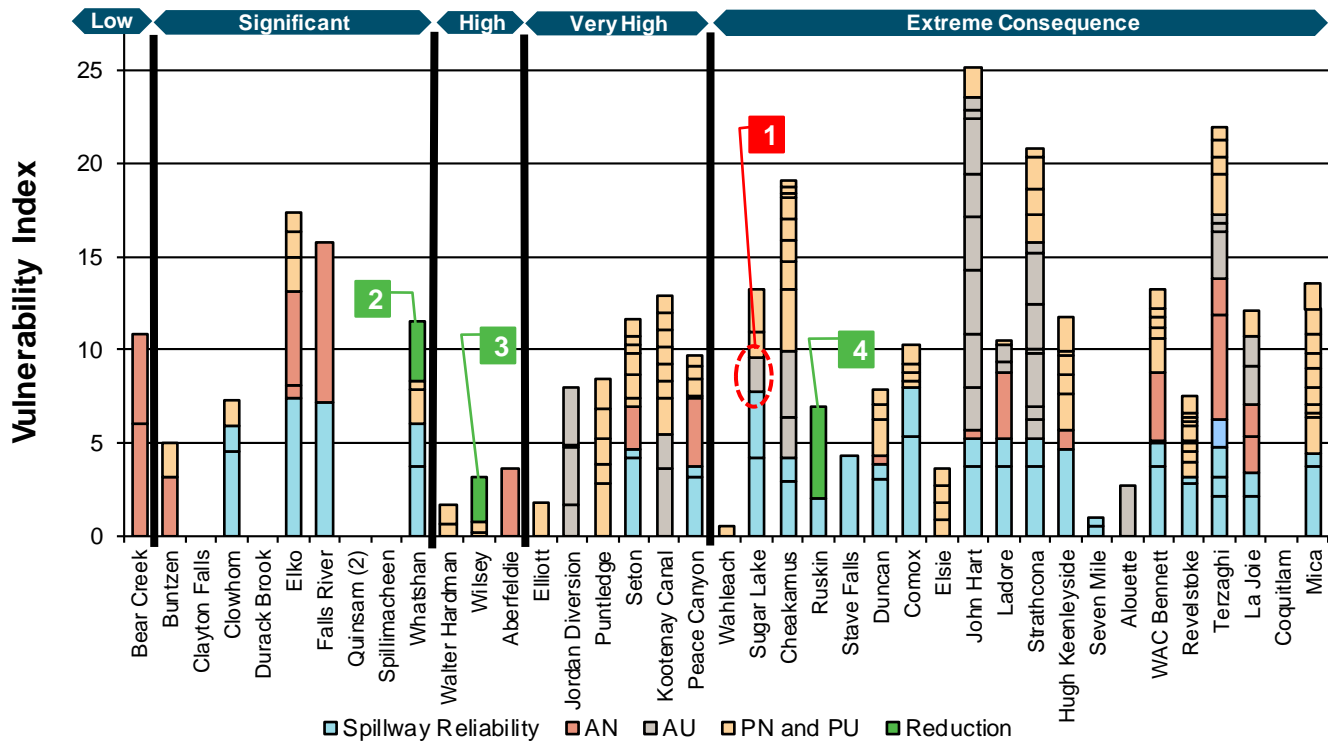


Figure 1 Dam Safety overall risk profile at the end of F2022 Q1, as represented by the Vulnerability Index. Changes this quarter are indicated by the numbered boxes.

- AN** Actual deficiency (demonstrated to exist) under *normal* load conditions
- AU** Actual deficiency (demonstrated to exist) under *unusual* load conditions
- PN and PU** Potential deficiency (requiring further investigation to demonstrate existence) under either normal or unusual conditions
- Spillway Reliability** Actual or potential deficiency related to operational reliability of the dam's spillway and/or other flood discharge systems

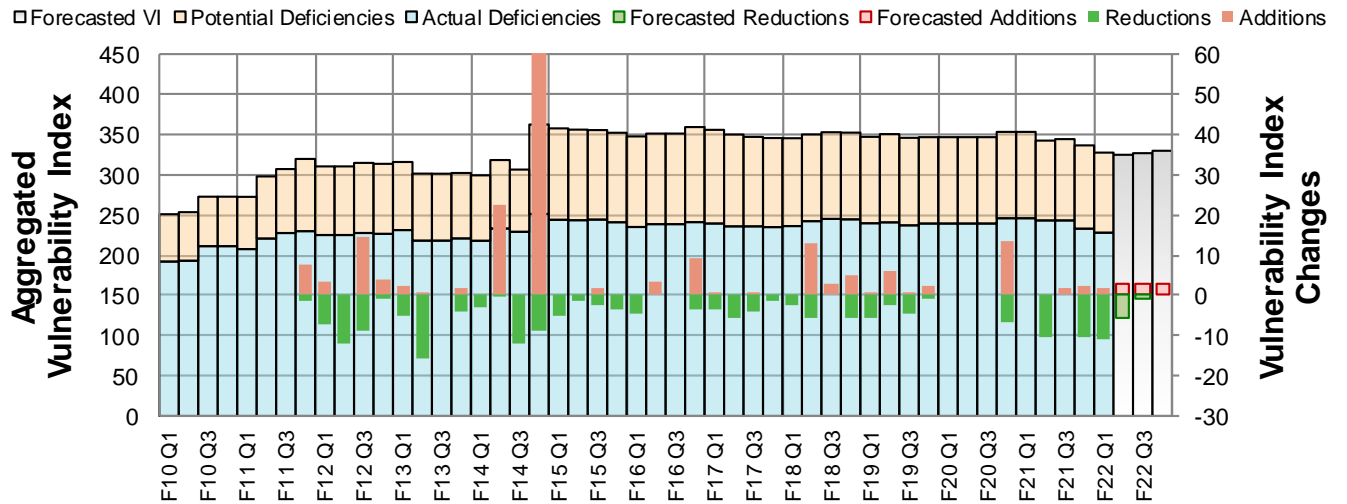


Figure 2 Historical and forecast changes and trends in the Vulnerability Index aggregated across the BC Hydro system.

