

**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 July 1, 2019 to September 30, 2019, 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 Dam Safety Program has been executed in a manner that is consistent with its stated objectives throughout the reporting period. The overall Dam Safety risk profile is shown in Figure 1. There has been no change in assessed risk this quarter.

With this quarter's report, a new feature is being introduced. A Dam Safety "book" has been added to the Board's "Diligent" platform, wherein brief descriptions of BC Hydro's dams and summary status updates of Dam Safety initiated capital projects and investigations will be available for reference. Dam descriptions and capital project summaries are now loaded into the book. Summaries of investigations will be added in the near future.

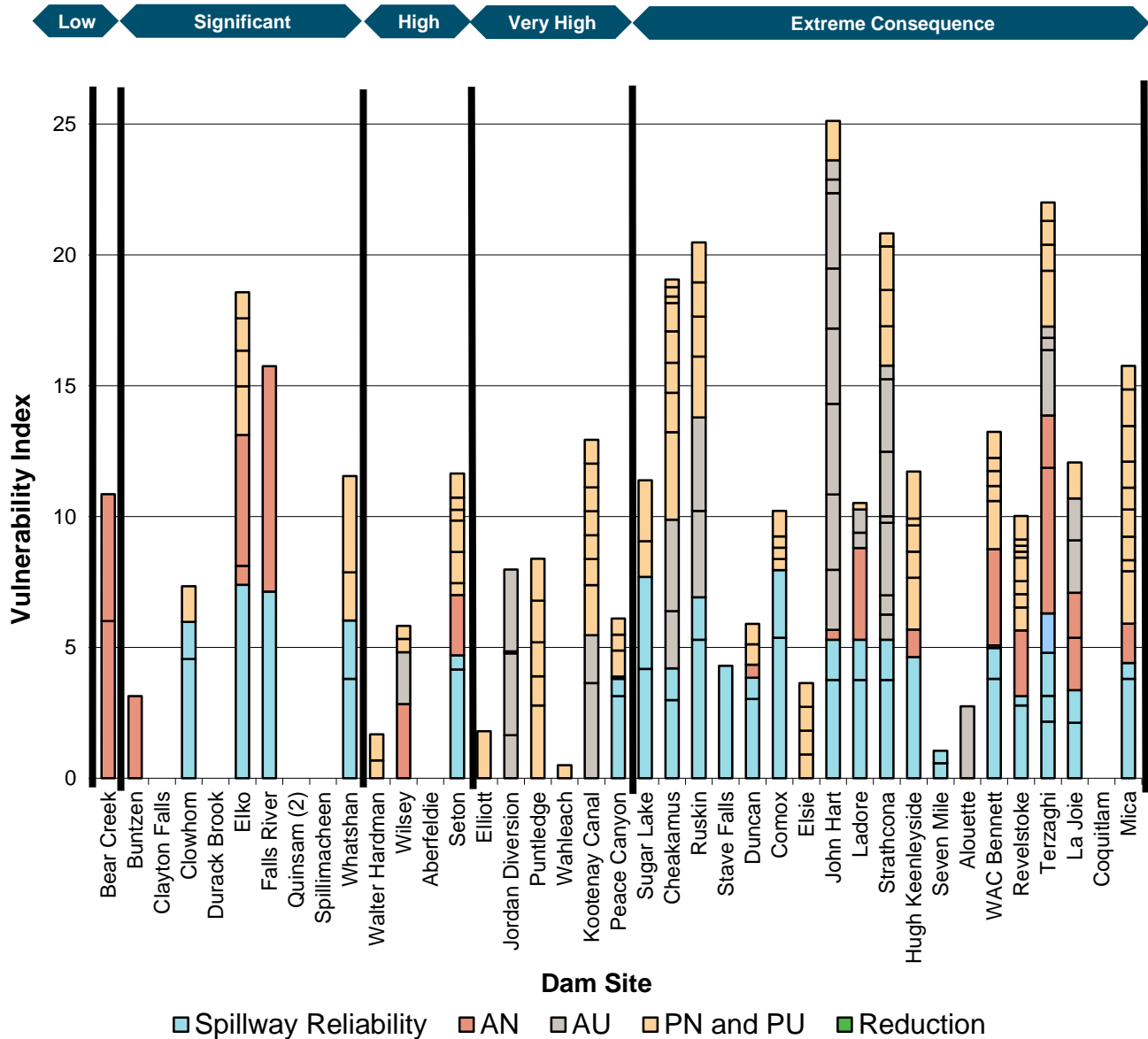
**Risk Profile of BC Hydro's Dam**
**Dam Safety Contribution to Enterprise Risk**

