

6.0: Quarterly Dam Safety Report

Executive summary

The purpose of this report is to update the Operations, Planning, Information & Technology Committee of the Board of Directors on key dam risk management activities during the period from October 1 to December 31, 2023 (F2024 Q3) and to provide reasonable assurance that the safety of dams operated by BC Hydro continues to be managed to the established guidelines and criteria of the Dam Safety Program. To keep the Committee as fully abreast of the Dam Safety Program as possible, some notable developments that took place after December 31, 2023, but before the completion of this report have also been included.

The key highlights from F2024 Q3 and the beginning of F2024 Q4 documented in this report are:




- In early January, several hundred cubic metres of rock fell from the steep slope adjacent to the spillway at Terzaghi Dam, blocking the spillway. While there are no immediate impacts to operations, as Carpenter Reservoir is well below the spillway's gate sill elevation and will remain below that level at least until summer, the spillway is a safety-critical feature of the dam and an Issue is being entered into the Dam Safety Issues Database with a Vulnerability Index of 7.5, which is far and away the highest in the system. Plans are being developed to safely remove the rock from the spillway chute when weather at Terzaghi is more amenable for safe working conditions and the rock face is less prone to rockfall; likely this summer. See pages 5 and 6.
- BC Hydro engaged a consultant to review BC Hydro's existing management practices for the navigation lock at Hugh Keenleyside Dam and assess them against good and generally accepted industry practice. The consultant's report identified several gaps and opportunities for improvement. BC Hydro is presently collaborating with Acuratek to develop the scope and work plan to implement these improvements.
- In December 2023, BC Hydro assessed that there may be a need to file an evidentiary update to the Ladore Spillway Seismic Upgrade Project and the Strathcona Discharge Upgrade Project Application, and requested that the Commission adjourn the regulatory proceeding until BC Hydro could make that determination. BC Hydro has since confirmed to the Commission that an updated Ladore Project Cost Estimate is required, and this will be submitted on or before May 31, 2024. See page 9.
- Surveillance of the dams, reservoirs and reservoir slopes was completed to largely to plan in Q3, but three routine inspections were missed. Formal dam and reservoir slope inspections, delayed by the summer's wildfires, were largely made up in Q3. Two slope inspections could not be performed; satellite remote-sensing data is being analysed to identify any unexpected slope movements. See pages 11 and 12.
- Construction on the John Hart Dam Seismic Upgrade Project continued with considerable progress made on the North and Middle Earthfill Dams. The new reservoir boom was installed on Carpenter Lake Reservoir upstream of Terzaghi Dam ahead of the 2024 freshet and the anticipated large debris load following the Casper Creek Wildfire. See pages 17-20.
- The Cheakamus Dam Hydraulic Assessment updated that dam's Safety Evaluation Flood and is recommending the closure of three Potential Deficiencies and two Non-Conformances. The findings from this Investigation will inform the scope of an upcoming capital upgrade project for the Cheakamus Dam that is planned to be released in F2026. See pages 20 and 21.

Presenter: Bob Schubak (Director, Dam Safety)

6.0: Quarterly Dam Safety Report

Dam Safety Program Dashboard

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

Risk Profile and Issues Management	 	<ul style="list-style-type: none"> • Vulnerability Index (pp. 3-4): The aggregated Vulnerability Index was unchanged through Q3. • Program Non-Conformances (pp. 4-5): The total number of non-conformances was further reduced by 24 through Q3. • New and Current Issues (pp. 5-9): Rockfall in the Terzaghi Dam spillway early in Q4 has led to a new issue with the largest Vulnerability Index in the system; planning to remove the rock and return the spillway to service is underway.
Regulatory Compliance	 	<ul style="list-style-type: none"> • British Columbia Utilities Commission (p. 9): Proceedings for the Ladore Spillway Seismic Upgrade and Strathcona Discharge Upgrade Projects Application were adjourned while BC Hydro prepares a Ladore Project Cost Estimate update. • Operation, Maintenance and Surveillance Manual Updates (p. 10): The Manual updates for four dams were issued in Q3. One remaining update is planned for Q4. • Dam Safety Reviews (p. 10): Dam Safety Reviews are proceeding to plan.
Surveillance	 	<ul style="list-style-type: none"> • Dam Inspections (pp. 11): 374 of 377 scheduled routine dam inspections were completed in Q3. The three missed inspections have been discussed with Stations Field Operations managers. Formal inspections delayed by wildfires were caught up in Q3. • Reservoir Slopes (p. 12): The wildfires prevented two inspections in the Bridge River system, which are being made up for by reviewing satellite remote sensing data to determine slope displacements and identify any unexpected behaviour.
Maintenance and Testing	 	<ul style="list-style-type: none"> • Civil Maintenance (pp. 13-14): Preventative and condition-based civil maintenance progressed well. Preventive maintenance continued to lag slightly in completions but is consistent with previous years' performance. • Spillway Gates (pp. 13-15): All 238 scheduled gate tests were performed; no gates failed to operate on demand. The number of outstanding maintenance tasks decreased by five over the quarter.
Projects and Investigations	 	<ul style="list-style-type: none"> • Capital Projects (pp. 17-20): Construction progressed on the John Hart Dam Seismic Upgrade and the Alouette Headworks Tower and Surge Tower Seismic Upgrade. The new reservoir boom was installed on Carpenter Lake at Terzaghi Dam. • Dam Safety Investigations (pp. 20-21): The Cheakamus Dam Hydraulic Assessment updated the Safety Evaluation Flood and is recommending the closure of three Potential Deficiencies and two Non-Conformances.
Legend:	     	<p>All areas within the Program element are being implemented to a satisfactory level. Minor, isolated issues may exist but are not deemed to be indicative of deteriorating performance.</p> <p>One or more areas within the Program element exhibit or are at risk of underperformance and are being monitored.</p> <p>One or more areas within the Program element exhibit unsatisfactory performance and require correction.</p> <p>Status of the Program element has improved over the quarter.</p> <p>Status of the Program element was unchanged over the quarter.</p> <p>Status of the Program element deteriorated over the quarter.</p>

6.0: Quarterly Dam Safety 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 higher the value of the Vulnerability Index (scale of 0-10), the higher the likelihood of that deficiency leading to poor performance. The Vulnerability Index for each identified issue at each dam site is shown in Figure 1. Vulnerability Indices for the individual deficiencies are aggregated into stacked bars for each dam, and 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. There were no changes in the Vulnerability Index in F2024 Q3.

