Discussion/Information

Board briefing – DAM SAFETY QUARTERLY REPORT

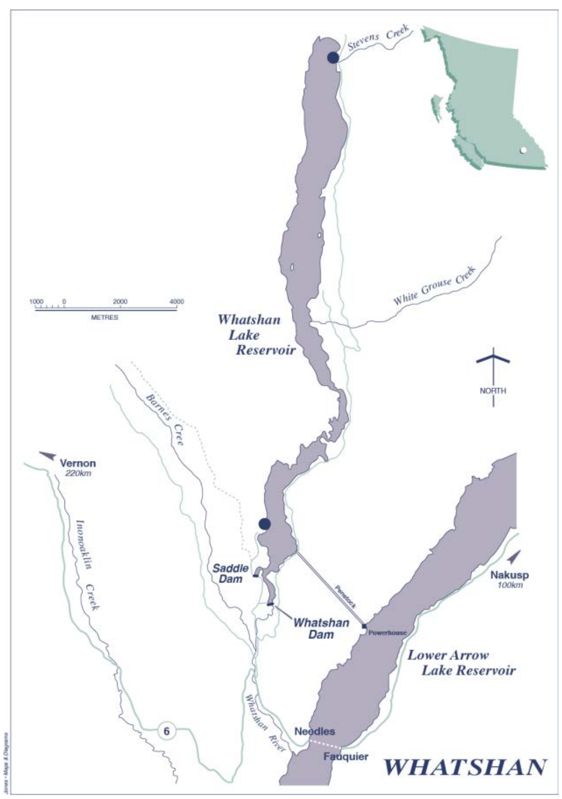
Executive Summary

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, 2018 to June 30, 2018, 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 carried out consistent with its stated objectives throughout the reporting period. The overall Dam Safety risk profile is shown in Figure 1. There has been an overall decrease in risk this quarter with the repair of the downstream left abutment at Whatshan Dam and completion of the issue related to the Revelstoke Marble Shear Block. There has been an increase at Mica Dam due to the addition of an issue into the database regarding the capacity of the downstream shell to manage high flows should an earthquake cause cracking within the dam's core.

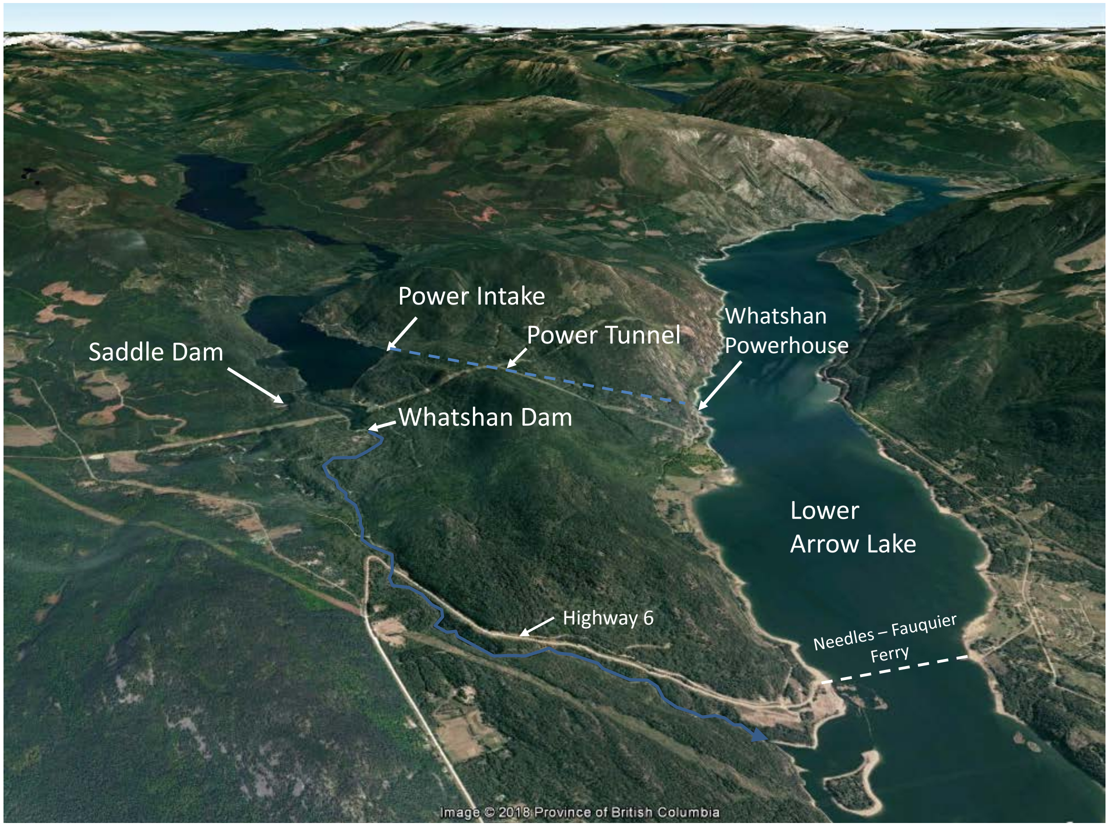
Quarterly Featured Damsite – Whatshan Dam

Whatshan dam is a 'Significant' consequence dam constructed in 1951. The Whatshan Project is located west of the Arrow Reservoir, about 130 kilometres east of Vernon in southeastern British Columbia. The project consists of a main dam with spillway, a saddle dam, and a power intake at Whatshan Lake. The power intake, located 3 kilometres northeast of the concrete dam, connects to a 3.4 kilometre long tunnel to the powerhouse located on Arrow Lake. The powerhouse contains one unit, with a rated output of 50 megawatts.