Dam Safety is assigned a high "risk priority" within BC Hydro's Enterprise Risk report, as depicted below. This high rating is arrived at by recognizing that: (1) there can be extremely severe consequences from the failure of a dam; (2) a dam failure can progress quickly without leaving adequate time to take effective actions to reverse the failure; and (3) our ability to mitigate this risk is considered to be "moderate" given that upgrades to existing dams are typically expensive, time and resource intensive and frequently technically challenging. The nature of dam safety risk is that it can only be realistically managed by minimizing to the extent practicable the probability of occurrence through a well-constructed and well-executed Dam Safety Program.

Risk	Severity	Likelihood	Speed of Onset	Ability to Mitigate	F20 Q2 Risk Priority	Change from Last Quarter
<b>Dam Safety</b> <i>Risk of a dam safety incident</i>	H	L	Fast	M		<ul style="list-style-type: none"> <li>For F20 Q2 the overall Dam Safety risk is stable.</li> </ul>

Given the nature described above, this Dam Safety component of the Enterprise Risk is not expected to change from quarter to quarter. Neither is it expected to diminish over time in response to dam upgrade projects delivered within the Capital Plan, such projects being intended to adequately manage this aspect of BC Hydro's risk rather than eliminate it.

Board briefing – DAM SAFETY QUARTERLY REPORT



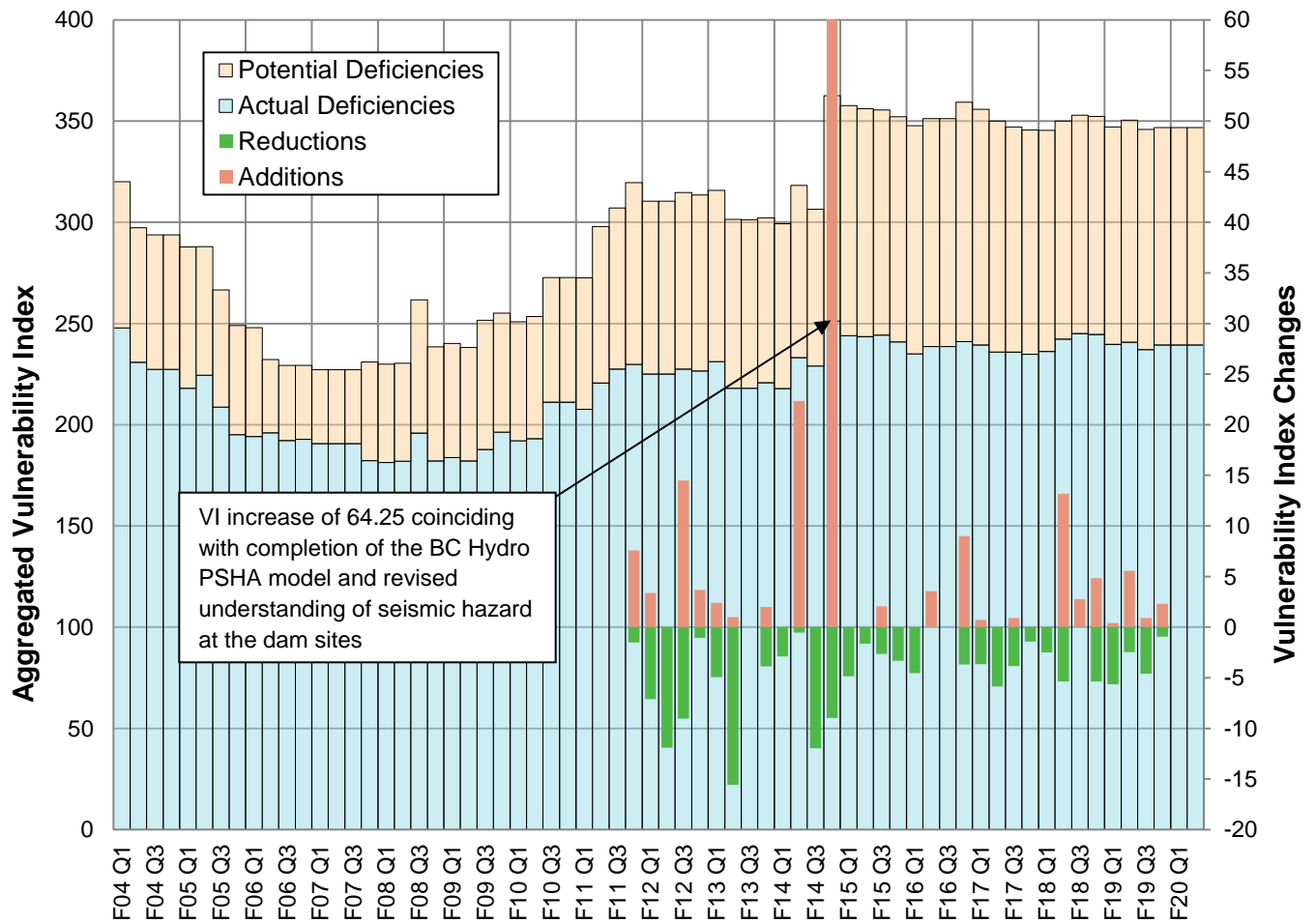
**Figure 1** Dam Safety overall risk profile at the end of F2020 Q2, as represented by the Vulnerability Index. There were no changes in this quarter.