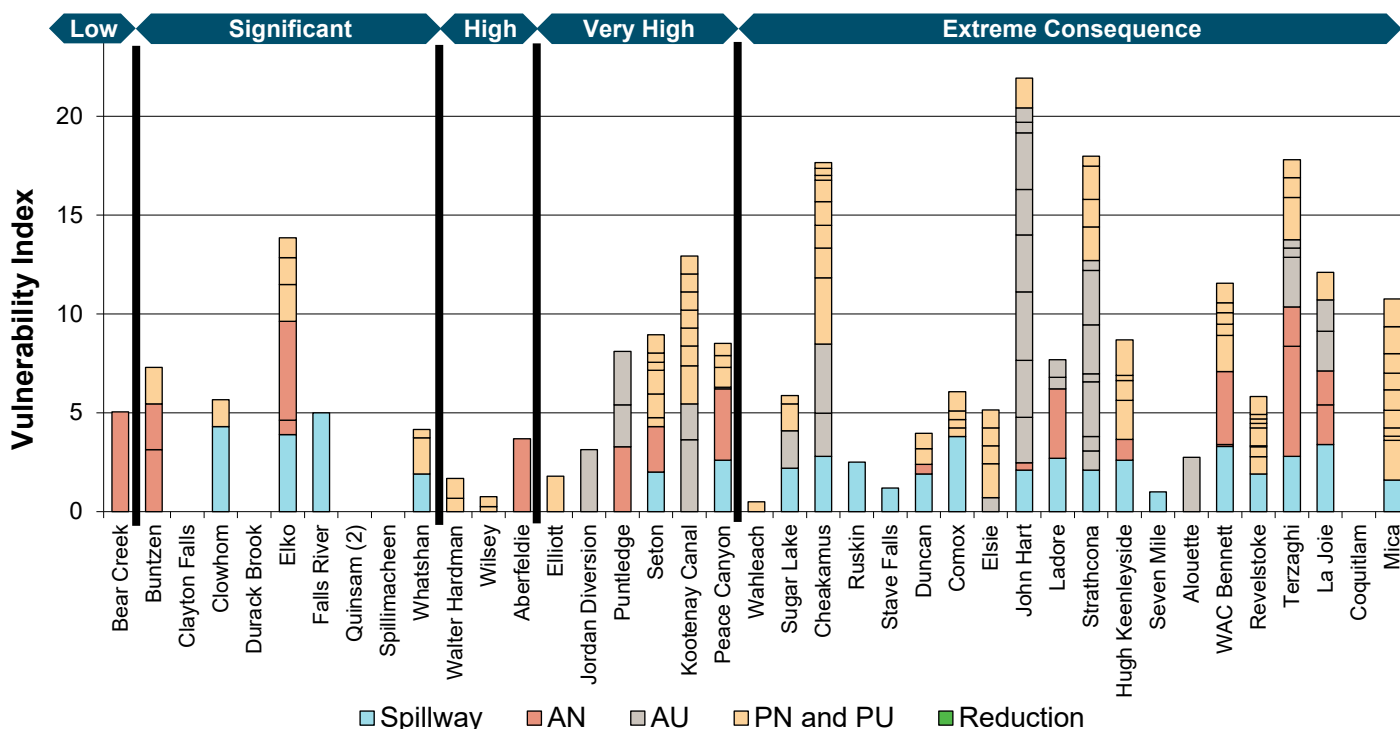


Figure 1 Dam Safety overall risk profile at the end of F2024 Q3, as represented by the Vulnerability Index. Changes this quarter are indicated by the numbered boxes.

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

6.0: Quarterly Dam Safety Report

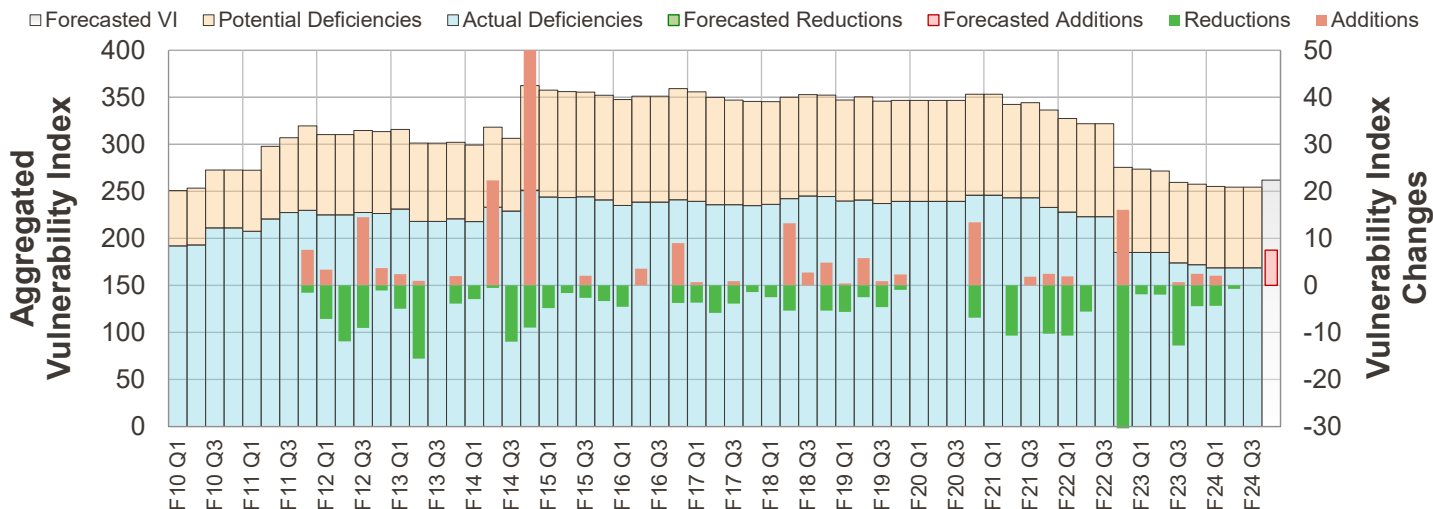


Figure 2 Historical and forecast changes and trends in the Vulnerability Index aggregated across the BC Hydro system.

Over the last several years, new issues have added to the aggregated Vulnerability Index at a rate of approximately 12 per year. To prevent deterioration of the overall risk position, reductions in Vulnerability Index through resolved issues should occur at the same pace or faster. As evident in Table 1, below, Vulnerability Index reductions are not expected to meet the target pace in F2024 but continue to exceed additions.