The concrete gravity dam is 12 metres high and 82 metres long. The dam contains eleven overflow spillway bays controlled by stoplogs and a low level outlet controlled by a vertical slide gate. An earthfill embankment with a concrete core cut-off wall extends 90 metres from the concrete dam to the right abutment. A short earthfill embankment with no core or cut-off wall extends from the concrete dam to the left abutment.

The saddle dam is located 1.6 kilometres northwest of the main concrete dam. It is 7 metres high and 104 metres long and is comprised of homogeneous fill material. There are a number of houses located on the shore of the lake in the vicinity of the Saddle Dam.



Overview of the Whatshan Project

History

The Whatshan Project was designed and constructed by the British Columbia Power Commission and first came into service in 1951. The original powerhouse contained two units, each 12.5 megawatts.

Whatshan Dam – Spillway in operation

Downstream face of the Saddle Dam

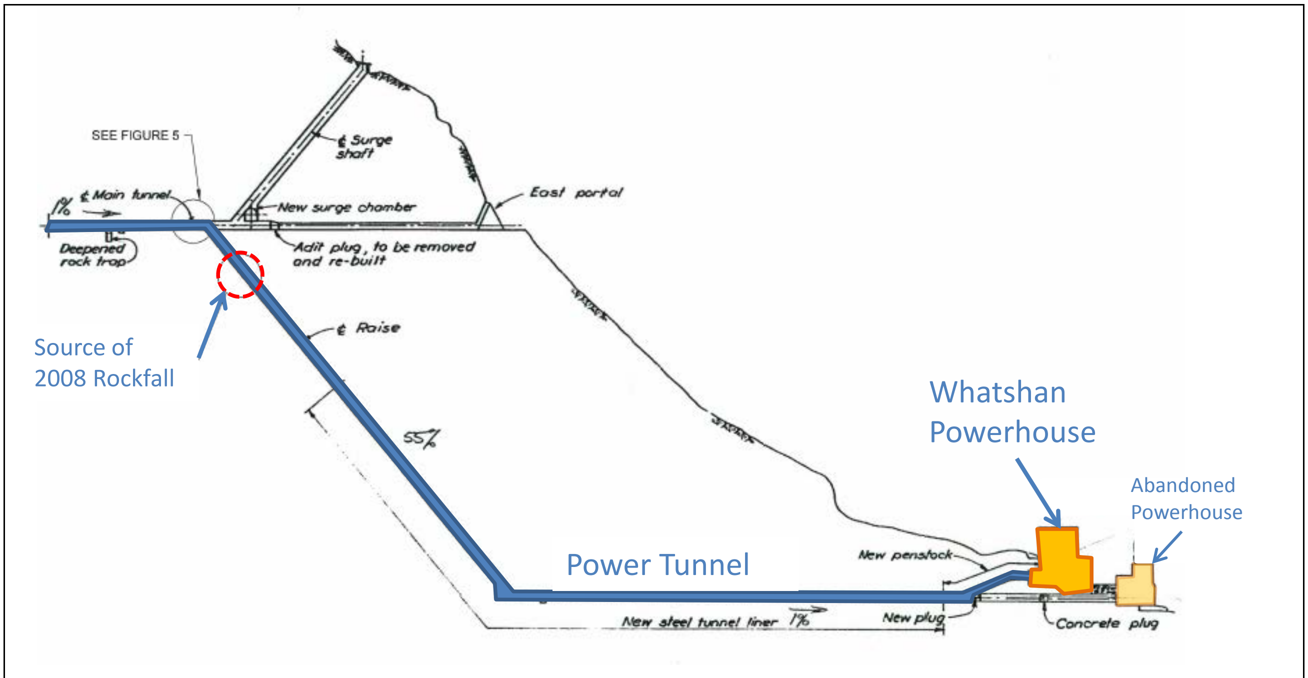
In August 1953, two successive rock and mud slides destroyed the original powerhouse and switchyard. A public inquiry into the circumstances of the landslide was carried out in which the B.C.

Power Commission and their Chief Engineer were found to be negligent in failing to take reasonable steps to prevent the danger of the landslides. The cause of the slide was investigated by Karl Terzaghi and was attributed to high pressure water leaking out of the power tunnel into the surrounding ground and destabilizing the adjacent slopes. The powerhouse was relocated, rebuilt and put back into operation in 1954. A third unit was added in 1956.

A number of improvements were made to the dam in 1961 to enable an increase in the maximum normal water level of Whatshan Lake by 1.22 metres. The dam was strengthened with post-tensioned cables anchored into bedrock to improve the stability of the dam, new retaining walls and slabs were added at the left abutment, concrete was added to shallower sections of the dam, piers were added to each side of the low level outlet and the saddle dam was raised. Stoplogs were installed in the spillway bays in order to increase the lake level.