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Over the last several years, new issues have been added at a rate that increases the aggregated Vulnerability Index by approximately 12 per annum. Therefore, to prevent deterioration of the overall risk position, reductions in Vulnerability Index through completed issues should occur at the same pace or faster. The table below shows this to be the case at present.

		Actual / Forecast	Target
Dam Safety Vulnerability Index	Reductions - Last 4 quarters	31.6	12 ✓
	Reductions – FY forecast	17.4	12 ✓
	Additions - Last 4 quarters	6.2	

Non-Conformances in the Dam Safety Program

Activities to identify, review, resolve and close non-conformance issues continued in F2022 Q1. Scheduled reviews of the existing issues in the Dam Safety Issues Database were conducted for nine sites. Memoranda for five of those reviews were finalized, sealed and issued within the quarter to document several changes to the Issues Database, including the resolution of 25 non-conformance issues. 22 new non-conformance issues were added to the database this quarter, mainly arising from two Dam Safety Reviews, for a net reduction of three non-conformances over the quarter.

Figure 3 shows the continuing progress in reducing the number of Program non-conformances.

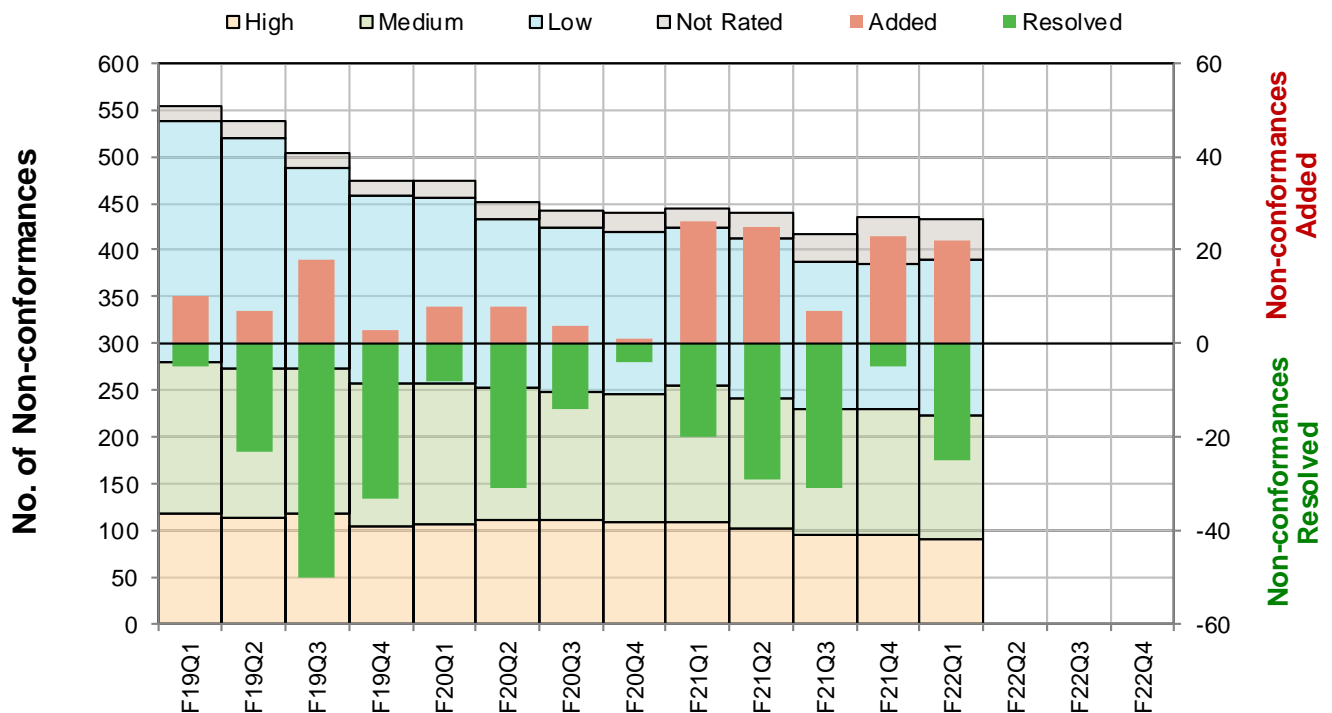


Figure 3 Changes and trends in the total number of non-conformances (characterized by level of importance) within the Dam Safety Program.

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New Issues

Dam Safety Impacts from Wildfires

The severe wildfire season has not, as yet, had a large impact on the Dam Safety Program but the demand for helicopters to support firefighting efforts may result in delays to planned reservoir slopes inspections or accessing other remote sites. Additionally, site visits for Dam Safety Reviews have been deferred to the end of the summer or beginning of fall, and construction activities for some projects may be slowed or halted.

Potential Kinbasket Reservoir Surcharge

The extreme heat wave in late June and prolonged hot temperatures through July resulted in record breaking inflows into Kinbasket Reservoir between late June and early July. These inflows, combined with low generation requirements, have led to a 30-50% probability of exceeding the Normal Maximum Reservoir Level (“surcharge”) and/or requiring spill as early as mid-August 2021. To have the flexibility to best manage the excess water and mitigate any negative effects, BC Hydro applied to the Comptroller of Water Rights for a surcharge order permitting BC Hydro to operate up to 0.3 m above the Normal Maximum Reservoir Level from August 1 through September 30, 2021. That order was granted by the Comptroller’s office on July 26. If required, surcharge will take place under an Interim Dam Safety Risk Management Plan similar to the one implemented last summer and, with the plan in place is not expected to incur significant incremental risk at Mica Dam.