Table 1 Trends and forecasts for Vulnerability Index changes in F2024.

		Actual / Forecast	Target	
Dam Safety Vulnerability Index	Reductions - Last 4 quarters	9.5	12	✘
	Reductions – Fiscal Year	7.1	12	✘
	Additions - Last 4 quarters	4.5		

Non-Conformances in the Dam Safety Program

Non-Conformance issues arise where the established procedures, systems and instructions of the Dam Safety Program Management System are not being followed at a particular dam, or where procedures that form part of established and generally accepted good practices have not been implemented within the Dam Safety Program Management System or at a particular dam. In F2024 Q3, Dam Safety Engineers reviewed and updated issues for six facilities, as a result of which:

- 15 Non-Conformance issues were resolved and closed;
- 15 Non-Conformance issues were recharacterized as either Potential Improvements or Information Uncertainties (described in the F2024 Q2 Quarterly Dam Safety Report); and
- 6 new Non-Conformance issues were identified.

With the net reduction of 24 issues, the total number of outstanding Non-Conformances has decreased from 350 issues at the start of F2024 to 251 at the end of Q3. See Figure 3, below.

6.0: Quarterly Dam Safety Report

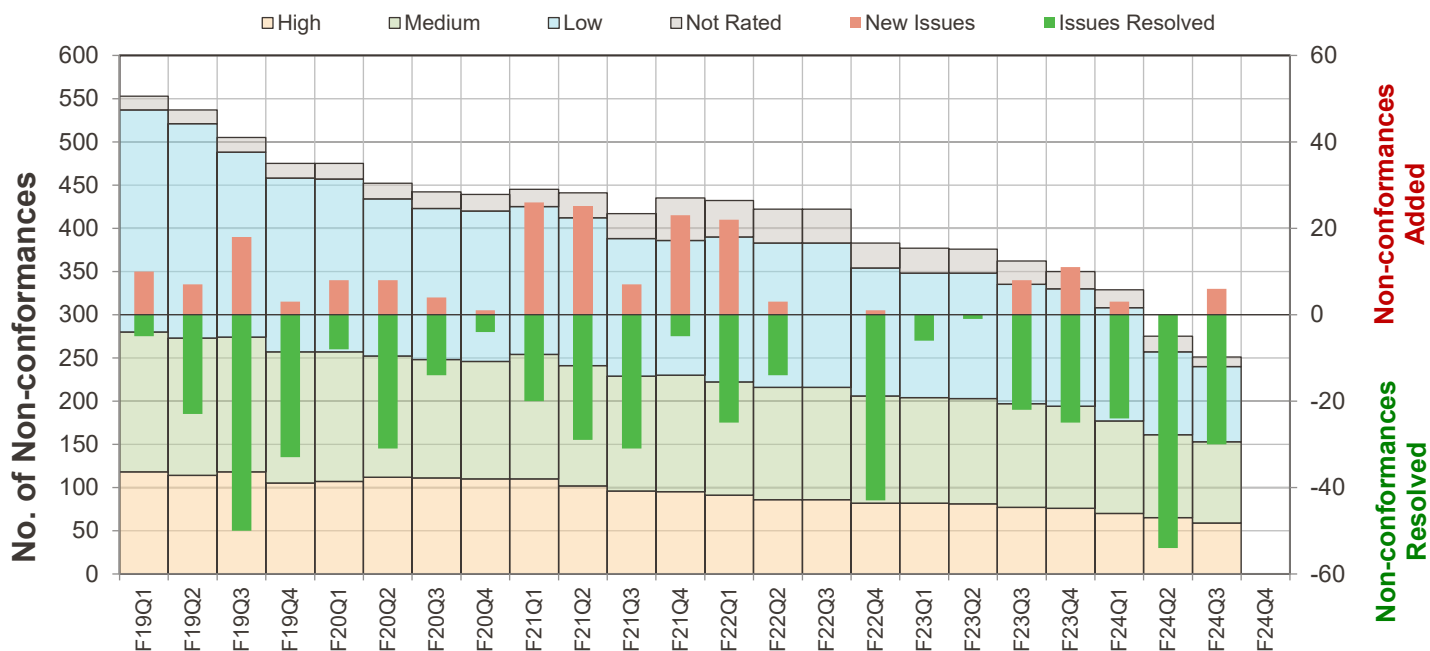


Figure 3 Changes and trends in the total number of Non-Conformance issues (characterized by level of importance) within the Dam Safety Program.

New Issues

Rockfall in Terzaghi Dam Spillway Chute

At some time between January 11 and January 15, 2024, during an extreme cold spell in southwestern British Columbia, several hundred cubic metres of rock fell from the steep slope adjacent to the spillway at Terzaghi Dam, blocking the spillway. See Figure 4, below.

There are no immediate impacts to operations. At the time of the incident, Carpenter Reservoir was at an elevation of approximately 638 metres and falling, well below the spillway’s gate sill elevation of 641.63 metres. The elevation of Carpenter Reservoir does not typically reach the gate sill elevation until July and current operating projections indicate that will be delayed this year if it is reached at all. Figures from Stochastic Event Flood Modelling indicate that, with the remaining discharge capacity of the dam’s low level outlet and at least one-half of the Bridge River generating units operating, we can safely route floods having return periods in excess of ten thousand years.

These results notwithstanding, the spillway is a safety-critical feature of the dam. An Interim Dam Safety Risk Management Plan is in preparation and an Issue is being entered into the Dam Safety Issues Database with a Vulnerability Index of 7.5, which is far and away the highest in the system. (Please note that this issue is not included in the end of Q3 results reported in the “Vulnerability Index Update”, above.)

To address this issue, plans are being developed to safely remove the rock from the spillway chute when weather at Terzaghi is more amenable for safe working conditions and the rock face is less prone to rockfall; likely this summer. An active project to design and construct stabilization and catchment works on this rock slope is currently moving into Definition Phase. Given that project team’s familiarity with the slope, they have been directed to take the lead in planning and implementing that work. An update on this work’s progress will be provided in next quarter’s report.

6.0: Quarterly Dam Safety Report



Figure 4 Rockfall in the spillway at Terzaghi Dam.