In 1969, the Arrow Lake levels were raised after the completion of Hugh Keenleyside Dam. The Whatshan powerhouse was relocated to its present location at an elevation 12 metres higher than the previous powerhouse. It contains a single 50 megawatt turbine with a rated head of 168 m. The new powerhouse was commissioned in 1972.

In 2008, rocks from an unlined portion of power tunnel washed into the turbine, causing a forced outage. The total volume of rock was small but two wicket gate shear pins were broken.



Cross-section showing downstream portion of Power Tunnel and source of 2008 rockfall

Recent Events and Current Issues

During the installation of the post-tensioned anchors in 1961, gravel was encountered at the base of the deepest dam section. The gravel was not shown on the original construction drawings and so the extent of the gravel is unknown. There remains a concern that the hydraulic head across the base of the dam in this section could cause the gravel to erode, leading to release of the reservoir although no indications of poor performance have been observed to date.

Seepage has been observed on the downstream left abutment of the concrete dam and there is a concern that the seepage could be originating from the reservoir. The left abutment does not have a robust design for controlling seepage and erosion. In May 2017, a portion of the bank failed, likely due to seepage combined with years of progressive undermining of the bank from spillway discharge. The bank was repaired in May 2018, prior to the onset of the freshet, in order to prevent further erosion.

Update on Other Major Dams

Mica Dam

A new issue was entered in the database in Q1. There is potential that, in the event of a significant earthquake leading to cracking of the dam's core, the drainage capacity of the dam's downstream shell of the dam may not be sufficient to pass the resulting increased leakage flows. This issue is to be investigated in the first of the two ongoing dam safety projects described below.

Special Investigations Project

The work on Mica under the special investigations project for large embankment dams was initiated in 2015. The overall objectives of this project are to carry out comprehensive performance assessments and develop better understanding of the performance of the subject dams, to develop tools and methodologies for performance monitoring, and to develop future risk management strategies. It is anticipated that a full review of Mica Dam will take 5 or more years to complete.

Work in Q1 included:

- Continuation of the work on the development of the 3D CAD and GIS models;
- Developing of the F2019 plan;
- Completion of the laboratory testing of the borrow source materials; and
- Preparation of the overall large scale laboratory soil testing strategy.

Rehabilitate Vertical Movement Gauges

During construction of the dam, six vertical movement gauges were installed in the core of the dam. The gauges are no longer used to measure settlement or deformation but have since been used to monitor water levels in the casings, making use of their "leaky" behaviour at casing couplings. Periodic sudden water level drops have been observed in the gauge casings, as well as an accumulation of fine material in the bottom of the casings, suggesting a lack or degradation of sealing at some or all casing couplings and a hydraulic connection through the dam core. This could potentially induce hydraulic fracturing or exacerbate internal erosion within the dam core. These gauges, and the associated issues, are similar to the gauges in the WAC Bennett Dam that were remediated in the past few years.

The Mica Dam project was initiated in F2018, with early work to evaluate the various sealing and instrumentation options. A site investigation to assess the condition and alignment of the casings was completed. Also, in F2018, the project to address the Revelstoke movement gauges was released and combined with the Mica project, for project design and construction efficiencies. No site work has been carried out at Revelstoke.

In Q1, the conceptual design to seal the casings for both the Revelstoke and Mica vertical movement gauges progressed, using the experience from the WAC Bennett observation well design and construction work. As the casings are slightly smaller in diameter than the WAC Bennett observation wells, the option to include both piezometers and fibre optic cables in the same casing is much more challenging, and work in the next phase of the project will be targeted at evaluating the value of the information obtained from the instrumentation as well as addressing the constructability concerns.

Revelstoke Dam

There are currently three ongoing dam safety capital projects, and one study (initiated in F2018) which are described in the following sections. Note that the project to seal/rehabilitate the vertical movement gauges in Revelstoke Dam was described in the preceding section for Mica Dam.

Left Bank – Slope Stabilization

The Left Bank Slope Stabilization Project was initiated in F2017, with the objective to address the risk posed by the '731A Nose' rock slope area on the safety and operation of the powerhouse and the new Penstocks 5 and 6. In addition, further upgrades are required to ensure the safe performance of the 731 Block, which was previously anchored just after construction of the dam and powerhouse. Ongoing rock falls have damaged the anchors' heads and seepage ingress into the heads of the restressable anchors has corroded the strands of the anchors.

In F2018, conceptual design of the 731A Nose, the slopes above and the 731 anchor head protection were completed. The options include scaling/bolting of the 731A Nose, excavation of the slopes above and scaling/bolting/meshing and/or shotcreting, and the construction of anchor protection sheds at the 731 Block.

In Q1, work on the feasibility design commenced, including a site visit to assess access road constraints and constructability concerns.

