

Board briefing – 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, 2020 to June 30, 2020 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. The key highlights from F2021 Q1 documented in this report are:

- There were no changes to the assessed Vulnerability Index.
- There was a net reduction of seven non-conformances, leaving a total of 428 issues outstanding, which is the lowest total number in the past decade. Work to further reduce this number is ongoing and progress will continue to be updated in future quarterly reports.
- The newly formed Regulatory and Asset Planning department in Dam Safety assumed responsibility for coordination of Operation, Maintenance and Surveillance (“OMS”) Manual updates and organizing and supporting externally performed Dam Safety Reviews. Ten OMS Manual updates and ten Dam Safety Reviews are scheduled to be completed in F2021 and progress in Q1 was on plan.
- The Regulatory and Asset Planning department further assumed responsibility for annual planning and oversight of civil maintenance on the dams and generating stations, and for identifying and prioritizing electrical and mechanical-based maintenance of gates and valves for water passages. This department also took the first steps to integrate Dam Safety into existing maintenance processes and business rules, giving Dam Safety much-improved direction and oversight of dam-related maintenance.
- The backlog of gate maintenance issues was assessed and actions to develop a plan to address them were initiated. Future quarterly reports will continue to provide updates on the progress of this work.

Impacts of COVID-19 on Dam Safety:

- Critical dam safety activities, such as surveillance, inspection and spillway gate testing, continued without interruption under safe work protocols.
- Kinbasket Reservoir at Mica Dam is expected to exceed its Maximum Normal Reservoir Level. Approval for this was obtained from the Comptroller of Water Rights and an interim risk management plan is in place to manage this condition.
- Five planned civil maintenance projects with a total value of approximately \$300,000 were deferred to F2022. In delaying this work, there will be no significant deterioration of the safety of the structures.
- Dam Safety capital projects in Implementation Phase have experienced some delays, as has been broadly experienced across all project portfolios.

Board briefing – DAM SAFETY QUARTERLY REPORT**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 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.

No Vulnerability Index changes relating to identified physical deficiencies were made in F2021 Q1. As reported last quarter, there remain a number of issues to close off and Vulnerability Index reductions to take at Ruskin Dam, pending correction of outstanding project deficiencies (spillway gates) and determination of the cause of the sinkholes that were discovered adjacent to the powerhouse in January of 2020.

Non-Conformances in the Dam Safety Program

Efforts to reduce the number of non-conformances within the Dam Safety Program continued in F2021 Q1. Despite the additional efforts required to continue performing essential dam safety activities under COVID-19 safe work protocols and by cancellation of regularly scheduled Issues Database review meetings (during which non-conformances are reviewed, updated, or closed as appropriate and actions for closure of non-conformances are developed), 22 non-conformance issues were completed and closed in Q1, which is almost exactly the average number for previous quarters over the past two years. An unusually large number – 15 – of new non-conformance issues were added, however, resulting in a net reduction of seven issues.

As of the end of F2021 Q1, the total number of outstanding non-conformance issues was 428, which represents a reduction of 26% since its 2015 peak and 23% since this issue was targeted for special management attention in 2018. The number of non-conformance issues is now lower than it’s been in a decade.

This positive overall trend notwithstanding, while non-conformances do not pose an immediate and present threat to the safety of BC Hydro’s dams, attention to the management and reduction of program non-conformances is critical to maintaining the effectiveness of the Dam Safety Program and will continue to be a program priority. The Issues Database Reviews have resumed in Q2. Moreover, new measures are being initiated to further improve the trend of non-conformance reductions. In Q1, a change was made to devote a portion of the annual Dam Safety Investigations budget to investigating and closing information non-conformances (“**NCIs**”). In F21, this should fund 5-10 small investigations to resolve a similar or slightly larger number of NCIs.

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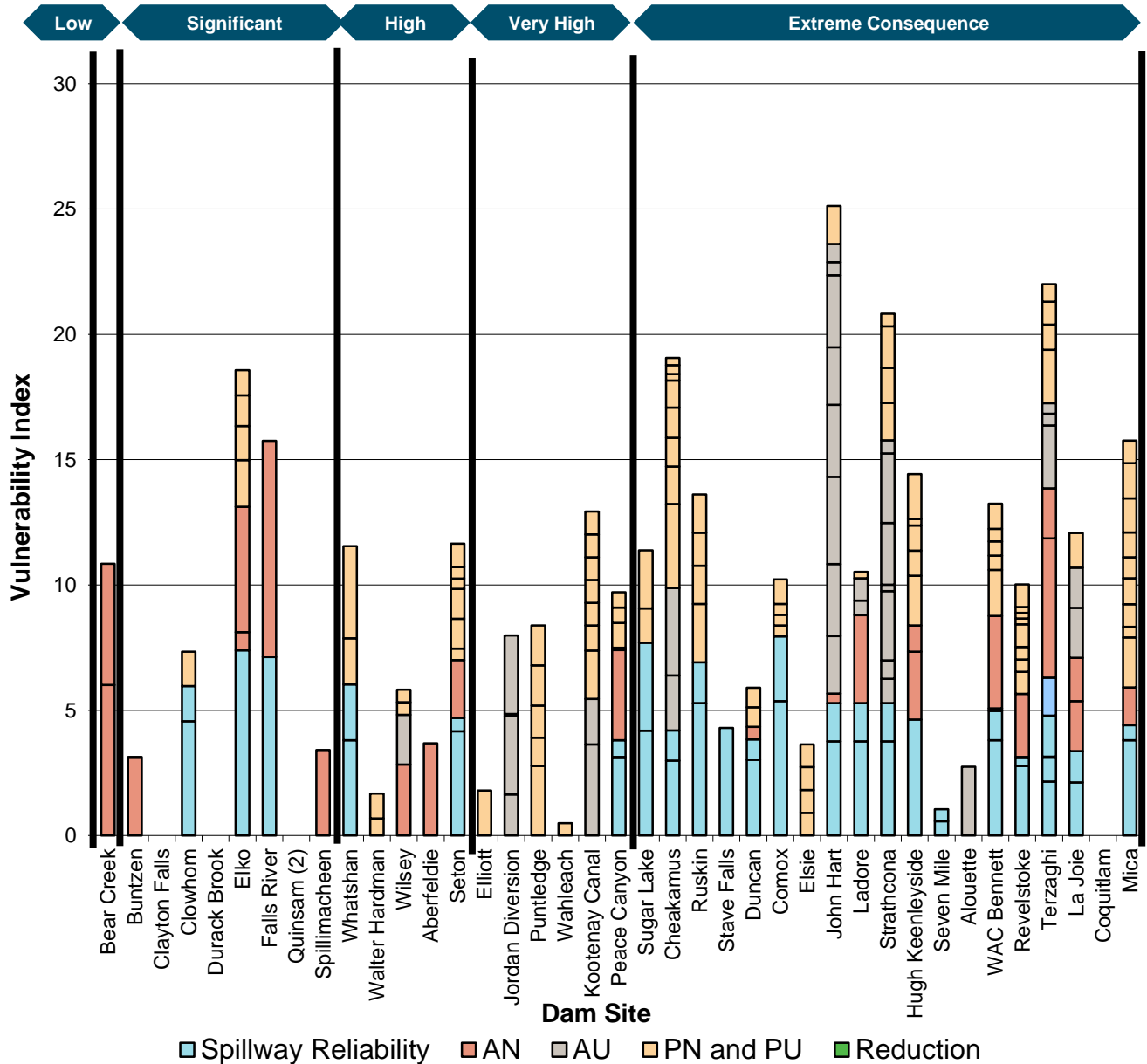