- 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

**Board briefing – DAM SAFETY QUARTERLY REPORT**
**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, the higher the likelihood of that deficiency leading to poor performance. The aggregated Vulnerability Index for all deficiencies at a particular dam characterizes the extent of concern for the dam’s poor future performance from all causes.

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. No Vulnerability Index changes relating to identified physical deficiencies were made in F2020 Q2.



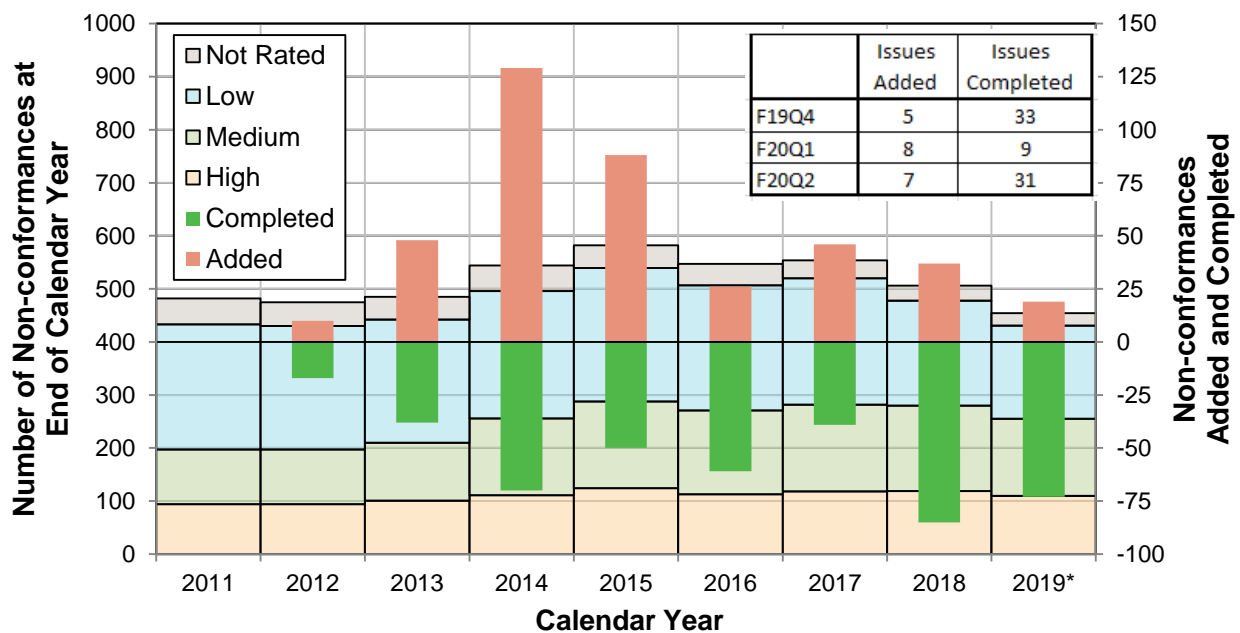
**Figure 2** Changes and trends in the Vulnerability Index aggregated across the BC Hydro system. Note: the bars are “stacked” such that total aggregated Vulnerability Index is given by the top of the Potential Deficiencies bar.