Falls River Penstocks

Falls River Generating Station is a small (7 MW), two-unit powerhouse fed by two penstocks. Unit 1 has been out of service since 2020 because of an upper bearing cooling coil issue. In November 2023, Powertech Labs finalized a fitness-for-service assessment report that concluded that both penstocks are at or approaching end-of-life under current operating conditions, due to their deteriorating physical condition from corrosion, and further concluded that corrosion has advanced to where the penstocks are no longer fit for service under the existing operating conditions. The report concluded that mitigation measures are required to restore short-term fitness-for-service of the penstocks until repairs are made to address the corrosion.

Following receipt of the report, Unit 2 was taken out of service. Engineering performed transient pressure modelling and concluded that slower wicket gate closing times, accompanied by corresponding de-rating of the units, would reduce pressures sufficiently to ensure safe operation of the penstocks until repair work is carried out. Along with field testing to confirm the model assumptions and results, these adjustments were made on Unit 2 in December 2023. An Interim Dam Safety Risk Management Plan has been issued to reflect the operating changes and will remain in effect until the issues with the penstock condition are resolved. An update of the Falls River Facility Asset Plan will be prioritized to review the facility's investment strategy in light of the limited remaining expected life of the existing penstocks.

6.0: Quarterly Dam Safety Report

Puntledge Penstock Overpressure

Water is fed to the Puntledge Generating Station by a single penstock consisting of 1.4 km of woodstave construction and 3.7 km of steel construction. In December 2023, the penstock experienced a brief overpressure event during a manual shutdown of the generating unit. The issue was identified during weekly checks of the fire protection system where it was found that the pressure in the fire water header was significantly above the expected operating pressure. As the fire protection system is fed from the penstock, the attending electricians concluded that the penstock had been pressurized to that same level and that the fire system had captured and held that pressure due to the presence of check valves. The generating unit was taken out of service while the issue was investigated and corrected.

Transient pressures in this penstock are controlled by operating the generating unit's wicket gates in coordination with a pressure relief valve. Station Field Operations and Puntledge's Field Maintenance Engineer have determined that a time lag between closing of the wicket gates and opening of the pressure relief valve caused a transient pressure spike in the penstock.

Analysis by Engineering determined that the Maximum Allowable Working Pressure was likely exceeded for both the steel and woodstave penstock segments. Dam Safety further engaged Engineering to perform a fitness for service assessment of the penstock based on available design and inspection information and supported by additional detailed visual inspections of the penstock carried out after the event. No signs of yield or other damage were calculated or observed on the penstock, and it has been deemed fit for continued service.

A root cause analysis is being completed in response to the forced unit outage. The preliminary finding is a combination of minor adjustment issues in the mechanical linkages and failure of the unit speed signal – the reason for the manual shutdown – combined to cause the delay in relief valve opening. Once repairs and maintenance to the governor and pressure relief valve are completed, it is expected that the generating unit at Puntledge will be returned to service.

Update on Existing Issues

Bridge River Wildfires

The F2024 Q2 Quarterly Dam Safety Report described how two very significant wildfires had impacted the Bridge River System, damaging or destroying BC Hydro infrastructure in proximity to Terzaghi Dam and the Bridge River 1 and Bridge River 2 Generating Stations. Damage to power supplies and lines of communications impacted Dam Safety operations, requiring use of backup power (solar panels, batteries) and communications (satellite) systems.

Operations crews were able to repair BC Hydro's distribution line to Terzaghi Dam in early December, restoring power to the spillway gate equipment, auxiliary buildings, the two intake structures/gates for the water conveyance tunnels to the generating stations, and Dam Safety instrumentation at the dam crest, spillway, and the Bridge River 2 intake.

The main communication path for instrumentation data at Terzaghi Dam is a radio link over Mission Mountain and down to the Bridge River 1 powerhouse. A pole-mounted repeater station was destroyed by fire around August 15th along with the cellular communications tower beside the intake structures on Carpenter Lake, and neither has been restored yet. Remote monitoring of Terzaghi Dam's instrumentation continues to rely on the backup satellite communication system.

With the fire having burned through the forested slopes around Carpenter Lake, BC Hydro anticipates increased debris loads in the reservoir with the coming freshet. In F2024 Q3, the Reservoir Booms Project was successful in replacing the debris boom at Terzaghi with a new style steel boom, greatly improving our ability to manage this debris and prevent it from blocking water passages. See "Capital Projects" page 20.

6.0: Quarterly Dam Safety Report

Blind Slough Dam Spillway Gantry Crane

The F2024 Q2 Quarterly Dam Safety Report described an error made during the replacement of filler materials adjacent to the crane's guide rails that damaged the rails' anchors and forced the crane out of service. As also previously reported at that time, the repairs have been completed and the gantry crane has returned to service. A root cause analysis was conducted by Dam Safety, with participation from Program and Contract Management, Engineering Design, and Construction Services. Identified contributing factors included insufficient definition and application of BC Hydro's concrete cutting and coring procedures, insufficient detail of concrete-encased hardware (rail clips and anchors) depicted on project drawings and specifications, the lack of a specified "hold" or "stop work" point if steel was observed to be damaged, and, within the Interim Dam Safety Risk Management Plan, a focus – in this instance – on operational hazards (*i.e.*, routing of water while work was proceeding) without consideration of the hazards posed to the structures and equipment by the work itself. Corrective actions have been identified to be undertaken by Dam Safety and by Program and Contract Management, which are in various stages of completion.

Hugh Keenleyside Dam – White Sturgeon in Low Level Outlets

As reported previously, white sturgeon have been observed entering the dam's low level outlet ports and swimming up the operating gate slots to access the tops of the gates during the summer months. To avoid injury or mortality to these fish, which is an Endangered Species under the Federal Species at Risk Act, BC Hydro is continuing to monitor for the presence of white sturgeon before any operation or testing of the gates. An engineering solution to prevent sturgeon from entering the gate slots has now been developed. In F2024 Q3, the first prototype was installed on one gate (Figure 5) to evaluate the effectiveness of the design and to ensure that it doesn't interfere with gate operation. The installation – basically a 1-inch thick rubber plate fastened to the downstream wall of the gate slot – performed well from a gate operating perspective. Material for the installation on the remaining low level gates is being received on site, with the next installation planned for January. The effectiveness of the solution at preventing sturgeon from entering the gate slots cannot be assessed until the summer months when the sturgeon are typically present in greater numbers.