Figure 1 Dam Safety overall risk profile at the end of F2020 Q4, as represented by the Vulnerability Index. There were changes this quarter as indicated by the numbered boxes.

- AN** *Actual* deficiency (demonstrated to exist) under *normal* load conditions (associated with daily or short-term operations)
- AU** *Actual* deficiency (demonstrated to exist) under *unusual* load conditions (associated with flood and earthquake loading)
- 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 reliability of the dam’s spillway and/or other flood discharge systems

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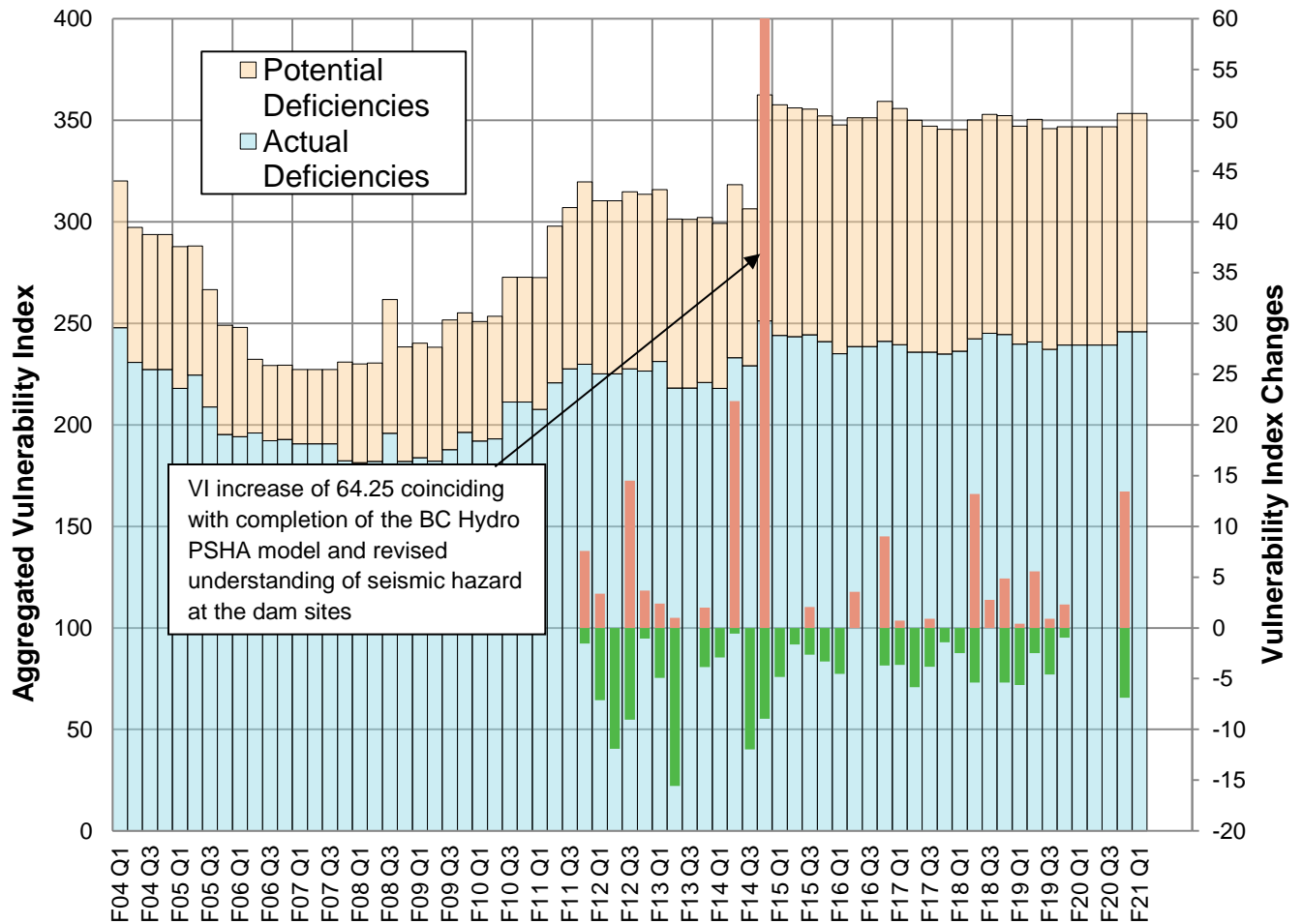


Figure 2 Changes and trends in the Vulnerability Index aggregated across the BC Hydro system. Note: the bars are “stacked” such that total aggregated Vulnerability Index is given by the top of the Potential Deficiencies bar.

New Issues

Pending Kinbasket Reservoir “Surcharge”

With generation at Mica limited to only two units for a significant period of 2020, higher than average inflows in both of the Peace and Columbia River watersheds, the oft-reported decrease in load related to the COVID-19 pandemic and, finally, the imperative to generate at the Peace River plants to condition Williston Reservoir for Site C Diversion, there is a strong probability that Kinbasket Reservoir will be “surcharged”, *i.e.*, rise above the licensed Normal Maximum Reservoir Level, and that spilling at Mica Dam will occur in August and September. Approval to operate Kinbasket Reservoir up to one foot (0.3 m) above the Maximum Normal Reservoir Level has been granted by the Comptroller of Water Rights, and all necessary inspections and tests of the spillway and outlet works structures and equipment have been completed in anticipation. An Interim Dam Safety Risk Management Plan has been prepared for use at Mica Dam during the reservoir surcharge; enhanced surveillance will be undertaken by a combination of staff from Dam Safety and Stations Field Operations.