**Board briefing – DAM SAFETY QUARTERLY REPORT**

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 on the preceding page. This is an indication of the changes in the understanding of BC Hydro’s dam safety risk profile over time. Additions are due to the development or recognition of new issues. Reductions are due to risk remediation projects delivered through the Capital Plan, completed repairs and corrective maintenance, and resolution of issues via Dam Safety Investigations. Existing issues are re-examined on a regular basis and re-rated as required. As indicated by the uniformity of the height of the stacked blue and sand-coloured bars, BC Hydro’s intent to not allow an overall increase in the dam safety risk profile continues to be realized.

**Non-Conformances in the Dam Safety Program**

The risk profile of BC Hydro’s dams—and our understanding of it—is very much dependent upon the effectiveness of the operational, maintenance and surveillance procedures in place and being utilized within the Dam Safety Program. Effective and rigorously followed procedures are required to collect and interpret the observations and measurements necessary to verify the adequacy of the physical performance of the dams. Non-conformances are identified through a number of activities within the Program, including Dam Safety Reviews performed by external consultants that function as the Dam Safety Program’s independent review. Program non-conformances are identified and tracked in the Dam Safety Issues Database and rated as being of high, medium and low importance. The overall numbers of non-conformance issues by calendar year are plotted in Figure 3.



**Figure 3** Changes and trends in the total number of non-conformances within the Dam Safety Program. This data is plotted by *calendar year*.  
 Note: \*2019 reflects the first nine months—January through September—of the present calendar year.

**Board briefing – DAM SAFETY QUARTERLY REPORT**

Previous reports have identified the growth of non-conformance issues in the database through 2015 and the more recent efforts to reduce those numbers. Since the start of calendar year 2019, scheduled database reviews for individual dam sites have included rigorous reviews of the non-conformance issues, ensuring the status of completed issues is updated and duplicate issues are consolidated or closed. As a result, 73 issues have since been resolved while only 19 new issues have been added for a net reduction of 54 issues. The number of non-conformance issues at the end of Q2 (454) is ten percent smaller than at the end of 2018, is 22 percent smaller than the 2015 peak, and is smaller than at any time in the last decade.

This “cleanup” of non-conformance issues in the database is the first step. A broader strategy to reduce the number of non-conformances within the Dam Safety Program is under development as a component of Dam Safety’s F2020 Business Plan, and will be presented in the next quarterly report.

**New Issues**

There were no significant new issues to report this quarter.

**Update on Existing Issues****Spillimacheen**

Work to prepare the site for winter is progressing. The intake stoplogs are not considered suitable for the potential ice loads and must be removed before freeze up. To allow removal of the stoplogs and subsequent filling of the tunnel, the damaged penstock intake valve (PIV) was removed and replaced with blocking flanges (Figure 4). Work to install heaters and thermal monitoring equipment in the surge tower building is underway. The heaters are required to prevent water from freezing and rupturing the steel pipes upstream of the PIV and blocking flange. This work, including removal of the stoplogs, is expected to be completed by mid-November.

An Interim Dam Safety Risk Management Plan that describes the requirements for enhanced surveillance and monitoring and emergency response procedures is in preparation and will be implemented prior to removal of the stoplogs.



**Figure 4** Blocking flanges and bypass valve installed to replace the damaged penstock intake valve at Spillimacheen.

**Board briefing – DAM SAFETY QUARTERLY REPORT****Aberfeldie Penstock Repair**

Repairs to the HDPE penstock at Aberfeldie Dam continued through the second quarter. Failed welds were repaired at eight elbow joints, but further investigation has revealed additional areas that require repair. Work to repair compromised welds is continuing.

Installation of monitoring equipment designed to detect a leak in the penstock started late in the second quarter and is expected to be completed by mid-November. The monitoring system is designed to detect a developing leak at one of the elbows, allowing the penstock to be dewatered before a rupture can occur. The monitoring system combined with increased visual inspection will be key components in the Interim Dam Safety Risk Management Plan that will be in place before returning the penstock to service.



**Figure 5** Repairing a damaged weld inside the penstock (left) and installation of a weir to monitor potential leakage at a penstock elbow (right).