Hugh Keenleyside Dam – Navigation Lock Downstream Gate

The navigation lock at Hugh Keenleyside Dam allows boat traffic – primarily commercial traffic towing bundled logs to and from nearby lumber mills – to pass through the dam. On July 15, following the passage of a tugboat and towed bundle of logs, an alarm sounded to indicate a problem on the lock’s downstream gate. The gate subsequently fell from the open position to the gate sill. There were no injuries, and the cause of the gate being dropped is still under investigation.

While this incident potentially impacts commercial interests on the Columbia River, it does not pose a dam safety risk. The navigation lock itself does not perform a specific dam safety function apart from the gates being required to safely retain the reservoir. The upstream gate was in the closed position when the downstream gate fell, and initial visual observations by the Dam Safety Engineer on site and underwater Remotely Operated Vehicle inspections have not revealed any signs of damage, so this function is not at material risk of having been impaired. The navigation lock does not have a water conveyance function for the passage of inflows through the dam; this function is provided by the dam’s four spillways and eight low level outlets.

Engineering investigations of the incident are in progress – material, mechanical, maintenance and human factors are all being investigated and considered as potential causes or contributors – and Dam Safety has initiated a project to implement any necessary repairs.



Figure 4 Downstream gate and control/hoist tower of the Hugh Keenleyside Dam navigation lock.

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Update on Existing Issues

Dam Safety Response to COVID-19

Dam Safety staff are generally continuing to work from home or dispatch from home to the dam sites and reservoir slopes. Although some projects and Program work have experienced delays, e.g., site visits in support of Operation, Maintenance and Surveillance Manual updates, Dam Safety critical work has continued with little impact.

La Joie Dam – Failure of Intake Gate Hoisting Mechanism

Last quarter's (F2021 Q4) report described the failure on March 23, 2021 of the lifting mechanism of Intake Operating Gate 4, one of two intake operating gates on the upstream end of the low level outlet, referred to as the North Conduit. The North Conduit passes water through a pair of hollow cone valves directly into the Middle Bridge River during generator outages and periods of high inflows and is typically used from July through September to manage levels in Downton Reservoir.

Over the course of April and May, resources were diverted to inspect the condition of the gate, sill, and remaining components of the lifting mechanism. Intake Operating Gate 4 and its lifting mechanism were raised to the intake tower deck, where the gate body and mechanism components called "followers" were found to be in very poor condition or, in some cases, in a failed state.

Intake Operating Gate 3 ("**Gate 3**"), the other operating gate on the North Conduit, has identical design and operating conditions to Intake Operating Gate 4 ("**Gate 4**") and is expected to be in similarly poor condition. To mitigate the risk of a similar failure occurring on Gate 3, the North Conduit is being operated with Gate 4 open (gate dogged at deck level) and Gate 3 closed with stop logs in place upstream of the gate. Hydraulic analysis by BC Hydro Engineering confirmed that the hollow cone valves could be operated through their full range with only one intake gate open. After concrete repairs in the intake structure were performed and the hollow cone valves were inspected, the North Conduit was returned to service on June 4 with an Interim Dam Safety Risk Management Plan in place. The two hollow cone valves are currently open and passing water downstream.

A project has been released to replace the gate followers for the lifting mechanisms of all four intake gates at La Joie Dam and to replace the gates and refurbish the guides for the two North Conduit gates. The manufacture of the followers has been expedited and they are currently expected to be replaced on the North Conduit gates within the year. Replacement of the gates will follow once design and manufacture can be completed.

Downton Reservoir (La Joie Dam) Surcharge

Last quarter's (F2021 Q4) report noted the forecast for a required surcharge of Downton Reservoir this summer to prevent or mitigate spilling down the Lower Bridge River during environmentally sensitive periods. At that time, the surcharge was forecast to commence at the beginning of August and run through late October. As a result of the very hot conditions in June and July, Downton Reservoir rose much more quickly than forecast and the Director, Dam Safety provided authorization to surcharge above the current Normal Maximum Reservoir Level of 734.0 m to a maximum elevation of 740.0 m under an Interim Dam Safety Risk Management Plan on July 7. The reservoir rose above 734.0 m on July 9 and is anticipated to remain in surcharge through late October.

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Being undertaken within an Interim Dam Safety Risk Management Plan, this surcharge is not expected to create any incremental dam safety risks. The current Normal Maximum Reservoir Level of 734.0 m has been in place since 2015 to manage the risk of failure of La Joie Dam in a major earthquake and the cascading failure of Terzaghi Dam downstream. In essence, this lowered reservoir elevation restricts the total amount of water stored in Downton and Carpenter Reservoirs such that water released from Downton in the event of a post-earthquake failure of La Joie Dam could be absorbed by Carpenter Reservoir without overtopping Terzaghi Dam. As is illustrated in the plot of actual and forecasted reservoir elevations (Figure 5), the amount of water in the two reservoirs is not forecast to be enough to overtop Terzaghi Dam in such a scenario.

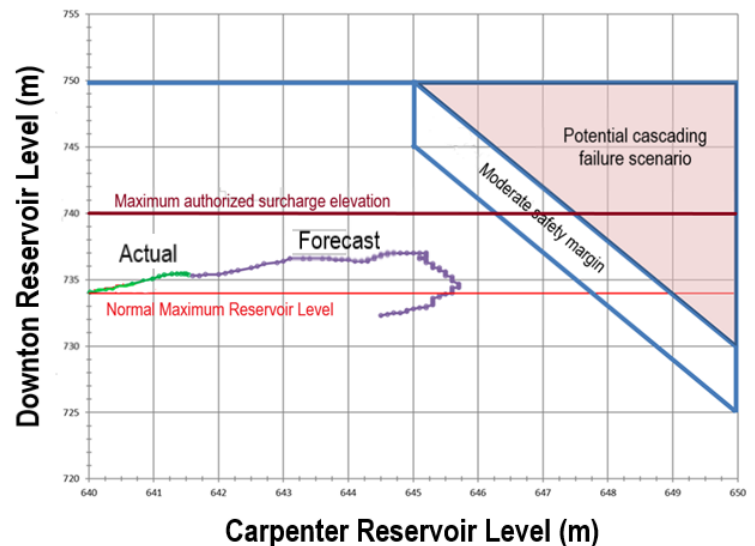


Figure 5 Actual and forecasted elevations of Downton and Carpenter Reservoirs during authorized surcharge of Downton Reservoir. (As at July 23, 2021)