Board briefing – DAM SAFETY QUARTERLY REPORT**Update on Existing Issues**

Last quarter's report described the Dam Safety Program's response to the COVID-19 pandemic and incidents at Hugh Keenleyside Dam, Ruskin Dam, and Jordan Diversion Dam. Updates of the response and follow-up to these incidents are described below. Please also refer to later sections in this report – namely "Capital Projects" and "Dam Safety Investigations" – for additional actions being taken to address previous incidents at Aberfeldie Dam (penstock leak) and Spillimacheen Dam (penstock inlet valve rupture).

Dam Safety Response to COVID-19

Dam Safety critical work such as dam inspections and spillway gate testing continued with very little impact. During Q1 there were no missed Dam Safety Inspections and only one spillway gate test was deferred. Other impacts to the program are described in the individual sections of this report.

Hugh Keenleyside Dam – Floating Guide Wall

As reported last quarter, on January 13, 2020, Pontoon Nos. 5 and 6 of the floating guide wall that directs marine traffic safely into Hugh Keenleyside Dam's navigation lock took on water and sank in high winds and below-freezing temperatures. The cause of the sinking has not yet been conclusively determined – a root cause analysis was begun but has not yet been completed – but water ingress into the pontoons through leaking seal and hatch covers is suspected.

Last quarter, a new issue relating to the compromised state of the boom's right anchor was raised. Since then, a new engineered anchor and connection between the boom and Pontoon No. 4 has been constructed, and this issue's Vulnerability Index will be reviewed and likely closed upon receipt of the associated engineering documentation. In addition, all excess accumulated water in the four remaining pontoons has been pumped out (some was later pumped back in as ballast to correct listing), all pontoon hatch covers and seals have been replaced, damaged anchor cables have been replaced and remaining anchor cables have been re-tensioned. An engineering report presenting long-term solutions for restoration of the guidewall has not yet been completed.

Ruskin Dam – Left Abutment

As reported last quarter, two sinkholes developed on the downstream slope of Ruskin Dam's left abutment, just upstream of the powerhouse and proximate to buried ductwork. Non-invasive investigations gave no indication that the sinkholes were the result of seepage from the reservoir or the adjacent G3 penstock. They were deemed not to pose an immediate safety risk to the dam, public or workers. Inspection and monitoring of the sinkholes is continuing and, since last quarter's report, the sinkholes have not appreciably grown in size and no new sinkholes have developed. The planned invasive field investigations have not yet commenced.

Jordan Diversion Dam – Public Safety Near Miss

As reported last quarter, on the evening of April 20, 2020, two members of the public had made their way into the river channel immediately downstream of Jordan Diversion Dam when the hollow cone valve was remotely opened, sending just over 40 cubic metres per second of water downstream. The warning siren did not sound prior to the valve operation. The members of the public escaped the river channel unharmed. A subsequent check of the siren found it to be inoperative, and the siren was promptly replaced. IMS #195340 "JOR: Member of the public reports water released downstream of

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Diversion Dam” was been entered as a Public Near Miss and, simultaneously, an incident investigation and Public Safety Review were launched.

The investigation considered whether a modification to the valve’s “ramp rate” – the rate at which it’s opened and flows are increased – would improve safety, but a trial concluded that there would be no significant safety benefit. Another option of extending the siren warning time prior to valve operation from the current five minutes to ten or fifteen minutes remains under consideration.

The Public Safety Review identified and recommended a number of repairs and improvements to warning devices, signage and barriers to the reservoir and river channel. Stations Field Operations has incorporated a number of the improvements into their F2021 work plan. The more substantive items – including replacement of the warning siren system that does not meet the guidelines published by the Canadian Dam Association – are being incorporated into the Investment Summary for a forthcoming public safety improvement project at the site. This project is planned to be released at the end of Q2 and completed by March 2022.

Compliance with Processes and Regulations**Regulatory Communications – BCUC**

The British Columbia Utilities Commission served BC Hydro with another round of Information Requests regarding the potential effects of induced seismicity from oil and gas industry operations in the Peace River region. These questions were submitted by Mr. Ben Parfitt of the Canadian Centre for Policy Alternatives on June 12, 2020 and passed onto BC Hydro by the BCUC on the same day. Responses to those 24 questions were provided to the BCUC on June 26, 2020.

Regulatory Communications – Comptroller of Water Rights

Regulatory Communications with the Provincial Dam Safety Office consisted of submissions required under the Dam Safety Regulation for invasive work and investigations at Kootenay Canal, Mica, Revelstoke and WAC Bennett. Approval was received for all of these requests. In addition, Dam Safety submitted a letter to the Comptroller of Water Rights supporting the request by Generation System Operations to surcharge the reservoir at Mica Dam.

Operation, Maintenance and Surveillance Manuals

Each dam has an Operation, Maintenance and Surveillance Manual (“**OMS Manual**”) for Dam Safety that identifies responsibilities and expectations within BC Hydro for maintaining the safety of the dam. The OMS 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 new Regulatory and Asset Planning department, described in last quarter’s report, is fully in place and the five new Regional Planning Engineers are familiarizing with their regions’ dams and taking on their new responsibilities, including the tasks required to manage updates to the OMS Manuals.

There are ten OMS Manuals scheduled for updating in F2021.

- Updates to the OMS Manuals for Seton and Wahleach Dams continued in Q1 as these are both due in F2021 Q2. The Regional Planning Engineer for Lower Mainland/Bridge/Coastal has been managing the updating and review of new content to meet this schedule.

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- There are four OMS Manuals scheduled to be issued in Q3: Bear Creek, Quinsam Diversion, Quinsam Storage, and Whatshan. Updating of the Quinsam Diversion, Quinsam Storage and Whatshan manuals was begun in F2020 and the Bear Creek Dam update was begun in F2021 Q1.
- There are four OMS Manuals scheduled to be issued in Q4: Elko, Buntzen, Coquitlam and Ruskin. The update to the Ruskin Dam OMS Manual was deferred from an earlier date pending receipt of documentation from the Seismic Upgrade Project required to support the update. Verbal acceptance on this delay has been provided by the Provincial Dam Safety Officer and formal written acceptance is forthcoming.

The work and delivery plans for the OMS Manual updates are depicted in Figure 3(a), below. Work is currently active on six of the ten updates and, at this early stage, is on track.