Replace Downie Slide Instrumentation

Downie Slide is a 1.5 billion cubic metre slowly moving rock slide located on the west slope of the Revelstoke Reservoir 65 kilometres upstream of the Revelstoke Dam. Between 1965 and 1993 eighteen inclinometers were installed during four separate field programs for the purpose of charactering the slide, measuring displacements and replacing failed instruments. Historically, at any one time, there have been between five and eleven inclinometers measuring the displacement of the slide. There are currently five inclinometers that are still operational at the slide. It is forecasted that these inclinometers will have been disrupted by the slide activity within the next five years. To proactively measure slide displacement, an instrument replacement strategy is required to define the degree/level of monitoring. Incorporated in this strategy is a requirement to evaluate alternative displacement monitoring capabilities that could address the high cost of conventional techniques, both from an installation and operation perspective. To proactively measure slide displacement, an instrument replacement strategy is required to define the degree/level of monitoring. Incorporated in this strategy is a requirement to evaluate alternative displacement monitoring capabilities that could address the high cost of conventional techniques, both from an installation and operation perspective.

This project was initiated in F2018 and development of the identification (conceptual design) phase work plan was completed, which includes both replacement of existing inclinometers, combined with the evaluation of alternative slope monitoring options. Funding for the conceptual design stage was also approved in F2018.

Conceptual design continued in Q1, with a review of the various identified slope monitoring options. A recommendation for a field trial of a ground-based GPS with the GPS unit installed on top of a tower was accepted, with the trial to take place between July and October 2018. If successful, this instrument has the potential to reduce the number of conventional inclinometers—and the associated high installation costs—required to adequately monitor the slope.

Spillway Chute Condition Assessment

Small movements of the Marble Shear Block have produced cracking of the spillway concrete slab, and although unrated, this deficiency has been monitored for some time. The cracking has become more pronounced with time and, together with the observation that one of the underdrains is now flowing during spillway use, has prompted a review of the design and the rating of the deficiency. A screening level assessment in F2018 concluded that generally, the spillway design at Revelstoke appears to be consistent with modern spillway design practices, considered satisfactory, and no immediate concerns were identified.

In F2019, studies will commence to determine at what point the long-term movement of the Marble Shear Block will endanger the proper functioning of the Revelstoke spillway, so that remedial works can be prioritized within the capital planning process.

The study and its results notwithstanding, the chute condition and Marble Shear Block drainage will continue to be closely monitored.

WAC Bennett Dam

There are six ongoing dam safety projects as follows:

Spillway gate reliability

The project will upgrade selected electrical and mechanical components of the three spillway gates. The project is currently in Implementation Phase. Detailed design is continuing. Construction is expected to start in December 2018.

Long-term performance of the dam core

A special investigations project for large embankment dams was initiated in 2011, starting with the WAC Bennett Dam. The overall objectives of this project are to carry out comprehensive performance assessments and develop better understanding of the performance of the subject dams, to develop tools and methodologies for performance monitoring, and to develop future risk management strategies. This has been a multiple year project, and the progress has been reported previously.

In Q1 of F2019, work continued with assessing the air theory concept to explain the observed behavior of WAC Bennett Dam during the first 30 years of operation. Air theory describes how air trapped within a dam core during construction can influence the behaviour of a dam during early to mid-life. The consultant is working on recommending the next steps, with a proposal expected to be submitted in Q2. Work continued on the development of the 3D CAD model, specifically to include the earthfill wrap-around section and its contact with the concrete portion of the spillway, which has proved to be challenging to implement in CAD. Finally, anticipating the need, a permit has been obtained to collect large quantity soil samples from the South Moraine area (the original borrow area for the WAC Bennett Dam).

Embankment Dam Instrumentation Upgrade

Following from the findings of the special investigations performance assessment work, an evaluation of the failure modes and a review of the existing instrumentation, sufficient characterization of the dam has been completed to determine future dam instrumentation requirements. A capital upgrade project to install new dam instrumentation was initiated in F2018. The objective of this project is to identify and install/upgrade dam instruments to ensure that, coupled with the existing monitoring network, the dam is, and will continue to be, adequately monitored. A plan was developed to systematically identify the gaps in the instrumentation network and to identify both conventional and potentially new, non-intrusive type methods of dam monitoring.

In F2018, four workshops were organized in order to share background information, identify monitoring deficiencies using failure modes and key performance indicators as the basis for evaluation, and to refine the scope of work for the project. A user requirements document was prepared to guide the assessment, and development of a 3D seepage model of the dam was begun.

In Q1, work continued with the development of the 3-D seepage model, including the calibration of the model using the past pumping and inflow testing results; in documenting the findings of the workshops; and in review of the cross-hole shear wave information to assess its usefulness in monitoring dam core performance changes.

Condition of the riprap layer protecting the upstream face of the dam

After a 20-year Dam Safety initiative and after 8 years of this project, the bedding and riprap construction on the dam face was successfully completed in late F2018.

In Q1, work on re-paving the dam crest road and reclamation of the Sand Flat Quarry continued, with completion of both activities targeted for Q2. Project documentation and completion is targeted for later in F2019.

Seal Low Level Outlets

A long term strategy was previously developed, as part of a separate study, to assess the best alternative for the future of WAC Bennett Dam’s Low Level Outlets, constructed in the original diversion tunnels and left in place since construction. Based on this study, the recommended alternative was to permanently decommission the Low Level Outlets, which was forwarded to and accepted by the Comptroller of Water Rights. The ensuing capital project was started in F2018. To date, a detailed planning phase has been carried out and, in Q1, the funding was approved for the Conceptual Design Stage. Site inspection is planned for Q2.