Alouette Dam – Interim Dam Safety Risk Management during Smolt Outmigration

The Alouette Dam spillway is expected to be damaged by ground motions arising from a major earthquake – expected to occur on average once every 1000 to 2500 years – after which it would not be safe for use. Last quarter’s (F2021 Q4) report described efforts to support a study on the potential benefits of higher flows over the spillway to smolt outmigration at Alouette Dam. From April 15 through June 15, the sluice gate on the spillway was opened to about 800 mm to discharge at 10-11 m³/s. To mitigate the risk of the gate being stuck open and allowing spillway discharge to continue after a damaging earthquake, a crane and very large, one cubic metre sandbags, commonly referred to as “Superbags”, were staged on the dam crest to provide a means of stopping the spillway flows if the gate could not be closed. The smolt outmigration study was concluded on June 15. Interim dam safety measures, including the crane and Superbags, were removed from site on June 16.

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Compliance with Processes and Regulations

Regulatory Communications – British Columbia Utilities Commission

During F2022 Q1, Dam Safety contributed to a number of submissions to the Commission, including: filing for regulatory approval of the Bridge River 1 Units 1 to 4 Generator Replacement and Bridge River Transmission Projects; filing for regulatory approval of the John Hart Dam Seismic Upgrade Project; and the Fiscal 2023 to Fiscal 2025 Revenue Requirements Application.

In providing its decision regarding BC Hydro's Fiscal 2022 Revenue Requirements Application, the Commission has directed BC Hydro to – in all coming rate applications – submit the Dam Safety Vulnerability Index aggregated across the system and for each dam as well as the long-term capital plan for dam safety improvements. These submissions are being prepared as a part of the Fiscal 2023 to Fiscal 2025 Revenue Requirements Application.

Regulatory Communications – Comptroller of Water Rights

Regulatory Communications with the Provincial Dam Safety Office consisted of a request to permanently remove the stanchions that support the flashboards at Falls River Dam, which was approved. Also submitted were the Engineering Design Conformance Record for new instrumentation installed at Kootenay Canal Dam and the Sugar Lake Dam Safety Review Report.

Operation, Maintenance and Surveillance Manuals

Each dam has an Operation, Maintenance and Surveillance Manual (“**Manual**”) for Dam Safety that identifies responsibilities and expectations within BC Hydro for maintaining the safety of the dam. These Manuals are a requirement under the Dam Safety Regulation and must be updated every seven to ten years, depending upon the dam's failure consequences classification.

The work and delivery plans for the Manual updates are shown in Figure 6(a). There are seven Manual updates planned to be completed in F2022: Elsie, Hugh Keenleyside, Ladore, Peace Canyon, Puntledge, Strathcona and Sugar Lake. Work began on five of these updates in Q1. The reader will note that Figure 6(a) indicates that progress is lagging the work plan as of June. In fact, progress on updating the Manuals' content is on track, but site visits by the Manuals' authors were delayed until July and August due to earlier COVID-19 travel restrictions. Otherwise, work is on plan.

As was discussed in the F2021 Q3 and Q4 reports, the update to the Manual for Ruskin Dam remains on hold until additional information is available from the project. The project documentation required to complete an update to the Manual consists of record issue drawings on which to base the Manual's drawings and the documented design intent of some of the new features. Dam Safety continues to communicate with the project team to identify a schedule for completion of this documentation, which we expect to share with the Committee in the next quarterly report. We are also in written and verbal communication with the provincial Dam Safety Program to keep them apprised of our efforts to complete this outstanding manual.

Dam Safety Reviews

Dam Safety Reviews are carried out at minimum intervals of every five to ten years for dams that are classified in accordance with the Dam Safety Regulation as High, Very High and Extreme consequence dams.

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The work and delivery plans for the Dam Safety Reviews are shown in Figure 6(b). Only two Dam Safety Reviews are scheduled to be fully completed and issued in F2022: La Joie and Seton. Site visits by the Dam Safety Review engineers are scheduled for September 2021, in order to avoid the height of the wildfire season. These Dam Safety Reviews are scheduled to be completed and issued in March of 2022. Work on two other Dam Safety Reviews – for Terzaghi and Wahleach – will proceed just slightly behind but aren't planned to be completed until early in F2023.

Work in Q2 will focus on gathering the information to support the Dam Safety Reviewers, organizing and completing site visits, and facilitating staff interviews.