	Year-To-Date			Year-End	
	Actual	Target	Indicator	Forecast	Target
OMS Manual updates completed	0	0		10	10
Completion of F21 work plan	7%	7%	✓	Measure only	

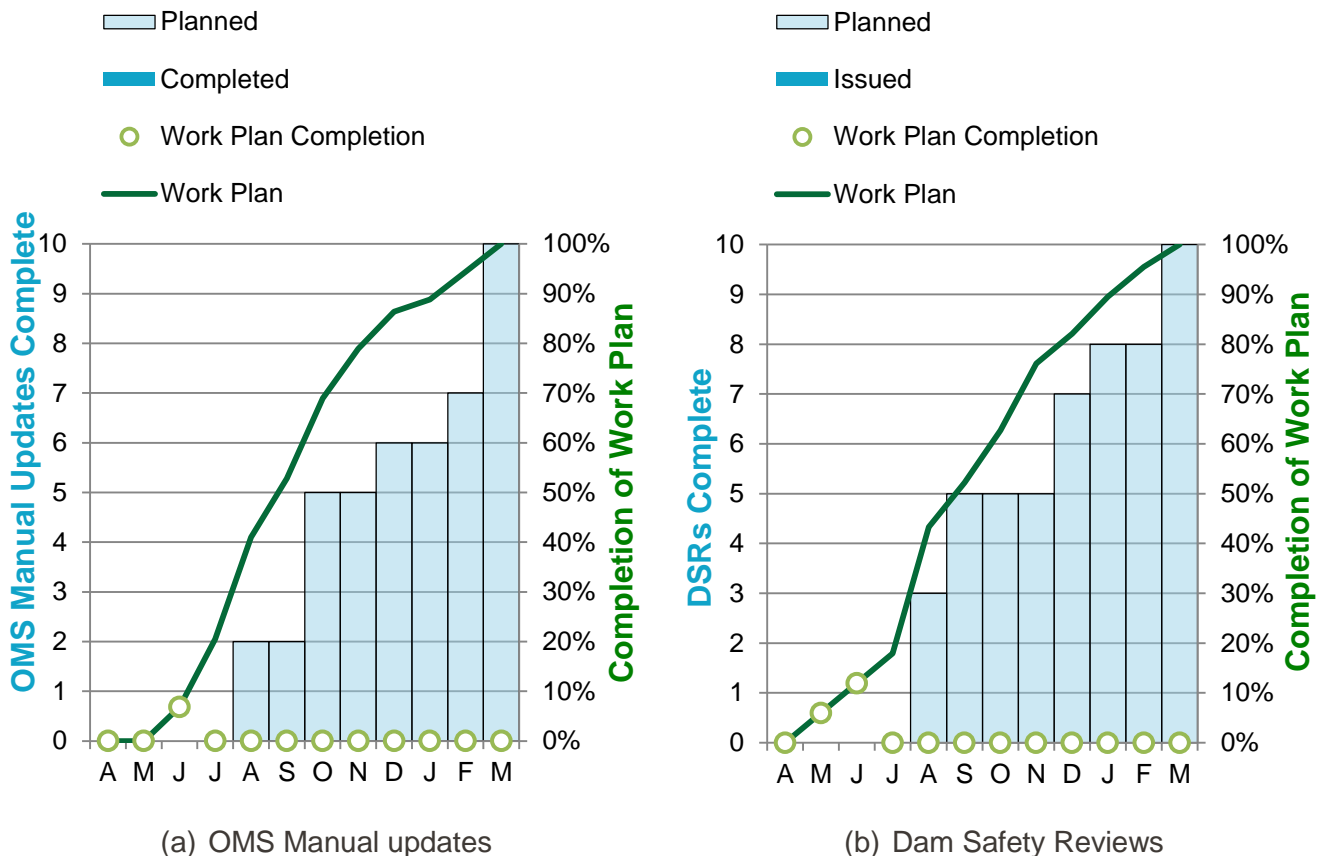


Figure 3 F2021 work and delivery plans for (a) OMS Manual updates and (b) Dam Safety Reviews.

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Dam Safety Reviews

Dam Safety Reviews are a regulatory requirement carried out at minimum intervals of every five to ten years for High, Very High and Extreme consequence dams.

Responsibility for managing the Dam Safety Reviews has transitioned to the new Regional Planning Engineers, who are taking over completion of the Dam Safety Reviews that are outstanding from F2020 as well as initiating the Dam Safety Reviews scheduled for F2021. Ten Dam Safety Reviews are slated for completion in F2021. The work and delivery plans for the Dam Safety Reviews are depicted in Figure 3(b), above. Work is currently active on nine of the ten Reviews and, at this early stage, is on track

	Year-To-Date			Year-End	
	Actual	Target	Indicator	Forecast	Target
Dam Safety Reviews completed	0	0		10	10
Completion of F21 work plan	12%	12%	✓	Measure only	

Of the five outstanding Dam Safety Reviews from last quarter, Ladore has been finalized and received from the external Dam Safety Review Engineer, although not yet distributed. Progress has continued on the other four:

- The Puntledge Dam Safety Review has also been finalized but is awaiting electronic signatures prior to issuing the report to BC Hydro.
- The second draft of the Kootenay Canal Dam Safety Review has recently been received in late July and a review meeting to finalize the findings has been scheduled.
- The Mica Dam Safety Review is in the process of being finalized by the Dam Safety Review Engineer and is expected to be received before the end of July.
- The first and second drafts of the Walter Hardman Dam Safety Review were received in Q1 and the report will be finalized in Q2.

There are five new Dam Safety Reviews underway in F2021 for Aberfeldie, Coquitlam, Jordan, Strathcona, and Sugar Lake Dams. Contracts have been finalized and site visits for all five sites will be carried out in Q2. The Coquitlam Dam Safety Review has had to be reassigned to a Canadian consultant due to COVID-19 restrictions on travel by the New Zealand based consultant originally assigned to this project. As a result, the start of this Dam Safety Review lags behind the others. However all five reviews are expected to be completed by the end of F2021.

Recommencement of the Ruskin Dam Safety Review has been postponed until F2021 Q4 to ensure that the information required for the review is available from the Seismic Upgrade Project. Verbal approval has been provided by the Provincial Dam Safety Officer and formal written acceptance is forthcoming.

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Surveillance

Inspections

Routine weekly / 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.

Despite the complicating effects of working during the COVID-19 pandemic, all 411 scheduled site inspections were completed in Q1.

Routine Inspections	F21 Year-to-date	F20	F19	F18	F17	F16
Completed	411	1642	1638	1595	1583	1594
Missed	0	6	2	16	29	24

Instrumentation and Monitoring

The Regional Dam Safety Technologists continue to build on last fiscal's initiative to drive consistent, regular checking of instrumentation data plots at all dams to identify any unusual trends and to ensure continued accuracy of the data being collected. They are each tasked to perform three such checks per week. During Q1 of F2021, 223 checks were completed, exceeding the target of 195.

Reservoir Slopes

Dam Safety's Slope Surveillance Program continued through F2021 Q1. Ongoing surveillance comprised the completion of all planned inspections—two aerial inspections and six site landslide inspections—and continuous monitoring of the Reservoir Slopes Instrumentation System. Our reservoir slopes personnel also provided oversight of the Downie Slide Instrumentation Project and the 731 Block Slope Stabilization Project, both associated with Revelstoke Dam.