Recommission/Seal Sluice Gates

As part of original construction, the WAC Bennett Dam included nine sluiceways and slide gates (sluice gate) located under the radial gate spillway ogee block, on the right abutment. The last known operation of any of the sluice gates was in 1987, when some problems were noted. Subsequent inspections have revealed further deterioration of components of the sluice gates.

Due to the potential risk of uncontrolled release of water if the gates are left in place in an unaltered, unmaintained and continuously deteriorating state, this project was initiated in F2018 to develop a long term strategy for the future role of the sluice gates. Also included in this project is to determine the future need for and possible upgrades to the leaky spillway stoplogs. Work completed in F2018 included site inspections (including visual and remotely operated underwater vehicle inspection of the sluice gates and visual inspections of the stoplogs), decision framework meetings to assess the functional requirements of the sluice gates and the stop logs, and to develop options.

In Q1, work continued in assessing the various options and estimating high level costs in preparation for a Q2 meeting to select a leading alternative to carry into the Feasibility Design Stage.

Ruskin Dam

After a 20 year Dam Safety initiative, and 11 years of this project, the construction of the upper part of the dam (including commissioning of the new gates) was completed in F2018.

In Q1, work to address needed improvements in spillway gate reliability was performed, including planning for the procurement of a permanent diesel generator and a battery inverter as auxiliary power sources and the reconfiguration of hydraulic piping to allow the hydraulic power units to serve as backups. Documentation of the construction in record drawings and the construction report continued. Work also continued to re-assess the dam using the comprehensive 3-D model of the dam, under development since 2014. This work is targeted for completion in F2019, at which time the question of the need for additional anchors will be concluded.

Terzaghi Dam – Spillway Chute

Deficiencies associated with the Terzaghi spillway chute were documented in the F2018, Q3 report, which concluded that the issues were a high priority. In F2018, a plan was prepared to gain partial access to the chute in order to carry out a limited inspection in June of 2019.

Access to the upstream end of the spillway—that portion between the headworks structure and the spillway bridge only—was enabled by rock scaling of the slope above, which sufficiently reduced the risk of rockfall to allow entry into the chute by BC Hydro personnel for cleanout and inspection. This portion of the spillway, and specifically an area on the left-hand side of the spillway adjacent to the dam's core, was targeted for first inspection due to concerns that a lower rock surface elevation might present a seepage path into and through the dam's core in the event of localized chute failure at that location.

This rock scaling and associated inspection by BC Hydro Engineering provided beneficial information to the recently initiated project to provide permanent safe access into the spillway and has provided confidence to the view that—in the upstream portion of the rock face, at least—there is a relatively straightforward rock meshing solution available. Design concepts for the downstream portions are still being developed.

Activities included in the inspection of the upstream portion of the spillway chute were: visual observations and photographs; basic dimensional checks of the spillway and measurements; mapping of damaged areas; Schmidt Hammer testing; core drilling for concrete and bedrock samples in the spillway chute; local reinforcement scans; drain cleanout inspection and drain flushing. The inspected portions of the chute indicate good materials and construction, fair to good condition considering the spillway's age, and free-flowing drains. No immediate risk to the structural integrity of the spillway's upstream portion was observed.

Engineering's site investigation report is in preparation, but preliminary findings have been communicated to Dam Safety, as follows. The rock under the spillway's concrete slab is competent: strong, not weathered, only slightly fractured near the surface consistent with the original excavation processes. There was very good observed contact and bond between the rock and the concrete slab, to the point where separating the rock and concrete for testing required breaking of the concrete rather than the interface. These conditions were found at all cored locations, including the targeted point adjacent to where the exposed rock elevation is lowest.

As a result of these findings, the concerns initially communicated in the F2018 Q3 report have been substantially allayed. There is no longer a heightened concern that deficiencies in the spillway's design could lead to a failure of the dam in the event of a spill. Recognizing that only the upstream portion of the spillway has been inspected and that there are verifiable deficiencies in the spillway's design relative to modern practices, however, there does remain some potential for significant damage to the spillway and associated financial loss resulting from a spill. Plans for future site investigations and drain maintenance on the lower spillway and analytical investigations of the impacts of the design deficiencies will be developed in Q2 through Q4. Until such time as the aforementioned investigations are complete and/or all identified concerns have been dispelled, spillway operation will be accompanied by enhanced surveillance. An Interim Dam Safety Risk Management Plan for enhanced surveillance during spills is being prepared.

Campbell River System

The high-level strategy for long-term risk management for the Campbell River System was described in a previous Executive Summary (Q3 of the F2014 report), and an overall update was provided in Q3 of the F2017 report. There are three ongoing dam safety projects:

Strathcona Dam – Upgrade Discharge

This project was initiated in 2015. The Identification Phase of this project determined the feasible alternatives for the new Low Level Outlet, including the sizing of the new discharge and options for safe discharge downstream through the Campbell River system. The spillway upgrade project (originally released as a separate project in F2016) was combined with the Low Level Outlet project in F2017. Work completed to date includes:

- Selection of the preferred alignment of the new Low Level Outlet on the right abutment;
- A decision to combine the spillway and low level outlet functionality, which provides dam safety risk reduction with improved reliability at the lowest cost; and

- Key design decisions relating to the Low Level Outlets, including selection of the number (two) and type of gates (vertical lift gates), the type of hoists (wire rope), and the selection of an open channel over the tunnel option.