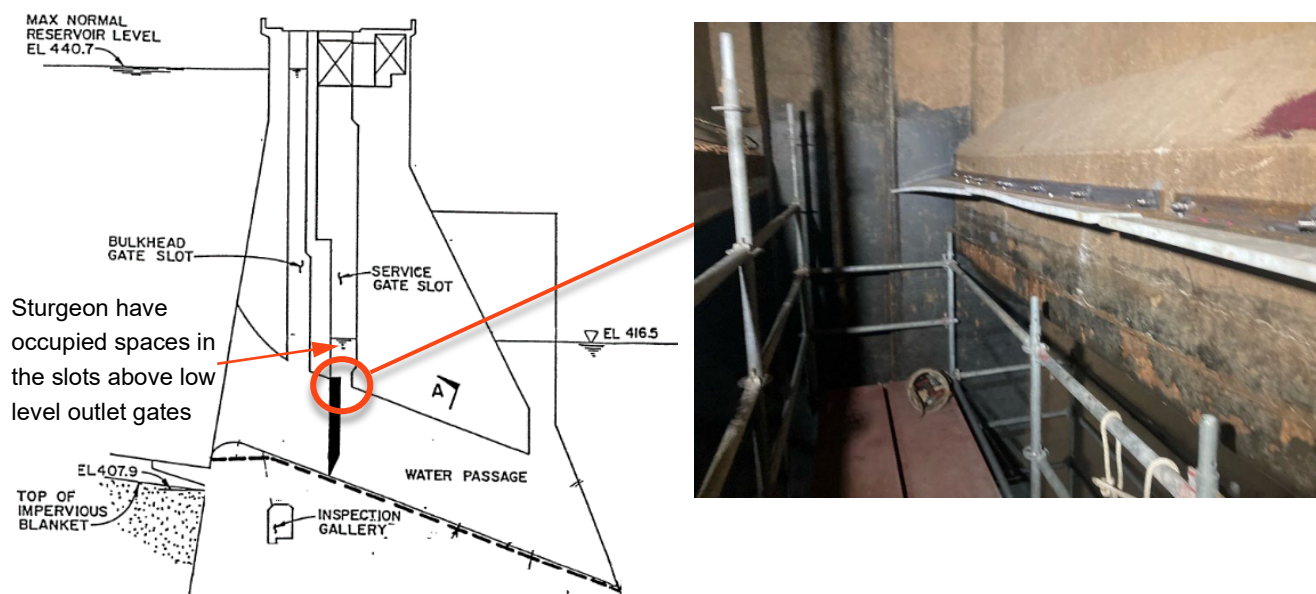


Figure 5 Prototype sturgeon exclusion plates installed in low level outlet gate slot at Hugh Keenleyside Dam.

6.0: Quarterly Dam Safety Report

Hugh Keenleyside Dam – Navigation Lock Floating Guide Wall

The F2020 Q4 Dam Safety Quarterly Report described the January 13, 2020 sinking of two pontoons of the upstream floating guide wall that directs marine traffic safely into the navigation lock. To date, those pontoons have remained where they sank on the bottom of the reservoir. This winter, Arrow Lakes Reservoir has been drawn down to an unusually low elevation, such that the pontoons have posed a potential hazard to the remaining guide wall. The guide wall has been repositioned to the north, away from the sunken pontoons, but the change in orientation has degraded the guide wall's stability. Stations Field Operations has been kept busy making these and other adjustments and modifications to protect the guide wall from further damage.

A project to refloat the sunken pontoons and move them to another location – where the pontoons can be safely inspected and potentially rehabilitated for return to service in an upgraded guide wall – has been initiated. The project is being managed by Program and Contract Management and is expecting to award a contract for the work in February, with a goal to recover the pontoons before the 2024 freshet. Further, a capital project to upgrade the floating guide wall, restoring and improving its integrity and facilitating improved operation and maintenance, has been advanced for release in Q1 of F2025. Updates regarding these projects will be provided in future reports.

Hugh Keenleyside Dam – Navigation Lock Management Practices

As reported in the F2022 Q1 Quarterly Dam Safety Report, a Near Miss incident occurred at the navigation lock on July 15, 2021, when the lock's downstream gate was dropped from a raised position shortly after a vessel had completed its transit of the lock. As the navigation lock at Keenleyside Dam is the only one in the BC Hydro system and transiting of marine traffic is not one of our core functions, BC Hydro engaged a consultant, Acuratek, to review BC Hydro's existing management practices for the asset management, operation, maintenance and public safety of the lock and assess them against good and generally accepted industry practice. Acuratek are experienced in assessing and recommending improvements to the practices of large navigation lock owners.

Acuratek staff visited the navigation lock to witness some vessel transits and the procedures for operating the lock. They familiarized with the configuration and operating status of the lock and its ancillary infrastructure, interviewed BC Hydro staff including Lock Keepers, Field Managers and Field Maintenance Engineers, and reviewed the facility's operating manuals, lockage logs, and maintenance records.

Acuratek submitted their report to BC Hydro in November 2023, which identified gaps and opportunities for improvement across the range of management practices listed above. BC Hydro is presently collaborating with Acuratek to develop the scope and work plan to implement these improvements, beginning with the preparation of a new manual of operational procedures, in the form of a Local Operating Order. Updates on the progress of this work will be provided in future reports.

Compliance with Processes and Regulations

Regulatory Communications – British Columbia Utilities Commission

Round 2 Information Requests for the Ladore Spillway Seismic Upgrade Project and the Strathcona Discharge Upgrade Project were received on November 16 and 23, 2023, and responses were submitted on December 7 and 14, 2023. On December 12, 2024, in light of information received through the Ladore Project Request for Proposal process, BC Hydro assessed that there may be a need to file an evidentiary update and requested that the Commission adjourn the regulatory proceeding until BC Hydro could make that determination. On January 25, 2024, BC Hydro confirmed to the Commission that an updated Ladore Project Cost Estimate is required, and this will be submitted as an Evidentiary Update on or before May 31, 2024.

6.0: Quarterly Dam Safety Report

Regulatory Communications – Comptroller of Water Rights

Two letters were submitted to the Provincial Dam Safety Office in Q3, requesting clarification on whether an Independent Engineer will be required for the Ladore Dam Spillway Seismic Upgrade Project. The John Hart and Strathcona Projects both have the requirement for an Independent Engineer embedded within the water licences, whereas Ladore does not. However, the Provincial Dam Safety Office has indicated they may require one in order to assist with their workload. A supplemental presentation was made on November 15, and it is expected to be discussed again at the annual meeting with the Comptroller of Water Rights office on January 30.