Unusual Events or Observations

The Dam Safety On Call Person (DSOP) responded to 217 calls in Q1 of F2021. The calls included instrumentation alarms, operational inquiries, operations notifications during floods and earthquake notifications.

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Maintenance

As of F2021, Dam Safety has taken on elements of maintenance planning and, jointly with Generating Stations Maintenance Planning (“GSMP”) within Stations Asset Planning, will prepare and administer the annual maintenance plans for the dams and generating stations. Consolidated Dam Safety / GSMP maintenance plans will be developed to avoid competition for the same program management, construction and/or operational personnel to deliver the plans. These plans will be jointly owned and approved by the Directors of Dam Safety and Stations Asset Planning and delivery of the plans will be regularly reported to those Directors.

The Maintenance Planning Engineer in Dam Safety’s new Regulatory and Asset Planning department will be responsible for the project-focused Civil Maintenance Program as well as the Civil Preventive Maintenance Program, working with the Dam Safety Engineers and Regional Planning Engineers to identify and prioritize the civil maintenance needs for the dam assets and with GSMP to receive and prioritize civil maintenance needs for the generating stations. These identified needs will then be integrated into a consolidated civil maintenance plan for the dams and generating stations, delivery of which (by Program and Contract Management in Operations) will be monitored through the year.

In a parallel process, required electrical and mechanical-based maintenance of dam assets, principally the gates and valves for water passages, will be identified and prioritized by Dam Safety personnel working in collaboration with GSMP. GSMP will integrate these needs with those of the generating stations and prepare a consolidated, “non-civil”, Stations maintenance plan for the dams and generating stations. GSMP will monitor the delivery of the program and apprise Dam Safety of progress.

This arrangement is depicted schematically in Figure 4, below.

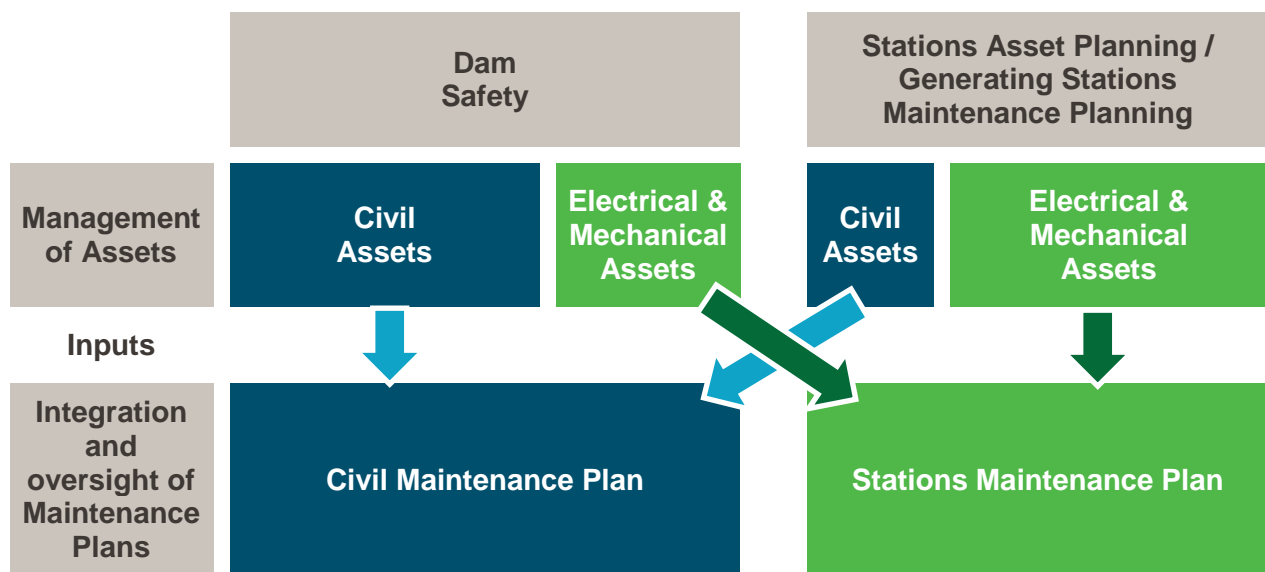


Figure 4 Schematic arrangement of asset and maintenance planning responsibilities between Dam Safety and Stations Asset Planning and the development of consolidated maintenance plans.

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This arrangement will result in a significant improvement to Dam Safety's decision-making and oversight of the maintenance of dam-related assets. Details of the procedures and governance for this arrangement are being developed. Over the past 3 months and the coming 6 months, Dam Safety is focussing on:

- Integrating Dam Safety into existing maintenance processes and business rules;
- Developing the F22 Civil Maintenance plan with engagement and input from Dam Safety and GSMP personnel; and
- Establishing stronger oversight and clarified prioritization of spillway gates maintenance.

Civil Maintenance

As of the end of Q1, the Civil Maintenance Program has completed five projects; three dam safety projects – La Joie Dam face joint and shotcrete repairs, Cheakamus Shadow Lake and Roe Creek bathymetric survey, and Salmon River Diversion Canal drain clean out and inspection – as well as two generating station-related projects at Revelstoke.



Figure 5 Shotcrete undergoing repairs on the La Joie dam face.

BC Hydro's F2021 maintenance programs have been adjusted to reflect work delays and cost pressures arising from the COVID-19 pandemic. Within the Civil Maintenance program, five planned projects have been deferred to F2022, reducing the F2021 budget from \$4.0M to \$3.737M and project count from 41 to 36. The deferred projects are: 1. Revelstoke Dam Spillway Bridge Repairs; 2. Revelstoke Dam "T" Block Pressure Washing; 3. Mica Dam Right Abutment Access Repairs; 4. Cheakamus Earthfill Dam Concrete Cap Moss Removal; and 5. Cheakamus Tunnel Shotcrete Repair. In making the decisions to defer this work, the Dam Safety Engineers for these facilities were

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consulted and determined that this work could be deferred until F2022 without significant deterioration of the safety of those structures.

Dam Safety has now begun monitoring the delivery of the Civil Preventative Maintenance Program. In F2021 Q1, 98 preventative maintenance tasks were completed on a plan of 149, which Dam Safety understands to be reflective of the impacts of COVID-19 pandemic work protocols. Progress in civil preventative maintenance is now being monitored on a monthly basis and will be reported in forthcoming quarterly reports.

Spillway Gate Testing and Maintenance*F2021 Q1 Results*

During Q1 of F2021, 59 of the 60 scheduled gate tests at 23 sites were carried out. The missed test was at La Joie Dam, where testing of discharge valves (pressure relief valve and two hollow cone valves) was deferred by the site due to resource constraints. The decision to defer the testing had not been discussed with Dam Safety in advance, however, and the importance of doing so has since been impressed upon the field manager.