In Q1 of F2019, Conceptual Design of the conversion of the existing gated spillway to a free overflow spillway neared completion. A key decision input to the design was the decision of whether to raise the dam crest in order to accommodate routing of the dam's Probable Maximum Flood. It was determined that by maintain the current dam height by either replacing or repairing the existing lock block and membrane flood wall, the new configuration of spillway and Low Level Outlet could safely route floods having return periods of significantly greater than 10,000 years, meeting the "risk-informed" performance targets in the CDA Guidelines. Due to the costs and marginal flood benefits associated with a dam raise, the project is moving forward on the basis that there will be no change to the current dam height, and this design decision has been presented in person and in a detailed letter to the Comptroller of Water Rights.

Ladore Dam

Work completed to date includes completion of the Conceptual Design, with the decision made to replace the existing gates, hoists, tower and deck. The project is currently in Feasibility Design, with design of the new vertical lift gates, the new hoist towers, deck and new control building on the right abutment continuing. In Q1, the site investigations program, including the drilling of three holes into the concrete and underlying rock foundation, was completed.

John Hart Dam

The project is currently in the Feasibility Design Stage. Work to date has identified preferred alternatives for the North Earthfill Dam, the Main Concrete Dam, the Middle Earthfill Dam and the existing Intake Dam. Designs are also continuing on converting the non-overflow section of the Concrete Dam into an overflow spillway.

In Q1, in-reservoir drilling was started, with the findings of the drilling expected to be available in time for the Advisory Board scheduled in mid-August. This will address one of the key Advisory Board's recommendations from the previous meeting, which was to obtain site-specific geotechnical information from the reservoir to confirm the upstream berm design details before proceeding to Preliminary Design. Drinking water quality issues associated with the planned reservoir drawdown during construction will need to be managed by the project. A recently completed engineering study has evaluated potential water quality mitigation options and has concluded that a temporary treatment facility is technically feasible. The project team is preparing an update and will seek a direction from management regarding a mandate for discussions and negotiations with the City of Campbell River about water quality mitigation.

Overall coordination of the Campbell River System

As the three projects progress, additional coordination work will be undertaken by Dam Safety, Project Delivery, Engineering, Supply Chain, Regulatory, Environmental, Indigenous Relations, Operations and others, as required, to ensure that the designs, construction, Supply Chain strategies, etc. will be strategically optimized and coordinated. The John Hart Dam Advisory Board's terms of reference has been expanded to include the Strathcona and Ladore Dam Safety Projects to further ensure coordination. The Advisory Board will now be referred to as the Campbell River Advisory Board and the first combined meeting is scheduled for Q2.

Salmon River Diversion

The dam removal/river restoration was completed in F2018 and work continued on post-decommissioning documentation and procurement of a Certificate of Compliance and Land Tenure.

GATE MAINTENANCE AND TESTING

During the period of March to June 2018, 78 scheduled gate tests at 23 sites were carried out. One gate system failed to operate on demand during testing. In fourteen 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 June 2018, operational restrictions were in place on nine out of 109 flood discharge gates due to known deficiencies (increased from two in the previous quarter).

A total of 38 corrective maintenance issues were identified through ongoing testing and maintenance from March to June 2018. A total of 26 new and previous issues were addressed in the same period, for an increase of 12 overall in this reporting period. There were 120 corrective maintenance issues outstanding at the end of June 2018, which was 17 more than in June 2017.

CIVIL MAINTENANCE

As of the end of the first quarter, nine of 33 planned projects are substantially complete and four others are underway. The total spend for the first quarter is $960,000. One project, Wilsey scaling, has been cancelled due to an operational change that significantly lowered its risk.

Among the projects completed are a rock trap cleanout, spillway, low level outlet and intake tower inspections, dam face repairs, spillway embankment improvements, slope drainage repairs, scaling and canal concrete repairs.

Work continues on the sustainable civil preventative maintenance program. The “Package 1” assets, which include booms and non-water-to-wire tunnels, are in implementation across the fleet. Rollout for other assets, including penstocks, spillways, canals, and foundationpressure relief drains, is scheduled for rollout in F2020. Implementation of preventative maintenance for dams and other water retaining structures has yet to be scheduled for implementation.

EMERGENCY PREPAREDNESS AND PUBLIC SAFETY

Emergency Preparedness is managed by the Strategic Emergency Management team. 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 is managed by the Public Safety team in Safety Engineering. 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.

COMPLIANCE WITH PROCESSES AND REGULATION

The Terzaghi OMS Manual was submitted in June 2018 and Dam Safety Reviews for Stave Falls, Clayton Falls, Duncan, Alouette and Seven Mile Dams were submitted. An Engineering Design Conformance Record was submitted for the WAC Bennett Core Casing Upgrades. Requests for investigation work at John Hart, Terzaghi spillway and Walter Hardman were submitted and approved and notice of the completion of repair work at Whatshan Dam was provided.