The annual meeting with the Comptroller of Water Rights office was held at BC Hydro's offices on January 29-30, 2024. The first day of discussion covered Dam Safety Program topics including the Program's new management system, regulatory compliance, surveillance highlights, and upcoming investigations. The second day of discussion consisted of presentations on ongoing and upcoming capital projects that will require authorizations under the Dam Safety Regulation or the Sustainable Water Act.

Operation, Maintenance and Surveillance Manuals

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

Four updated Manuals – for Elliott Dam, Mica Dam, La Joie Dam and Spillimacheen Dam – were completed and issued in Q3. One more Manual update (Revelstoke Dikes) is planned for F2024, and work continues on the update to the Falls River Manual that is scheduled for issue in F2025.

Dam Safety Reviews

Dam Safety Reviews are independent, systematic reviews and evaluations of all aspects of a dam's physical condition, design, construction, operation, maintenance, processes, and other systems affecting the safety of the dam. Performed by external consultants, they are carried out at minimum intervals of every five to ten years for dams that are classified in accordance with the Dam Safety Regulation as High, Very High, and Extreme consequence dams.

Seven Dam Safety Reviews are planned for completion in F2024. In Q3, the Ruskin Dam Safety Review Report was issued, and draft reports for Wilsey Dam and Stave Falls Dam were received. Draft reports for Comox, Cheakamus, John Hart, and WAC Bennett are expected in early Q4.

Dam Safety Program Audit

BC Hydro's audit of the Dam Safety Program, performed on a five-year recurrence and last performed in F2019, commenced in F2024 Q3. The BC Hydro audit team is being supported by three external subject matter experts. Tony Bennett, formerly Director of Dam and Public Safety for Ontario Power Generation, is supporting the audit team in reviewing the conventional dam safety components of the Program. Tom McDermott and Susan Steyn of the Woodhouse Partnership, a highly recognized asset management consulting firm, are reviewing the new asset management components of the Program. The audit is scheduled to be completed in F2024 Q4.

6.0: Quarterly Dam Safety Report

Surveillance

Key activities comprising dam safety surveillance include inspections, monitoring of instrumentation and quality control of data, and characterization of dam performance. Table 2 below provides key metrics regarding these activities, which are described in the following sub-sections of the report.

Table 2 Dam safety inspections and surveillance activities.

		Quarter Q3		Year-to-date	
		Actual	Target	Actual	Target
Routine dam inspections	Completed	374/377 = 99.2%	100%	1127/1131 = 99.6%	99.5% ✓
	Missed	3		4	
Formal (annual and semi-annual) dam inspections	Field work completed	19	16	71	71 ✓
	Reports issued	14	21	34	31 ✓
Instrumentation data checks		199/195 = 102%	97%	582/585 = 99.5%	97% ✓
Reservoir slopes inspections	Field work completed	5	2	17	19 ✗
	Reports issued	5	8	8	12 ✗

Routine Dam Inspections

Routine weekly and monthly inspections are a regulatory requirement. These visual inspections are carried out by trained inspectors within Dam Safety or Stations Field Operations using checklists prepared by the Dam Safety Engineer. The purpose of these inspections is to identify changing conditions at a dam, reservoir or appurtenant structure that could threaten the safety of the dam.

374 out of 377 of the scheduled routine inspections were completed in Q3. Of the three inspections missed by Station Field Operations, two were due to scheduling errors and one – over the week of December 25 – was scheduled and assigned but simply missed by the crew member. The Dam Safety Engineers for those dams have spoken with the field managers to understand the reasons for these misses and to remind them of these inspections' importance.

Formal Dam Inspections

Formal inspections of the dams are regulatory inspections completed by Dam Safety Engineers on a semi-annual or annual frequency, as dictated by each dam's Consequence Classification. These inspections include a comprehensive visual inspection, a review of the monitoring data and an assessment of the condition of the water containment and conveyance structures. 71 of these inspections and reports are to be completed annually. As at the end of Q3, Dam Safety Engineers have completed the field work for all 71 inspections. A total of 34 reports were issued by the end of Q3, exceeding the work plan target of 31 reports.

6.0: Quarterly Dam Safety Report

Instrumentation and Monitoring

Dam Safety Surveillance collects, checks, and assesses about two million data points a month. A vast majority of the data is collected and checked against threshold values automatically by the Automated Data Acquisition System. Even though most of the data is checked automatically it is essential that qualified staff review the data regularly to ensure the systems are functioning as expected. The Dam Safety Technologists in each region regularly check instrumentation data plots for all dams to ensure the Automated Data Acquisition System is functioning as expected, identify any unusual trends, and ensure continued accuracy of the data being for ongoing engineering assessment. They are tasked to perform three such checks per week. 199 checks were completed against a plan of 195 in Q3.

Reservoir Slopes

Reservoir Slopes inspections are completed on a frequency ranging from semi-annually to once every 10 years depending on the assessed hazard of the slope. They are typically carried out by the Reservoir Slopes Geologist and the Specialist Dam Safety Engineer for the Upper Columbia Region. Each inspection generally consists of a review of all monitoring data, a visual inspection completed from helicopter with boots-on-ground assessment of identified areas of concern, and documentation by a sealed engineering report.

The St. Cyr landslide (see the F2022 Q2 Quarterly Dam Safety Report) has been added to the list of reservoir slopes requiring annual inspections, resulting in a total of 19 reservoir slopes to be inspected in F2024. The field work for six inspections – including St. Cyr – was completed in Q3 and 17 of the 19 inspections were completed for the year. The wildfires in the Bridge River prevented inspections and monitoring from being completed at Santa Claus and Wedge Drop Mountains before the onset of snow in the region. To compensate, satellite-acquired remote sensing (Interferometric Synthetic Aperture Radar, or “InSAR”) data, as was used to discover the St. Cyr landslide, has been acquired and is being processed for these two areas to determine the magnitude of slope displacements over the past year. If the satellite data indicates uncertain or unexpected slope behaviour, visual inspections and surveys will be performed at the earliest opportunity following melting of the snow cover.

Related to above, completion of slopes inspection reports has also been delayed. All 19 inspection reports are expected to be issued by the end of the fiscal year, however, including reports documenting the assessment of the satellite data for Santa Claus and Wedge Drop Mountains.

Unusual Events or Observations

The Dam Safety On Call Person responded to 81 calls in Q3, which typically includes instrumentation alarms, operational inquiries, operations notifications during high inflows and earthquake notifications. This number of calls and responses is in line with typical activity.