One gate system failed to operate on demand during testing, when the gantry crane on the deck at Ruskin Dam suffered a control failure and maintenance stoplogs could not be removed from the opening of Spillway Gate 3. In eight other cases, while gates did operate on demand, certain individual components of the gate system that are critical to one or more operational paths of a gate – “lines of defence” – malfunctioned.

A total of 29 corrective maintenance issues were identified while a total of 26 new and previous issues were addressed in Q1 of F2021, for an increase of three overall and an accumulated total of 174 corrective maintenance and procedural issues outstanding at the end of June 2020.

Assessment of Spillway Gate Maintenance since 2006

Emerging issues identified through the course of gate testing are frequently brought forward and executed in the same year. Since the gate testing program began, an average of 66 issues per year has been completed within 6 months of being identified. Nevertheless, previous reports have shown there to have been a continual and consistent growth in the number of outstanding maintenance issues on the spillway gates since monthly testing and tracking was initiated in 2006. This growth over time is shown in Figure 6, which plots the numbers of issues identified (tan bars) and closed (blue bars) in each calendar year. On average, maintenance activities have closed only about 87% of the number of issues identified in any given year. The resulting steady accumulation of outstanding issues – now standing at 174 – is shown by the dark blue line.

These outstanding gates maintenance issues have been broken down into:

1. “Line of defence” issues, which comprise failed or defective major components and other failed or defective components that have or potentially will lead to the operational failure of the gate system or one of its operational paths. Some examples are the failure of a diesel generator where the primary AC power feed or other backup power sources remain online, or the failure of a primary control circuit with the backup circuit remaining operational.

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- Other deficiencies that, while not presently impacting one of the gate’s operational paths, contribute to overall deterioration of the gates system. Some examples are aging and degraded components, such as hydraulic hoses, and poorly operating mechanical components like seized gate rollers.

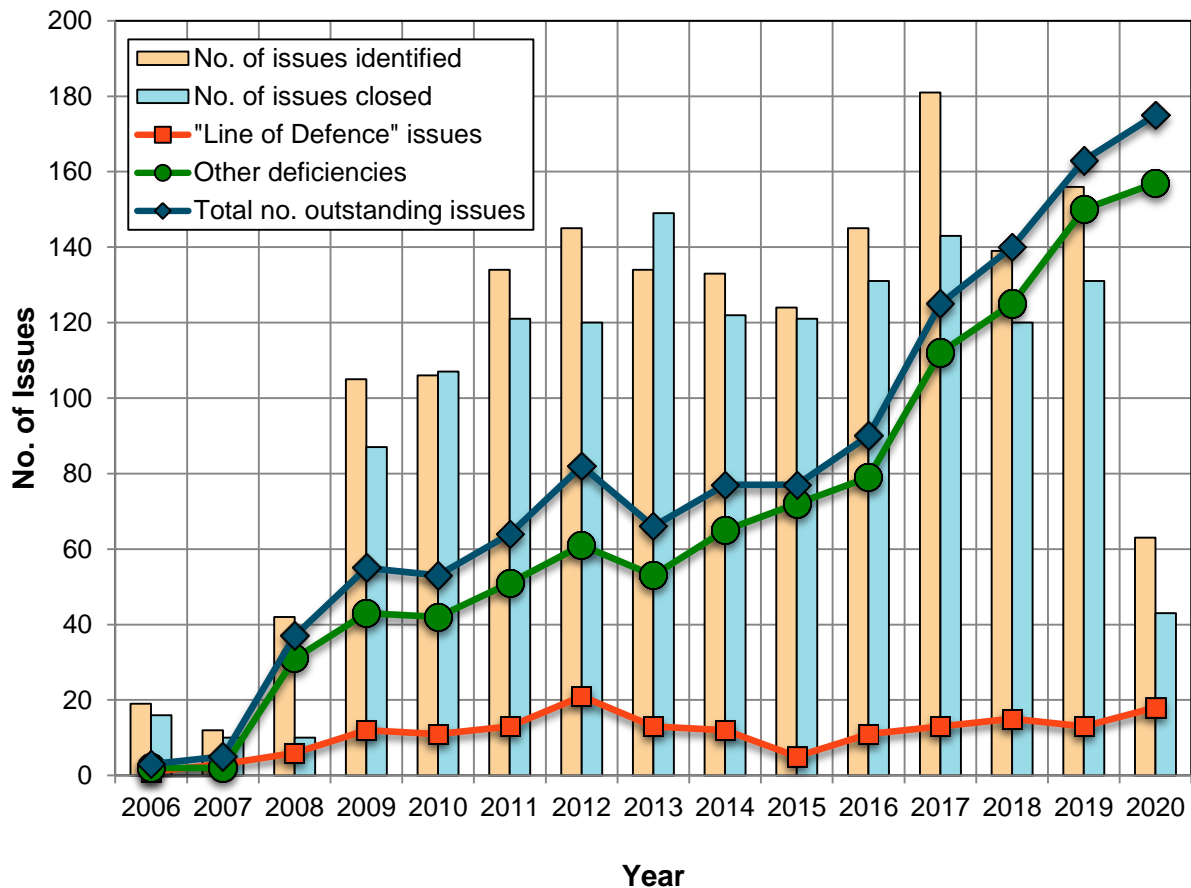


Figure 6 Number of cumulative identified and outstanding CO/CB/Procedural Issues at the end of each calendar year.

Figure 6 further shows the growth trends of outstanding issues with this breakdown. While there has been a significant growth in the “other deficiencies” category – represented by the dark green line in Figure 6 – there is a comparatively positive picture when it comes to the line of defence issues – the orange line. Owing to their relative criticality to the gates systems, line of defence issues have, in general, been resolved on a timely basis, such that the number of outstanding line of defence issues has remained relatively constant and manageably small over recent years. In this regard, maintenance has adequately addressed the direct and immediate risks related to spillway gates failing to operate when needed.

The significance of the growth in the “other deficiencies” category is not to be discounted, however. As mentioned above, the accumulation of such deficiencies leads to the overall deterioration of the condition and reliability of the gate systems, *i.e.*, it is a leading indicator of future gate performance.

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Moreover, it leads to a condition of “normalization of deviance”, which prevailed in BCH’s spillway gate systems before the start of the Gates Program in 2005, and is a root cause of safety incidents in the dam industry (e.g., Oroville spillway 2017) as well as other high hazard industries. It is therefore important to identify and implement the means to arresting and reversing the current trend of growth.