**Alouette Dam Interim Dam Safety Risk Management Plan**

Engagement with First Nations and stakeholder groups regarding various issues relating to Alouette Dam is continuing. The variety and complexity of these issues has resulted in this engagement activity being extended for a longer period of time than had been initially anticipated. A public information session, wherein focus was paid to the expected post-earthquake status of reservoir discharge, the projects underway to address the issues, and the required reservoir operations (including construction-related drawdowns) was held at Maple Ridge City Hall in September, and a presentation to Maple Ridge Mayor and Council was made in late October. The Interim Dam Safety Risk Management Plan is complete and is expected to be issued to the Comptroller of Water Rights in November.

## Board briefing – DAM SAFETY QUARTERLY REPORT

### Compliance with Processes and Regulations

#### Regulatory Communications

Communications and submissions to the Comptroller of Water Rights and Dam Safety Section in Q2 included:

- Request to alter Bear Creek Dam to decommission the intake tower and low level outlet;
- Request to alter Walter Hardman Dam to construct a headwall adjacent to the headworks; and
- Request to replace a piezometer at Hugh Keenleyside Dam through the upstream blanket.

In addition, five yearly dam safety audit reports were provided by the provincial Dam Safety Officer for Aberfeldie, Spillimacheen, Elko, Hugh Keenleyside, Jordan and Elliott Dams.

#### Operation, Maintenance and Surveillance Manuals

Each dam has an Operation, Maintenance and Surveillance (OMS) Manual for Dam Safety that identify 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.

Work on updates to OMS Manuals are lagging behind the F2020 work plan, primarily due to an unexpected vacancy that has arisen in the department. There is a strong risk of not meeting our target for OMS Manual updates for the year, though efforts are being made to recover the plan.

	Year-To-Date			Year-End	
	Actual	Target	Indicator	Forecast	Target
OMS Manual updates completed	1	1	✓	6	8
Completion of F20 work plan	18%	38%	✗		

#### 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.

While overall work progression is on plan for F2020, consultants have been late in issuing draft reports for the Hugh Keenleyside and Kootenay Canal Dams, and these two specific reviews are behind schedule. Nevertheless, we are still forecasting to meet the plan for completing Dam Safety Reviews in F2020.

	Year-To-Date			Year-End	
	Actual	Target	Indicator	Forecast	Target
Dam Safety Reviews completed	2	4	✗	8	8
Completion of F20 work plan	39%	39%	✓		

**Board briefing – DAM SAFETY QUARTERLY REPORT**
**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. During the second quarter of this year, all 411 (100%) scheduled inspections were completed.

Routine Inspections	F20 Year-to-date	F19	F18	F17	F16	F15
Completed	822	1638	1595	1583	1594	1603
Missed	0	2	16	29	24	8

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 the second quarter of F2020, 204 checks were completed, exceeding the target of 195.

Reservoir Slopes

Dam Safety's Slope Surveillance Program remained active through Q2. All fifteen planned reservoir slope / landslide inspections were completed as of September 30, though two were delayed due to poor weather conditions (both required helicopter access) and were completed by October 10. Based on the inspection and surveillance program, no significant changes to the behaviours of the slopes were observed.

Of special note, Tom Stewart, Dam Safety's Specialist Slopes Surveillance Engineer, has been invited by the Norwegian Water Resources and Energy Directorate (NVE) to serve on a panel of internationally recognized experts that will act as an advisory body to the NVE's Director for Avalanche, Landslides, Flood and River Management. This panel will provide independent assessments of Norway's National Rock Slope Management Program and specific projects or issues within the program.

Unusual Events or Observations

The Dam Safety On Call Person (DSOP) responded to 115 calls this quarter. The calls included instrumentation alarms, operational inquiries, operations notifications during floods and earthquake notifications.



**Board briefing – DAM SAFETY QUARTERLY REPORT****Maintenance****Civil Maintenance**

As at the end of Q2, the Civil Maintenance program had completed 16 of 32 projects in this year's plan, with a total spend year-to-date of \$2.747 million against a plan of \$3.203 million. The remaining 16 projects are on schedule for completion in F2020, and the current forecast for F2020 spend is \$4 million.

The F2021 Civil Maintenance projects plan has been drafted and distributed for review amongst the Dam Safety Engineers.

The Civil Preventative Maintenance program has continued to progress. The F2020 rollout has been completed, and the F2021 plan has been set and distributed for review.