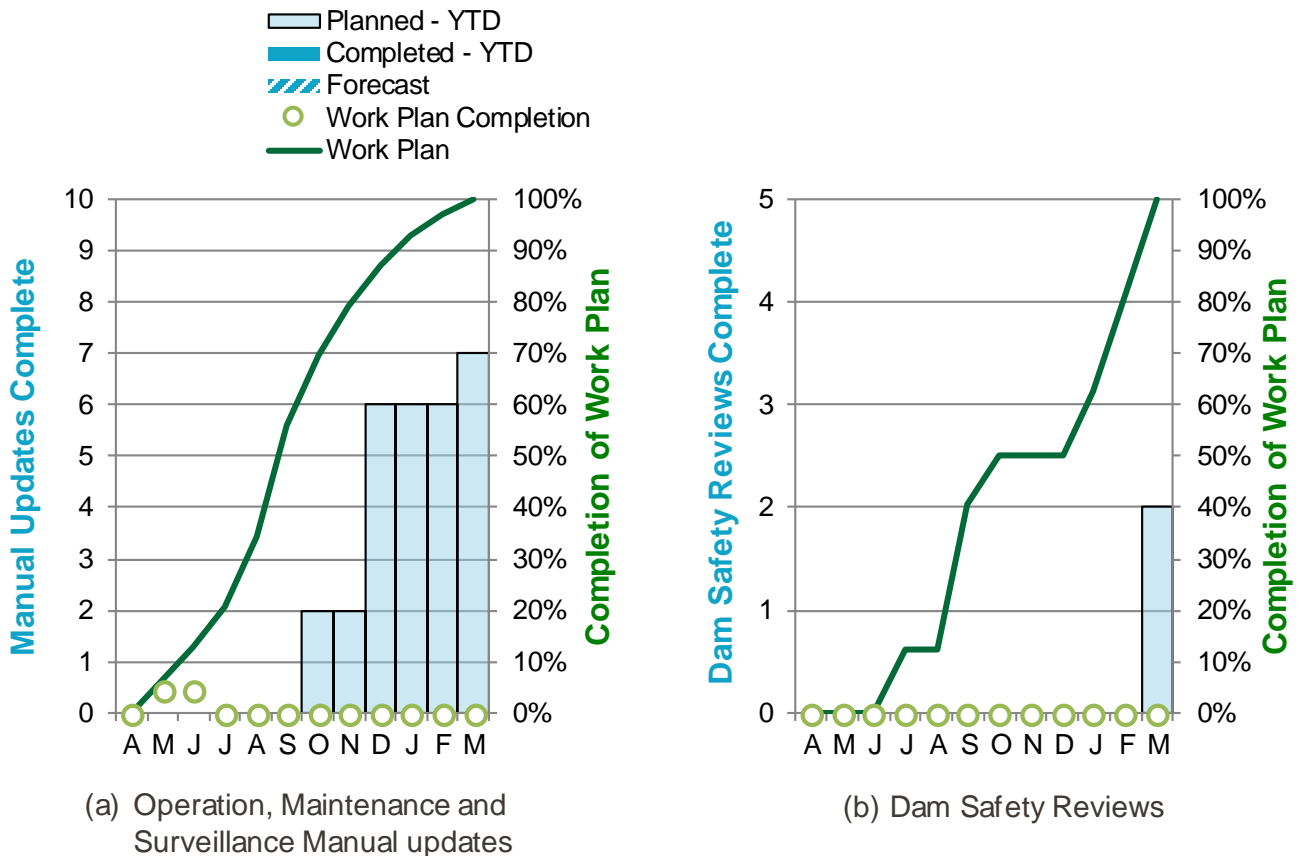









Figure 6 F2022 work and delivery plans for (a) Operation, Maintenance and Surveillance Manual updates and (b) Dam Safety Reviews.

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Surveillance

Key activities comprising dam safety surveillance include inspections, monitoring of instrumentation and quality control of data, and characterization of dam performance. The table below provides key metrics regarding these activities, which are described in the following sub-sections of the report.

		Quarter		Year-To-Date	
		Actual	Plan	Actual	Target
Routine dam inspections	Completed	408/411 = 99.3%	100%	408/411 = 99.3%	99.5% 
	Missed	3		3	
Formal (annual and semi-annual) dam inspections	Field work completed	37	20	37	20 
	Reports issued	13	0	13	0 
Instrumentation data checks		187/195 = 95.9%	95%	187/195 = 95.9%	95% 
Instrumentation Data and Dam Performance Peer Reviews		2	2	2	2 
Reservoir Slopes inspections	Field work completed	2	2	2	2 
	Reports issued	0	0	0	0 

Dam Inspections

Routine Inspections

Routine weekly and monthly inspections are a regulatory requirement. These visual inspections are carried out by trained inspectors within Dam Safety or Stations Field Operations using checklists prepared by the Dam Safety Engineer. The purpose of these inspections is to identify changing conditions at a dam, reservoir or appurtenant structure that could threaten the safety of the dam. As shown in the table above, 408 out of the 411 scheduled site inspections were completed in Q1 with three inspections having been missed.

- One inspection completed at Revelstoke Dam did not meet the expected quality and thoroughness required for an inspection of the facility and upon review by the Dam Safety Engineer was considered a missed inspection. This quality concern was discussed with the inspector and has since been corrected.
- An inspection at Seton Dam was missed at the end of May during the refilling of the canal forebay after dewatering. Although frequent inspections of the canal and forebay area were occurring as part of the procedures for refilling the forebay, the inspections were not documented and the inspection of some components of the facility may have been missed.
- A monthly inspection of Whatshan Dam was missed due to a scheduling oversight as the inspector had an unplanned absence.

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Formal Inspections

Formal inspections of the dams are regulatory inspections completed semi-annually or annually – as dictated by each dam’s Consequence Classification – by Dam Safety Engineers. These inspections include a comprehensive visual inspection, a review of the monitoring data and an assessment of the condition of the water containment and conveyance structures. In F2022 Q1, the field work for these inspections was completed at 37 dam sites and 13 inspection reports were completed and issued, exceeding the quarter’s work plan.

Instrumentation and Monitoring

Dam Safety Surveillance collects, checks and assesses about two million data points a month. A vast majority of the data is collected and checked against threshold values automatically by the Automated Data Acquisition System. Even though most of the data is checked automatically it is essential that qualified staff review the data regularly to ensure the systems are functioning as expected. The Dam Safety Technologists in each region regularly check instrumentation data plots for all dams to ensure the Automated Data Acquisition System is functioning as expected, identify any unusual trends, and ensure continued accuracy of the data being for ongoing engineering assessment. They are tasked to perform three such checks per week. During Q1, 187 checks were completed on a plan of 195.