F2021 Spillway Gates Maintenance Plan

The current F2021 maintenance plan contains \$349k in approved funding to address 36 outstanding issues from prior years related to gate reliability. Seven of those are line of defence issues, while the remainder are “other deficiencies”.

Next Steps

As described previously in this report, Dam Safety is assuming a more active role in the management and oversight of the maintenance of dam-related assets, including flood discharge gate systems. Dam Safety is taking steps to inject itself into the existing management processes around maintenance and to obtain more complete and more timely reporting of the status of gate maintenance. A method to prioritize spillway gate maintenance activities in a manner that reflects the safety-critical nature of spillway gate systems and is compatible with existing GSMP practices is under development. And further, although historical data is not complete enough to support a quick and simple analysis, efforts are underway to evaluate the costs that would be incurred in performing spillway gate systems maintenance to a level that would substantially reduce the current backlog and then keep pace with newly identified issues. Improvement of Dam Safety’s oversight of spillway gate maintenance – and all other dam-related maintenance – is a high priority for F2021 and progress will be reported to the Board each quarter.

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 other reports for quarterly updates on emergency preparedness and public safety around dams.

In Q1 of F2021, a Public Safety Review of the Jordan Diversion and Elliott Dams and the Generating Station was performed. The area was assessed for known and potential public interactions with safety hazards and was risk rated according to the Canadian Dam Association Guidelines for Public Safety Risk Matrix. The findings were described previously in “Update on Existing Issues”.

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 for the projects where significant developments occurred or milestones were achieved.

Work on Dam Safety capital projects continued in F2021 Q1 under the “Work Management during Pandemic” protocols. In general, the engineering design work for projects in the Identification and

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Definition Phases continued without serious impediment, although there were instances where planned site investigations were delayed and corresponding design schedule delays arose. Projects in construction within the Implementation Phase, however, generally experienced delays as BC Hydro scaled back work at dam sites and generating stations to manage the numbers of workers and risks of virus exposure to our personnel. Construction work has slowly ramped back up through the summer and all projects are advancing, albeit on revised schedules. This is typical of projects across all BC Hydro portfolios. Please refer to the Quarterly Major Capital Projects Report for additional details.

Ladore Dam – Spillway Seismic Upgrade

In Q1, the Capital Projects Committee provided approval for the preferred alternative – which includes complete replacement of the spillway gates, hoists and hoist structure, reliability upgrades via new controls and power supplies, and reinforcement of the spillway piers – and funding for Definition and Partial Implementation work.

Mica/Revelstoke Dams – Vertical Movement Gauges

As part of the original construction of the Mica and Revelstoke earthfill dams, vertical movement gauges (“**MVs**”) were installed in the dam’s cores to monitor settlement and lateral displacement. Sudden, periodic water level drops observed in both the Mica and Revelstoke MVs have given rise to the concern that the MVs create conditions in the core that could induce hydraulic fracturing and/or internal erosion. The objectives of this project are to seal the MV casings with grout, so as to address that concern, and to make appropriate use of the MV casings to install additional instrumentation.

In Q1 the project progressed into Implementation Phase and the contracts for grouting of the MVs were awarded and construction activities commenced. The grouting of seven core MVs at Revelstoke Dam is scheduled to be completed by the end of July 2020 and six core MVs at Mica Dam by the end of September 2020. This work will significantly reduce the risks of hydraulic fracturing and internal erosion in these dams. Installation of additional instrumentation within the MV casings is expected to be complete by the end of Q1 in F2022.

Revelstoke Dam – Concrete Dam Instrumentation Upgrade

A number of the piezometers monitoring the uplift pressures beneath the concrete gravity dam at Revelstoke have either failed or are nearing end-of-life. Moreover, there are no foundation piezometers installed in the transition (T) blocks of the concrete dam. This project started in Q2 of F2020, and a single viable alternative was subsequently endorsed to replace the failed and faulty piezometers and to install new piezometers in order to fill in uplift pressure measurement gaps. In Q1 of F2020, funding for the Feasibility Design Stage was approved and work commenced to prepare the feasibility level design.

Spillimacheen Dam-Tunnel Plug Installation (New Project)

The Spillimacheen Powerhouse has been out of service since March 2019, when a penstock inlet valve (PIV01/02) ruptured due to freezing and caused an uncontrolled release that flooded the powerhouse. Over the past winter, temporary measures to protect the integrity of the water barrier – heaters to prevent ice build-up in front of the stoplogs and to prevent freezing damage to the remaining penstock inlet valve and components of the blanking plate that replaced the failed valve – were implemented and enhanced surveillance, monitoring and emergency response procedures were put in place through an Interim Dam Safety Risk Management Plan. Without such mitigation

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measures, freezing in extreme cold winter weather could have led to a repeat of the failure and uncontrolled release that occurred in 2019.

The Facility Asset Plan for Spillimacheen Dam lays out a strategy for safely mothballing the station until decommissioning and dismantling can be undertaken. A permanent solution to isolate the water conduits is desired to bring the station to such a safe state. This project will install a concrete plug within the intake structure at the upstream end of the tunnel, targeting to do so in Q3 before the coming winter freeze-up. The tunnel plug will be designed to function as a permanent structure but is expected to include features that would facilitate the plug's removal in the event that refurbishment of Spillimacheen Generating Station is eventually re-contemplated.

WAC Bennett Dam – GMS Spillway Gate Upgrade

The objective of this project is to improve the reliability of the WAC Bennett Dam spillway gate system through selected replacement of protection and control, electrical and mechanical hoist equipment and installation of an additional diesel generator for post-earthquake emergency backup power. Broader scoped and longer-term upgrades for post-seismic functionality have been deferred to future projects. This project addresses 14 of the 27 specific issues associated with the WAC Bennett Dam spillway gates.

In F2021 Q1 the spillway gates hoist and electrical upgrades were put into service and the gates were recommissioned to partial (5-foot) opening. Work to complete the installation of the new backup diesel generator is continuing and full-open gate testing and commissioning is scheduled for spring 2021.

Dam Safety Investigations

Dam Safety Investigation Projects (“DI”s) are generally performed to either refine knowledge regarding potential issues or non-conformances of information recorded in Dam Safety’s Issue Database or to perform precursor work for planned capital upgrade projects. In Q1 of F2021, Dam Safety initiated eight new Dam Safety Investigations ranging from small DIs with short duration to complex, multi-year, multi-disciplinary ones, as summarized below.