6.0: Quarterly Dam Safety Report

Civil Maintenance

The Preventative and Condition-Based Civil Maintenance programs were well-executed in F2024 Q3. Although Table 3 suggests that Condition-Based Maintenance may have lagged in Q3, those figures are the result of updates to the plan that will be reflected in Q4 reporting, as described below.

Table 3 Dam Safety and Generation Civil Maintenance for F2024.

		Quarter Q3		Year-to-date	
		Actual	Target	Actual	Target
Corrective and Condition-Based Maintenance	Spend (\$k)	-34k	432	2538	2940
	Work Orders Completed	13	21	22	26
Preventative Maintenance	Tasks Completed	250	276	601/693 = 87%	

Preventive Maintenance

Civil Preventative Maintenance is being completed at a rate that is comparable to the last two years. Year-to-date, program completion is 87 percent to plan, while through Q3 Stations Field Operations and Engineering Services completed just over 90 percent of assigned tasks, indicating a positive trend in the work. Recent review meetings with the execution teams have provided confidence that the program will be successfully executed through the remainder of F2024.

Corrective and Condition-Based Maintenance

Civil maintenance on Dam Safety and Generation assets progressed well in Q3. There were some changes to the plan in Q3 that will be reflected in the Q4 report. Firstly, there were two work orders at Clowhom Dam that were reclassified as capital expenditures after completion, leading to a reduction in spend of \$550k (causing the spend to appear negative for the quarter) and a reduction in reported work order completion of 2. Further, another work order has been removed from the plan to be re-released as a capital project, one has been removed due to insufficient outage availability, and a third has been removed and reprioritized due to increased requirements for scope and budget. Four new work orders have been added to the plan in their place, with completion dates in F2024 Q4. Overall, net of these updates to the plan, the program is on track to complete 28 of 29 work orders and a spend of \$3.5 million for F2024.

One particularly notable maintenance project that was completed in Q3 was load confirmation testing of the three post-tensioned, 61-strand steel anchors in the concrete transition structure at Coquitlam Dam. Ranging in length from 29 to 43 metres, these anchors were installed during construction to provide additional stability to the concrete transition under seismic loading. After installation, they were each tensioned to 9540 kilonewtons (over 2 million pounds) and “locked off” to hold that tension in the anchors. In the event of an extreme, design-level earthquake, this tensioning will allow the anchors to resist the seismic loads without allowing excessive sliding or lift-off of the transition from its rock foundation. Given their importance to the seismic performance of the dam, these anchors must be periodically tested to ensure that they remain tensioned to their design level. See Figure 6 on the following page.

6.0: Quarterly Dam Safety Report



Figure 6 Above: Coquitlam Dam and the concrete transition structure. Right: Setting up the equipment to pull-test the concrete transition's three post-tensioned anchors.

The anchors are slightly inclined from the vertical to provide additional stability on the sloping bedrock foundation. To ease the threading of a large jack to the inclined anchor heads, and importantly to avoid damaging the threads, an articulating harness was designed and fabricated, and added to the anchor testing apparatus. The contractor-designed and supplied modification was very successful, and all three anchors were verified to remain within their design envelop. Testing was overseen and directed by Generation Stations Civil Engineering and supported by Stations Field Operations.

Spillway Gate Testing and Maintenance

Spillway Gate Testing

During Q3 of F2024, all 238 scheduled gate tests were completed, including annual gate tests of 4 gates. A single gate test was performed one month behind schedule, but still completed within the quarter. Table 4 below provides key metrics related to spillway gate testing. No gates failed to operate on demand in Q3.

Table 4 Spillway gate testing results for F2024 Q3.

		Quarter Q3		Year-to-date	
		Actual	Target	Actual	Target
Monthly Tests	Completed	238/238 = 100%	100% ✓	711/709 = 100%	98% ✓
	Missed	0		0	
Gates Failing to Operate on Demand during Testing	No. of failures	0		1	
	Failure rate	0/235 = 0 %		1/711 = 0.1%	

6.0: Quarterly Dam Safety Report

Exceptions to Gate Testing Program

At Hugh Keenleyside Dam in December, the elevator to the gates hoist house was out of service. Access was restricted to short duration low risk work due to the impaired ability to rescue any injured workers. The four spillway gates were operated from the control room, but the other monthly maintenance set out in the maintenance program was not performed. Repairs to the elevator have been initiated, but this restriction is expected to last through February. Testing of the eight low level outlet gates is unaffected.

Gate testing scopes were reduced to exclude gate movements at some dams, as described below.

- At WAC Bennett Dam, the GZ-0274 GMS Spillway Gate Upgrade Project Team addressed the identified deficiencies. The gate tests in October did not include gate movements, but full testing including gate movements resumed in November.
- At Terzaghi Dam, one of the two low level outlet gates was not operated in November and December because the position transducer is broken and operators re unable to determine gate position.
- Six gate tests at various sites did not include moving the gate due to conflicts with other work, such as construction downstream.
- Twelve gate tests at various sites did not include moving the gate due to winter conditions.

Gates Out of Service or Under Restricted Service

The availability of flood passage devices is a key measure of our ability to pass high inflows and manage reservoir levels. As at the time of writing this report, all spillway gates and flood passage devices are in service except the two spillway gates at Terzaghi Dam. While those spillway gates are operational, available and being maintained, the rockfall into the spillway chute means both the free crest spillway and the spillway gates should not be used to release flow. The two low level outlet gates are unaffected.

Spillway Gate Maintenance

Spillway gate maintenance results for Q3 and F2024 year-to-date are shown in Table 5. The number of outstanding gate maintenance tasks is shown in the chart in Figure 7.

In Q3, six tasks were completed compared to a plan of three, and eight emergent tasks were completed. Despite this progress, completion for the year continues to lag the plan. Seven tasks have been deferred to F2025 and one task has been transferred to a small capital project, so the intent is now to complete 25 of the 33 tasks this fiscal year. The number of outstanding gate maintenance tasks is shown in the chart in Figure 7. Through Q3, the total number of outstanding maintenance tasks decreased slightly from 114 to 109. Following a significant decrease in F23, the inventory has been holding fairly steady this year, having increased slightly from 104 at the end of F23 to 109 at present.

Table 5 Spillway gate maintenance results for F2024.