Reservoir Slopes

Reservoir Slopes inspections are completed on a frequency ranging from semi-annually to once every 10 years depending on the assessed hazard of the slope. These inspections are typically carried out by the Reservoir Slopes Geologist and the Specialist Dam Safety Engineer for the Upper Columbia Region. The inspections generally consist of a review of all monitoring data and a visual inspection completed from helicopter with boots-on-ground assessment of identified areas of concern. In Q1, as planned, the field work was completed for 2 of the 17 inspections scheduled for F2022 (**Wahleach Slope and Revelstoke Rock Slopes**). It is noted that the scheduled inspections (field work) of some of the slopes may be delayed in Q2 because of a lack of helicopter resources due to the forest fire situation in BC.

Last quarter’s (F2021 Q4) report described Dam Safety’s partnering with the Canadian Space Agency and two Vancouver-based consulting firms, TRE ALTAMIRA and BGC Engineering, to advance the use of satellite-acquired remote sensing (Interferometric Synthetic Aperture Radar, or “**InSAR**”) data for landslide detection and monitoring. Early results had identified a potential – and previously unidentified – landslide 10 km north of Revelstoke Dam. Work to confirm this finding will consist of an aerial Light Detection and Ranging (“**LiDAR**”) scan and a ground inspection, both scheduled to occur in Q2 subject to wildfire status in the region.

Unusual Events or Observations

The Dam Safety On Call Person responded to 64 calls in Q1 of F2022, which included instrumentation alarms, operational inquiries, operations notifications during high inflows and earthquake notifications. This number of calls and responses is consistent with expectations and past experience. None were sufficiently noteworthy for inclusion in this report.

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Maintenance and Testing

Civil Maintenance

		Quarter		Year-To-Date	
		Actual	Target	Actual	Target
Corrective and Condition-Based Maintenance	Work Orders Completed	1	1 ✓	187/195 = 96%	90% ✓
	Spend (\$k)	1,221	939	1,221	939
Preventative Maintenance	Tasks Completed	99/242 = 41%	90% ✗	99/242 = 41%	90% ✗

Preventative Maintenance

In Q1 the Civil Preventative Maintenance program completed 99 work orders against a plan of 242. Programs and Contract Management, the program's delivery group, has indicated that the shortfall is mainly attributable to incorrect curving of the plan that erroneously increased the number of work orders due in Q1. An updated completion forecast curve for the F2022 Civil Preventative Maintenance work plan is expected in Q2.

Corrective and Condition-based Maintenance

The Civil Maintenance program for corrective and condition-based maintenance progressed well through Q1 and completed one project, per plan, with many others well underway and ahead of schedule. The year-to-date spend is \$1.22M against a plan of \$0.94M. The completed project is the La Joie Dam Face shotcrete and joint repairs, which is scheduled and completed on an annual basis until the La Joie Dam Improvements capital project completes a more permanent upgrade to the dam face. Figure 7 is a photograph of one of the defects that was exposed and repaired during this year's maintenance program.



Figure 7 Large repair area chipped open and exposed at the lower portion of Panel 70-71 on the face of La Joie Dam.

A number of planned civil maintenance projects are likely to be deferred to accommodate maintenance budget pressures arising from the La Joie intake gate hoist failure (see "Update on Existing Issues") and the Keenleyside Dam Navigation Lock gate failure (see "New Issues"). Dam Safety is working with Stations Asset Planning to revise the plan in Q2.

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Spillway Gate Testing and Maintenance

Beginning in F2022 Q1, Dam Safety has implemented the following changes to the way spillway gate testing and maintenance is tracked and reported:

- Gate testing metrics are now based on the number of individual gates tested, not gate systems. This change is being made to track the frequency of individual gates failing to operate on demand as an improved indicator of gate reliability.
- Identified gate maintenance issues are no longer classified as “Line of Defence” or “Other Deficiency”. Starting in F2022, gate reliability work orders are being reported using the Maintenance Risk Matrix, as published in the F2022 Station Business Rules, to prioritize outstanding work orders. This change was made to improve alignment across asset classes and to leverage existing processes.
- “High priority” gate maintenance work orders are now defined as those having a Likelihood rating greater or equal to 5, corresponding to a frequency of 1/100 years or greater, and a severity rating greater or equal to 4.5, corresponding to a loss of reservoir control with long intervention time available.

Spillway Gate Testing

		Quarter		Year-To-Date	
		Actual	Target	Actual	Target
Monthly Tests	Completed	214/216 = 99.1%	100% ❌	214/216 = 99.1%	98% ✅
	Missed	2		2	
Gates Failing to Operate on Demand during Testing	No. of failures	3		3	
	Failure rate	3/214 = 1.4%		3/214 = 1.4%	

During Q1 of F2022, 214 of 216 gate test operations at 23 sites were completed. Tests at Elko Dam were missed in May due to a planning and scheduling error. Dam Safety has followed up with Stations Field Operations personnel to discuss the omission and prevent future occurrences.

Three gates failed to operate on demand during Q1:

- At Terzaghi Dam, a low-level outlet gate (one of two) was unable to raise above 80 mm. The exact cause is not yet known, and an Operational Restriction has been put in place. A capital project, Terzaghi Low Level Discharge Reliability Improvement, is planned for release in Q3.
- At Terzaghi Dam also, both spillway gates failed to operate correctly due to a phase reversal caused by changes recently made to the alternating current distribution system; pressing the “raise” button caused the gates to lower and vice versa. The problem has since been corrected.

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Spillway Gate Maintenance

The number of outstanding gate maintenance work orders is shown in the chart on the right-hand panel of the dashboard. The total number of outstanding work orders increased from 153 to 165 in F2022 Q1, while the number of “high priority” maintenance work orders has decreased from 12 to 11.