Aberfeldie Dam – HDPE Penstock Repair Options

The penstock at Aberfeldie Dam developed a significant leak in May 2019 and subsequent inspections revealed numerous failures of welds in the high density polyethylene walls. Repairs were undertaken between May and October of that year and the penstock was returned to service on January 6, 2020. These repairs notwithstanding, manufacture of the penstock’s elbow joints has been shown to be deficient and the risk of leaks developing in this penstock is higher than in other penstocks in our system. The penstock has been returned to service under an Interim Dam Safety Risk Management Plan that identifies enhanced surveillance and monitoring of the penstock as well as response procedures in the event of a detected leak. The objective of this DI is to recommend long-term repair options that will establish the long-term fitness of the penstock so that the Interim Dam Safety Risk Management Plan can be removed.

Board briefing – DAM SAFETY QUARTERLY REPORT**Cheakamus Dam – Updating Flood Parameters and Performance Assessment of Discharge Structures**

This investigation project is aiming to fill in a number of information gaps needed to better plan and scope out a planned capital upgrade project to address the seismic and flood passage deficiencies at Cheakamus Dam. The objective is to update Cheakamus Dam's Inflow Design Flood and assess the dam's discharge and flood passing performance – particularly via the unlined emergency overflow channel, through the application of sophisticated, Computational Fluid Dynamics modelling tools.

Elsie Dam – Performance Assessment of Dam

Elsie Dam is located on the Ash River, approximately 40 km northwest of Port Alberni on Vancouver Island. The overall objective of this DI is to assess the performance of the Elsie Main Dam and its components for normal and unusual loading conditions. First and foremost, there is limited design information available to confirm the stability of the dam and to rationalize the location and reading frequency of the instrumentation; this DI will perform site investigations to “reverse engineer” the dam's design and construction. Other key issues and deficiencies to be investigated are: unknown seismic resistance of the Main Dam and its appurtenant structures, particularly the potential for crest settlements leading to overtopping after an earthquake; and the potential for internal erosion through the original fill of the Main Dam and Saddle Dam 1.

Hugh Keenleyside Dam – Assessment of Right Abutment Berm Performance

The right abutment berm at Hugh Keenleyside Dam was constructed in 2015 to address excessive seepage and potential erosion of the dam's right abutment. In March 2018, the tailwater elevation was sufficiently low to expose the entire berm for inspection. It was then observed that fine sand and silt resembling the native soils in the abutment had accumulated at the toe of the downstream rip rap slope, leading to concerns that seepage may be carrying native soil through the reverse filter berm and that the berm may not be fulfilling its design intent. The objectives of the first stage of this DI are to: identify any potential deficiencies in the design and construction of the right abutment berm; determine whether interim risk mitigation measures are required, and if so, develop option(s); and develop a work plan for successive stage(s) of the investigation.

Peace Canyon Dam – INOG E-Close Assessment and Test Planning

Peace Canyon is the only large plant in the BC Hydro system that does not currently perform emergency close testing on its penstock intake gates. In accordance with the Operation, Maintenance and Surveillance Manual and in order to verify its ability to close under flow, a Full Flow Closure Test on the intake gates must be performed. This investigation consists of hydraulic, structural, and mechanical assessments that are necessary precursors to the development of a test plan to safely verify the ability of the Peace Canyon intake gates to close under flow. The actual emergency close testing is presently expected to take place in F2022.

Peace Canyon Dam – Stability Assessment of the Spillway Blocks and Flip Bucket Structures

Peace Canyon Dam is founded on sedimentary rock with a number of underlying, relatively weak bedding planes. The dam relies upon efficient drainage to achieve acceptable sliding factors of safety under normal and unusual conditions, and seismic analyses using simplified methods of analysis have indicated that some blocks of the dam do not have sufficient resistance to earthquake loading. Moreover, use of the spillway has resulted in the development of a downstream scour hole within the

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plunge pool that is deeper and has flatter slopes than was initially expected by the designers. Over time and without strict controls over spills, the scour hole would work its way back to the dam and potentially undermine the dam's stability. Spills at Peace Canyon are therefore limited and carefully monitored.

The objective of this multi-year, multi-disciplinary DI is to investigate the stability, overall, of the concrete dam and the factors that affect it. Anticipated activities are to: establish a detailed baseline survey of the scour hole for future monitoring and hydraulic modelling; develop and calibrate a computational fluid dynamics model of the spillway and plunge pool to assess effects of varied spillway operation and/or armouring on the progression of erosion; update characterization of the foundation's bedding planes for use in future stability analyses; develop a three-dimensional finite element model of the dam that incorporates and considers the linear and nonlinear interactions between the individual dam blocks, the buttressing powerhouse structure, their foundations (including rock downstream of the spillway blocks and upstream of the plunge pool) and the reservoir, and use that model to assess the dam's mechanisms and capacity for stability in normal, earthquake and post-earthquake conditions; and, finally, develop high-level, conceptual alternatives for works to remediate any verified deficiencies. This DI is expected to extend through F2024 and possibly into F2025.

Terzaghi Dam – Hydraulic Assessment of Spillway and Spillway Chute

The spill facilities at Terzaghi Dam consist of two low level outlets, a 2-bay gated spillway, and an overflow weir. A 2011 BC Hydro study concluded that the spillway chute was originally designed (in 1956) to pass the 1-in-1000-year flood and, based on 1959 model study results, the chute walls may not be high enough to contain the required discharge for the current Probable Maximum Flood. Overtopping of the left chute wall could cause erosion of the dam structure. The objectives of this DI are to: assess water surface profiles in the spillway headworks and assess the potential for wall overtopping; assess tailrace flow patterns and potential for erosion; and investigate whether potential spillway structure deficiencies (e.g., slab offsets, spalls, and cracks) might lead to cavitation and assess the implications for operation and maintenance.

Waneta Dam – Performance Assessment of Dam and Intake/Spillway Structures and Discharge System

In 2010, BC Hydro purchased a one-third share of the Waneta Dam and Generating Station, and in 2018 BC Hydro purchased the remaining two-thirds interest in the facility from Teck Resources Limited. The Waneta project consists of a concrete gravity dam and a four-unit hydroelectric generating station located on the Pend d'Oreille River just downstream of Seven Mile Dam. Waneta Dam is a "High" consequence dam. There is, as yet, no summary description of Waneta Dam available in the Dam Safety "book" in Diligent.

Waneta Dam has two characteristics that suggest there could be potential issues requiring upgrades. Firstly, the design and condition of the spillway gate systems are similar to BC Hydro facilities prior to the initiation of the Spillway Gate Reliability Program about 15 years ago, which suggests that reliability upgrades may be required. Secondly, previous stability assessments have resulted in inconsistent and inconclusive findings and recommendations for the need for seismic reinforcement or anchoring of the dam body and spillway piers. Two capital upgrade projects – spillway gate reliability and dam stability improvement projects – are provisionally planned to be released in F2026 and F2029, respectively. The objectives of this multi-year and multi-disciplinary DI are to conclusively establish the needs for these projects and their respective scopes.