Key project highlights from Q2 include:

- Wilsey Dam headpond silt dredging (Figure 6, below)
- GMS Spillway concrete repairs



**Figure 6** Wilsey Dam headpond silt dredging (August 2019).

**Board briefing – DAM SAFETY QUARTERLY REPORT****Spillway Gate Maintenance and Testing**

During Q2, all 60 scheduled gate tests at 23 sites were carried out. One gate system failed to operate on demand during testing. In seven other cases, while gates did operate on demand, certain individual components of the gate system malfunctioned or were found to be in unacceptable condition.

As of the end of September 2019, operational restrictions were in place on two out of 109 flood discharge gates due to known deficiencies (no change from the end of F2020 Q1).

A total of 26 corrective maintenance issues were identified through ongoing testing and maintenance from July to September 2019. A total of 14 new and previous issues were addressed in the same period, for an increase of 12 overall in this reporting period. There were 159 corrective maintenance issues outstanding at the end of September 2019.

While these identified issues have been scheduled to be addressed within the maintenance plan in F2020 and F2021, with the continuing rise in numbers of maintenance issues, funds have been allocated to address a substantial portion of the backlog more immediately. Dam Safety, meanwhile, is continuing to work on developing approaches to maintenance prioritization that are commensurate with the safety-critical nature of spillway gates.

**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.

**ShakeOut 2019**

Dam Safety supported Strategic Emergency Management in developing an emergency response exercise to a large earthquake affecting Vancouver Island. The exercise is scheduled for October 17 at the same time as the Great British Columbia ShakeOut. All available Dam Safety staff will participate in the exercise, fulfilling roles in the Emergency Coordination Centre and the Emergency Operations Centre in Campbell River and providing general support for the exercise. The results of the exercise will be reported next quarter.

**Board briefing – DAM SAFETY QUARTERLY REPORT****Capital Projects**

There were 38 Dam Safety initiated capital projects underway in Q2 of F2020. Summaries of these projects are available for reference in the Dam Safety “book” in Diligent. Updates regarding projects just launched, where significant developments occurred or where milestones were achieved within the fiscal quarter are provided below.

**Hugh Keenleyside – Upgrade Spillway and LLOs Concrete (New Project)**

The concrete structures downstream of Hugh Keenleyside Dam’s spillway and low level outlets, including the downstream energy dissipation structure, have sustained significant damage since operations began in 1968. The damage ranges from minor abrasion to significant erosion of several cubic metres of concrete to the point where reinforcing bars have been exposed, worn smooth or broken off.

Modified gate operations have been implemented to reduce the rate of ongoing damage in the short-term, but capital upgrades are required to fully restore the operational function of the discharge structures, and that is the objective of this project. This restoration will extend these structures’ service lives and permit a wider range of operational options relating to the passage of water.

The project is currently in the Needs Stage. A project gate review meeting is planned to take place in Q3, and it is anticipated that a single viable alternative consisting of underwater concrete placement and repair will be endorsed.

**John Hart Dam Seismic Upgrade**

BC Hydro Board approved the project to move to Definition Phase in June 2019 and the project team is now advancing the approved scope of Definition Phase. Design development is progressing as planned. Capacity Funding Agreements were signed with all three project First Nations. K’omoks First Nation continues to make progress on their Traditional Use Study to inform this and other Campbell River System projects. An Environmental and Socio-economic Impacts Assessment of the project is underway.

**Kootenay Canal – Replace Silt Slope Piezometers Project**

During construction of the Kootenay Canal Generating Station, a slope of unconsolidated silts to the south of the penstocks and powerhouse was excavated and benched. Groundwater levels were lowered and a blanket of rockfill and sand filter was placed on the lower portion of the slope to buttress it while maintaining natural drainage. Nineteen piezometers were installed to measure groundwater pressures. In 1983, signs of instability were observed, and additional drainage and eight additional piezometers were installed in the following years.

Failure of the “silt slope” could lead to rupture of one or more of the penstocks and an uncontrolled release of water from the canal onto the generating station. Maintaining the stability of the slope via drainage and ensuring the same through ongoing monitoring is therefore essential to the safety of the station. The current understanding is that the slope’s drains are still functioning, but that the piezometers that monitor their effectiveness have either failed or are becoming unreliable. The objective of this project is to install new piezometers in the silt slope.