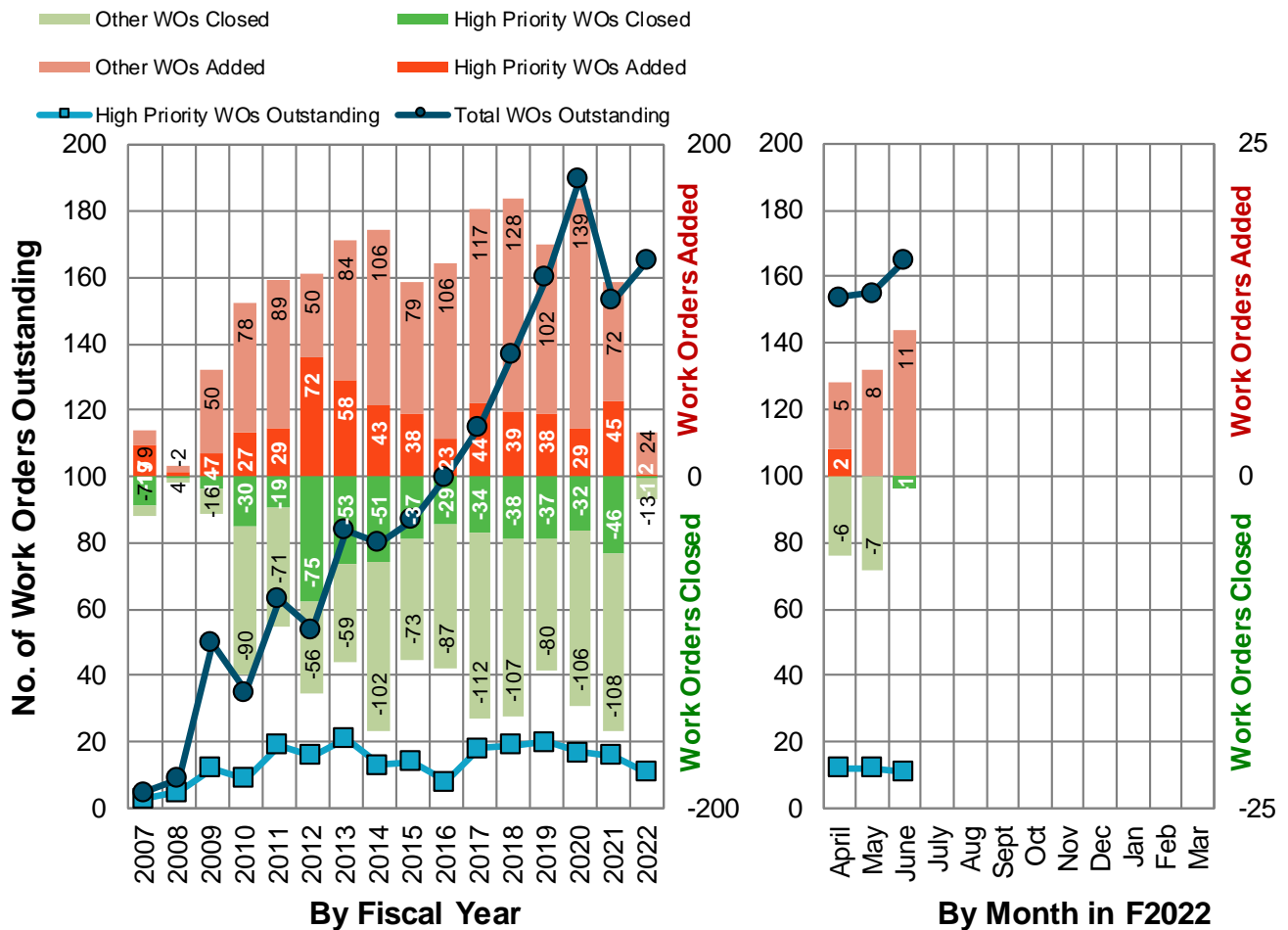


Figure 8 Number of outstanding corrective and condition-based spillway gate maintenance work orders, new work orders added, and work orders closed as at the end of each previous fiscal year and the end of each month in the current fiscal year.

As alluded to in the discussion under “Civil Maintenance”, BC Hydro is experiencing significant budgetary pressure in F2022 for maintenance in general and condition-based maintenance in particular. This is due in part to the emergent issues described earlier in this report and to unforeseen demands in other asset portfolios. Dam Safety is working with Stations Asset Planning and the Senior Vice-President of Integrated Planning to identify additional maintenance funding, to ensure that all available funding is targeted to completing the highest priority maintenance work orders across Dam Safety and Stations and that there is no significant deterioration in the maintenance profile of the spillway gates through F2022.

3.5 DAM SAFETY QUARTERLY REPORT

Emergency Preparedness and Public Safety

Emergency Preparedness is managed by Security & Emergency Management. Dam Safety reports on the updating of emergency plans for compliance with the BC Dam Safety Regulation as part of annual compliance reporting to the Comptroller of Water Rights. Public safety near dams and reservoirs is managed by the Public Safety team in Safety Engineering & Work Methods. Dam Safety reports on Public Safety activities related to dams during the Dam Safety Reviews. Please refer to the Safety & Emergency Management Quarterly Report delivered to the Operations and Planning Committee for updates on emergency preparedness and public safety around dams.

Capital Projects

Summaries of Dam Safety Capital projects are available for reference in the Dam Safety “book” in Diligent. This section provides updates for the newly launched projects and updates for the projects where significant developments occurred or milestones were achieved.

Bridge River 1 – Penstock Foundation Refurbishment

Inspections have found that the concrete foundations for each of this generating station’s four penstocks have visible cracking, spalling and other structural defects. Further, rockfall has partially buried a number of supports and significant lengths of the penstock invert (bottoms), preventing full inspections and eventual planned recoating of the penstocks. This project has been released to upgrade the penstock supports, clear the penstock alignments of rockfall debris and improve rockfall containment/protection for the penstocks.

In Q1 the project was confirmed to have a Single Viable Alternatives. Work Package Agreements for Identification Phase have been prepared and are being reviewed. The project team is planning to submit the Statement Of Objectives and End of Needs Phase documents to Finance in Q2 for Identification Phase funding approval.