Audit of the Dam Safety Program

An independent audit of the Dam Safety Program was conducted by Audit Services in Q1 using two external subject matter experts: Dr. Georges Darbre, Commissioner for Dam Safety of the Swiss Federal Office of Energy, and Mr. Tom Osorio, a specialist inspector for hazardous process industry with the Health and Safety Executive of the United Kingdom. The independent audit is carried out every five years.

The audit rated the Dam Safety Program as "Green" but identified some areas for improvement related to surveillance, maintenance and regulatory compliance. Of note to the Capital Projects Committee is a finding that this quarterly report, focussed on capital projects and deficiency investigations, provides good and detailing reporting on those elements of the Dam Safety Program but that the equally important surveillance, maintenance and regulatory compliance elements are reported in much less detail. The subject matter experts have suggested that the identified weaknesses in the program may have been corrected previously had there been greater exposure of these issues and recommend that further emphasis be placed on these other elements in the quarterly report.

A Summary Audit Report has been prepared for the Audit & Finance Committee of the Board.

Inspections

All 411 (100%) of the scheduled inspections were completed during Q1.

Dam Safety Reviews

Dam Safety Reviews are a regulatory requirement carried out at minimum intervals of every five to ten years at high, very high and extreme consequence dams. Two Dam Safety Reviews—Revelstoke and Comox Dams—are currently in process of being finalized. Final Reports for Clayton Falls, Duncan and Seven Mile were received in Q1.

An RFP sourcing event for Dam Safety Reviews was concluded in Q1 and "blanket contracts" have been awarded to five consulting firms for F2019 to F2021. Amending Agreements will be signed in Q2 for the Dam Safety Reviews scheduled to start in F2019: Hugh Keenleyside, Kootenay Canal, WAC Bennett, Peace Canyon and Walter Hardman.

VULNERABILITY INDEX: UPDATE

Changes in Vulnerability Index for actual and potential deficiencies, as outlined in Figure 1, are tracked on a quarterly basis and shown on Figures 2 and 3. This is an indication of the changes in the understanding of the dam safety risk profile. In Figure 3, the total index is shown (sum of actual and potential deficiencies), as well as separate plots for decreases and increases in the total index. Decreases are due to remediation projects as per the Capital Plan, completed repairs and corrective maintenance, and resolution of issues via Performance Investigations. Increases in the index are due to the recognition of new issues. Existing issues are re-examined on a regular basis and re-rated as required.

The baseline for the separate plots of decreases and increases to the Vulnerability Index has been set at the time of the development of the first 10 year capital plan.

Notable changes in Vulnerability Index in Q1 are:

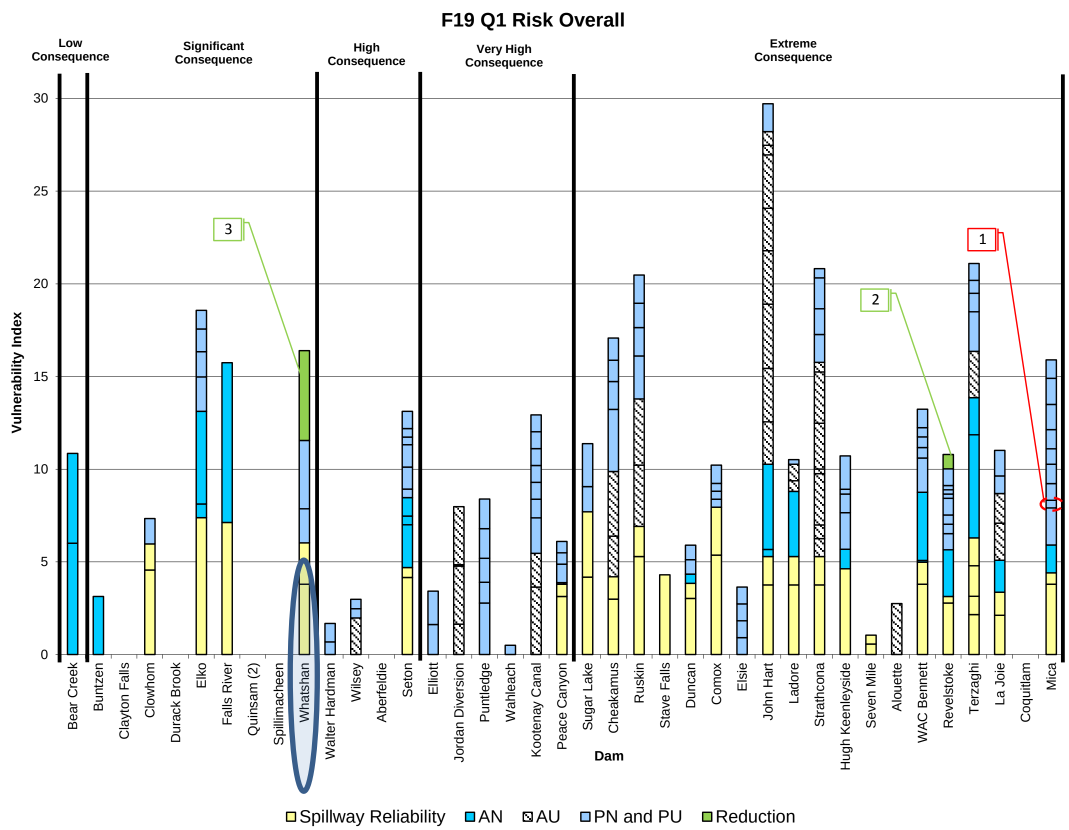
- A Vulnerability Index reduction of 4.85 following repairs to the left abutment at Whatshan Dam (Actual Normal deficiency), as described in the F2018 Q4 report and previously in this F2019 Q1 report;
- A Vulnerability Index reduction of 0.78 on determination that the seismic stability of the Marble Shear Block will not impact the Revelstoke Dam spillway.
- A Vulnerability Index addition of 0.42 at Mica Dam due the addition of a new issue into the database regarding the drainage capacity of the downstream shell to manage high flows subsequent to earthquake cracking of the dam core.