**Board briefing – DAM SAFETY QUARTERLY REPORT**

In Q2 of F2020, procurement activities for construction and drilling services commenced. The project's planned In-Service Date is December 2019.

**Revelstoke Dam – Concrete Dam Instrumentation Upgrade (New Project)**

The Revelstoke Dam consists of a combined earthfill and concrete gravity dam. Currently, a large number of the piezometers monitoring the uplift pressures beneath the concrete gravity dam 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. Reliable uplift pressure measurements are required in order to confirm adequate performance of the dam's grout curtain and drains and to ensure the stability of the dam. The objective of this project is to ensure that the uplift pressures at the bedrock-concrete contacts and within the bedrock geological features are adequately monitored for an Extreme Consequence Dam.

This project started in Q2 and is currently in the Needs Stage. A project gate review meeting is planned to take place in Q3, in which it is anticipated that a single viable alternative of: replacing the suspect and faulty piezometers and installing new piezometers to fill the potential information gaps in uplift pressure measurements will be endorsed.

**Strathcona Discharge Upgrade**

Feasibility Phase was completed in Q2 and the Project Plans has been endorsed. The project team is working towards bringing its recommendations for the Preferred Alternative to the Capital Projects Committee in November. The recommendations comprise constructing a new low level outlet—that will also function as the dam's operating spillway—by excavating a deep channel through rock on the dam's right abutment and converting the existing gated spillway into a free crest overflow spillway.

**Various Sites – Replace Multiple Debris Booms (New Project)**

The existing debris booms at the following seven facilities are well past their intended service life: Mica, Terzaghi, Sugar Lake, Cheakamus, Stave Falls, Jordan Diversion and Bear Creek. They are not effective enough to intercept floating debris. Several have broken in the past. Most of them do not have public safety features or complementary robust public safety booms in place to conform to Canadian Dam Association Guidelines for Public Safety.

BC Hydro has recently developed a “next generation boom” that meets both debris interception and public safety functions and piloted this new design at Kootenay Canal. While early in its service life, evaluation of the boom has so far has been very positive.

The objective of this project is to prioritize and develop scope (e.g., anchor requirements) for the replacement of the referenced booms. It is anticipated that individual projects for each site will be spun off this project in order to develop detailed designs and implementation.

**Walter Hardman Dam – Headworks Operating Gate Improvement**

Past spills—primarily one in 1996—from the Walter Hardman Dam's headpond through the spillway have led to structural damage and erosion of the downstream channel and consequent environmental impacts. Presently, management of the headpond elevation so as to avoid spills relies heavily on

**Board briefing – DAM SAFETY QUARTERLY REPORT**

discharges through the powerhouse turbines, which are aging and have diminishing reliability. This project's objective is to improve the control of flow *into* the headpond of Walter Hardman Dam from the diversion headworks structure at Cranberry Creek and improve control of the headpond elevation from the upstream end.

This project commenced Implementation Phase started in Q2, and made significant progress towards completion, including::

- Obtaining the permits required for implementing the upgrades;
- Replacing the existing operating gate with a new, taller gate;
- Installing a new, more reliable hoist actuator and power supply; and
- Adding a headwall along the left and right banks of the structure to prevent overtopping of the abutments during flood inflow conditions.

The new operating gate will be installed and commissioned in Q3. The project's planned In-Service Date is November 2020.

**Dam Safety Investigations**

There were eighteen Dam Safety Investigations and System-Wide Initiatives underway in Q2 of F2020. Summaries of these investigations and initiatives are being prepared for inclusion in the Dam Safety "book" in Diligent—similar to those for capital projects—but are not yet available for reference by the Committee. Updates regarding projects just launched, where significant developments occurred or where milestones were achieved within the fiscal quarter are provided below.

No new Dam Safety Investigation projects were initiated in Q2. It is anticipated that the following Dam Safety Investigations will be finalized by end F2020:

- GMS Spillway Seismic Performance Assessment
- Hydraulic (3D Computational Fluid Dynamic- CFD) Modelling for Revelstoke Spillway
- Wilsey Dam Stability Assessment – Stage 1
- Sugar Lake Abutments Seepage Assessment – Stage 1

**Update on Changes to the Report**

With the dam and project summaries now residing in a new Dam Safety "book" within Diligent, the reformatting of the Dam Safety Quarterly Report is complete. Over the coming months, summaries of the in-flight investigations and initiatives will be completed and posted to this same book.