Bridge River 1 – Mitigate Surge Spill Hazard

The objective of this project is to mitigate the hazards caused by overtopping of the surge shafts due to rapid closure of the Penstock Inlet Valves. Overtopping of the surge shafts could damage downslope BC Hydro facilities with potential loss of life. This project was initiated in 2017 following the Bridge River 1 Penstock Leak Detection Project in which a Penstock Leak Detection System as well as a Penstock Inlet Valve auto-closure system were installed to automatically close upon detection of a penstock leak. Construction of surge mitigation will enable the auto-closure system to be commissioned as well as facilitate a future project to upgrade the Penstock Inlet Valves to be capable of closure under ruptured flow.

Excavation of the two containment basins is complete and other construction activities are progressing. Issued For Construction drawings are being updated by Engineering to reflect excavated site conditions. Currently, there are concerns regarding existing exemptions for working under conditions of elevated fire risk. If these exemptions are not extended, construction may have to be slowed or halted.

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Bridge River 1 – Slope Drainage Improvements

The objective of this project is to reduce the risk of debris flows on the slope above Bridge River 1 Generating Station. The steep mountain slope has experienced numerous debris flows due to poor drainage. There is also a risk of a debris flow associated with a spoil pile along the “School Creek” that is a remnant of the original power tunnel excavation. This project follows the work to install instrumentation to monitor drainage and stability of the penstock hillslope and powerhouse.

In Q1, a contractor-led constructability review and cost estimate for the School Creek spoil pile removal was completed and Engineering completed the spoil pile removal memo. The conceptual design for the drainage improvements for School Creek and Town Creek are ongoing.

Cheakamus – Concrete Dam Instrumentation Upgrade

In 1985, 21 piezometers were installed in the foundation of Cheakamus Dam to monitor uplift pressures beneath the Main Concrete Dam which provides a routine check on the conditions along the base of the dam and confirmation that uplift pressures remain within design values. Only 11 of these piezometers remain functional. The objective of this project is to install new instrumentation needed to monitor the uplift pressures under the concrete dam.

In Q1, the project was confirmed to have a Single Viable Alternative; replacing/installing instrumentation with real-time monitoring capabilities on the concrete dam. The project will follow a scaled approach with a combined Identification and Definition Phase for project efficiency.

Hugh Keenleyside – Spillway and Low Level Outlet Concrete Repair

The objective of this project is to repair the damaged concrete at the Hugh Keenleyside discharge facilities and energy dissipator. Damage at the water passages range from minor abrasion to erosion of several cubic metres of concrete to the point where reinforcing steel has been exposed, worn smooth or broken off. Operating procedures are being applied in the interim to reduce additional concrete erosion when possible; however, there is still a potential for rapid progression of damages leading to significant structural impairment of the discharge facilities. Repairing the concrete within the water passages is needed to ensure the continued, safe passage of water downstream to manage inflows and meet Columbia River Treaty obligations. The project will repair the concrete surfaces of the spillway, Low Level Outlet ports and energy dissipator to original or near-original condition.

In Q1 Fraser Burrard Diving Ltd. was retained to perform material mix design and site investigations in October of this year. In June, the contractor conducted a field investigation in preparation of the planned work to identify test areas for repair.

Mica – Discharge Facilities Seismic and Reliability Upgrades

The objective of this project is to upgrade the discharge facilities at Mica Dam to address flood and seismic deficiencies and to ensure safe reservoir containment, post-seismic operability, and safe passage of inflows by the discharge facilities. The seismic stabilities of the dam and reservoir slopes will be addressed in separate projects. This project will address most of the gates-related issues.

In Q1 the bathymetric survey of the tailrace was completed, and the Design Basis Memorandum for Conceptual Design stage was finalized. The Design Basis Memorandum covers the methodology that will be used to carry out the conceptual engineering assessments to analyze the existing spillway and

3.5 DAM SAFETY QUARTERLY REPORT

outlet works structures, embedded guides for the spillway and outlet works operating gates, outlet works guard gate and bridge crane, power supply, Protection & Control and communications components, and the methodology for development of conceptual upgrade options.

Mica – Little Chief Incliner Installation

This project was released in Q1. The objective of the project is to install new instrumentation to ensure that there is an adequate and ongoing monitoring of the slide as existing instruments are damaged and fail due to ongoing slide displacement. Recent experience with the Downie Slide Instrumentation Improvement project is being referenced in the Needs Stage to develop the scaled Single Viable Alternative approach for the project to expedite the start of construction. Both conventional instruments and new real-time, large-scale monitoring techniques similar to those being deployed at Downie Slide are being considered to meet the Project objective.

Terzaghi – Spillway Chute Access Improvement

The objective of this project is to mitigate rockfall hazard to allow detailed in-chute inspection of the Terzaghi Dam spillway structure, as well as drain maintenance, concrete repairs, and, if required, facilitate subsequent capital projects to address the design deficiencies in the spillway.

In Q1 the project completed the Conceptual Design Memo that outlined and reviewed the Alternatives. The basis of the identified leading alternative is to allow full in-chute access on an ongoing basis for inspections and potentially short investigations. The leading alternative comprises select slope treatment of meshing, bolting, and shotcreting of identified rockfall sources on the step sloped above the spillway.

Wahleach – Unit 1 Tailrace Tunnel Upgrade

The objective of this project is to upgrade and restore structural integrity of the tailrace tunnel that runs under Highway 1 and the adjacent railway line. The construction work to refurbish the concrete tailrace tunnel and corrugated steel conduit has been substantially completed. Project completion documentation is in preparation.

Dam Safety Investigations

Dam Safety Investigation Projects (“**Investigations**”) are generally performed to either refine knowledge regarding potential issues or non-conformances of information recorded in the Dam Safety Issue Database or to perform precursor work for planned capital upgrade projects. This section provides descriptions of newly launched Investigations and updates for those Investigations where significant developments have occurred or where milestones were achieved.

There are no notable significant developments or milestones to report this quarter.