The result is a net decrease in the system-wide Vulnerability Index of 5.2.

Discussion/Information

Board briefing – DAM SAFETY QUARTERLY REPORT

Figure 1 - Dam Safety: Overall Risk Profile



Legend and Summary of Changes

Increase in Risk

***Mica Dam** – Potentially insufficient drainage capacity in the downstream shell*

Reduction Risk

***Whatshan Dam** – Erosion of downstream left abutment was repaired in May 2018.*

***Revelstoke Dam** –Seismic stability of the Marble Shear Block no longer expected to impact the spillway*

Quarterly Featured Dam

A – Actual deficiencies have been shown to exist.
P – Potential deficiencies require further investigation.
N – Normal Load conditions; associated with daily or short-term operations.
U – Unusual Load conditions: associated with flood and earthquakes

Consequence classifications reflect current BC Dam Safety Regulations.
Dam order reflects generally increasing downstream consequences

NOTES:

- Vulnerability Index (Rating) is a qualitative assessment of future dam performance from all causes – the higher the rating the higher the likelihood of poor performance.
- 33 dam sites as identified have reportable risk at present
- This Risk Profile represents only currently known and rated issues. Changes do not necessarily indicate a physical change to BC Hydro assets that increase or decrease risk; rather they often represent a change in knowledge and understanding of the risk. Additionally, many known deficiencies (those without a direct impact on potential dam failure) have yet to be rated.

Figure 2 – Change in Actual and Potential Vulnerability Indices

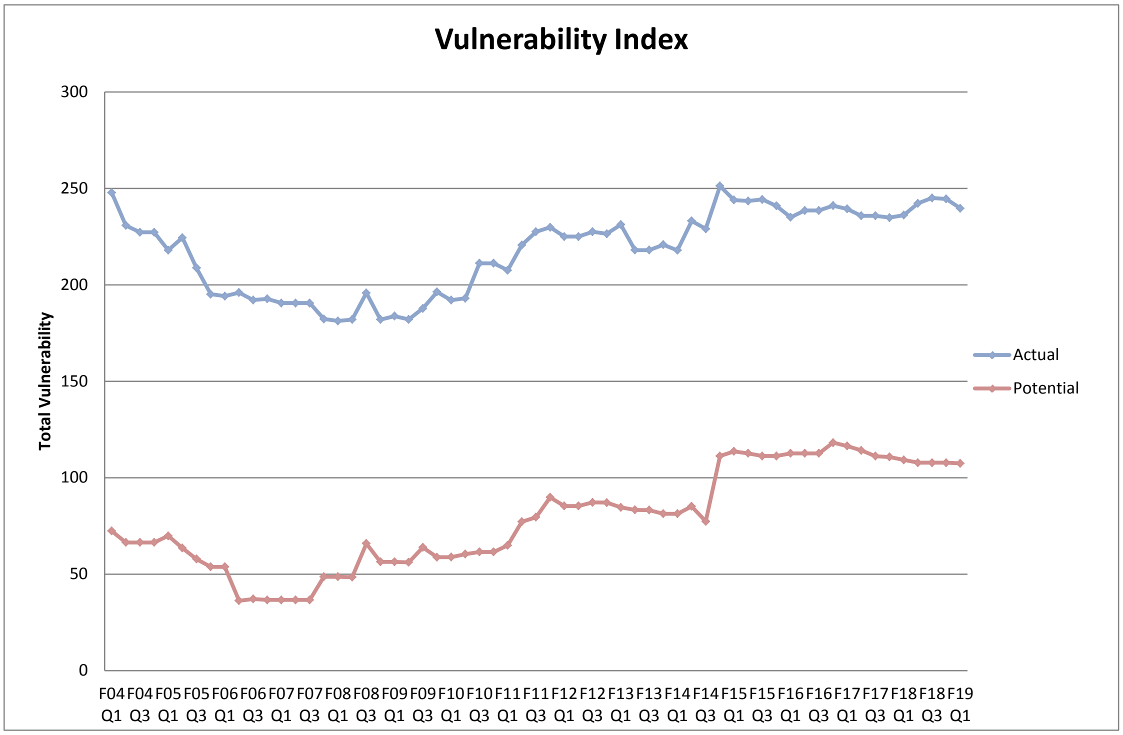


Figure 3 – Change in Total Vulnerability Index Components