Corrective and Condition-Based Maintenance Tasks	Quarter Q3		Year-to-date
	Completed	Planned	
Planned Tasks	6	3	23/33 = 70%
Emergent Tasks	8		11

6.0: Quarterly Dam Safety Report

“High priority” maintenance tasks are those where the asset shows moderate to severe signs of deterioration and/or its ability to perform its intended function may be compromised and failure of the asset could lead to loss of reservoir control, albeit with a long intervention time available. The number of high priority tasks decreased to nine at the end of Q3.

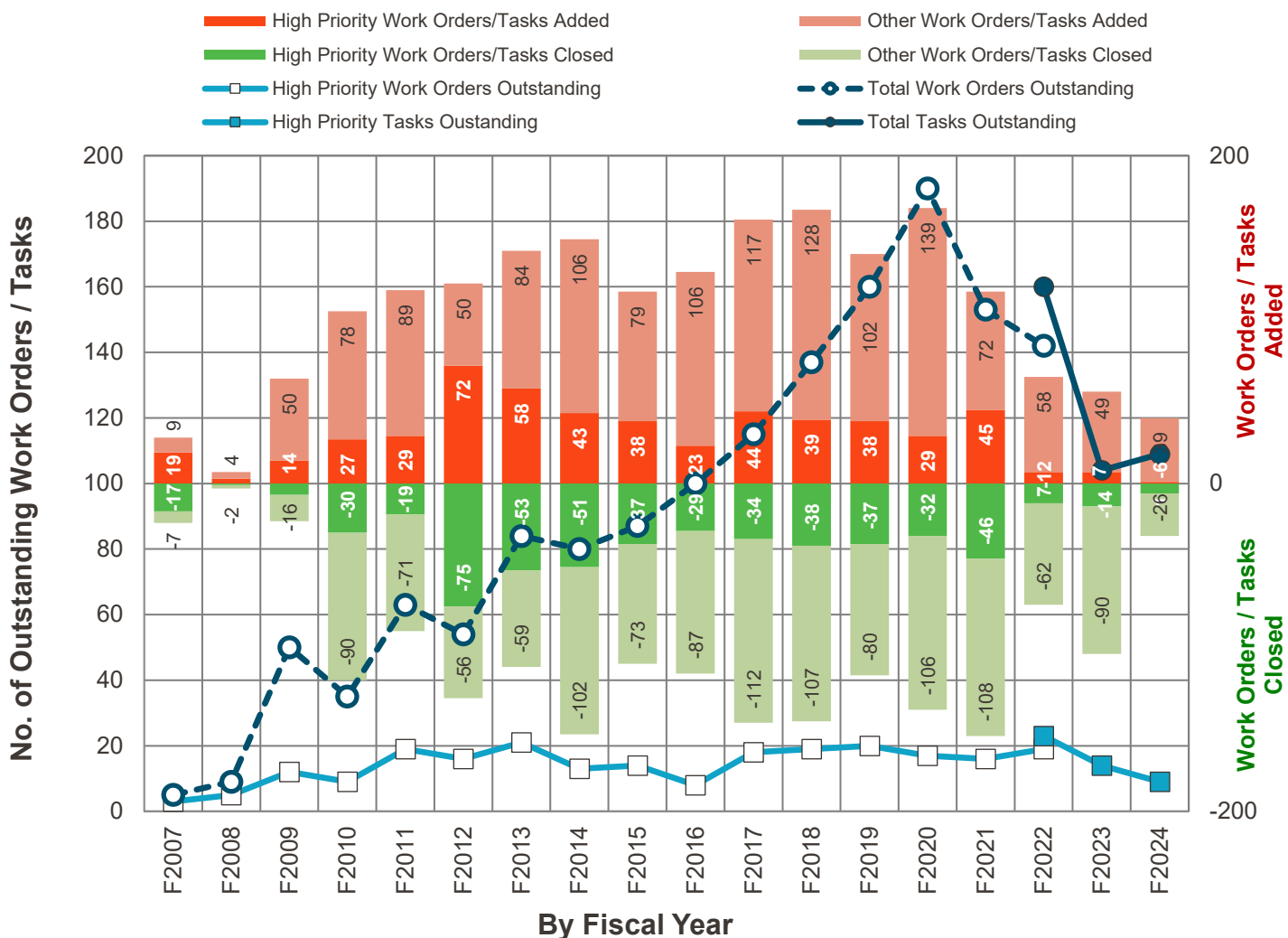


Figure 7 Number of outstanding corrective and condition-based spillway gate maintenance work orders and tasks, new work orders and tasks added, and work orders and tasks closed as at the end of each previous fiscal year.

Notes:

1. At the conclusion of F2022 moving forward into F2023, figures were restated as outstanding tasks instead of outstanding work orders to align with Operations reporting.
2. Work Orders / Tasks Added includes new work orders / tasks created in the year and identified with the gate reliability work group. It does not include work orders / tasks from previous years that were recategorized with the gate reliability work group.
3. Work Orders / Tasks Closed includes work completed through the annual maintenance program. It does not include cancelled work orders / tasks or work orders / tasks that were recategorized out of the gate reliability work group.
4. Due to notes 2 and 3, above, the net change in the number of Outstanding Work Orders / Tasks will not always equal Work Orders / Tasks Added less Work Orders / Tasks Closed

6.0: Quarterly Dam Safety Report

Emergency Preparedness and Public Safety

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

Site C Clean Energy Project

Dam Safety, Generation System Operations and the Site C Clean Energy Project team are engaged in ongoing collaborations to integrate the Project's design and construction activities and the eventually constructed facilities into BC Hydro's Dam Safety Program. With the decision made to fill the reservoir in 2024, the groups began to modify planning for next year's activities.

Personnel from Dam Safety continued collaborations with Stations Asset Planning, Engineering Services, Stations Field Operations and the Site C Clean Energy Project team to plan and prepare for the project acceptance processes.

The newly hired Dam Safety Engineer and Dam Safety Technologist were onboarded and are familiarizing with the facility. Recruitment is continuing for the second Technologist and a temporary Dam Safety Engineer to assist in establishing the dam's performance baseline and prepare for its first Dam Safety Review once that's accomplished.

Capital Projects

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

Alouette Headworks Tower and Surge Tower Seismic Upgrade

The objective of this project is to ensure that operation of the tunnel that diverts water from the Alouette Lake Reservoir to Stave Lake can be relied upon for control of the Alouette Lake Reservoir after a major earthquake. The components of the tunnel's discharge facilities include the headworks tower and shaft, the headworks operating gate, the surge tower and shaft, the slopes adjacent to these structures, the power tunnel concrete lining, and mechanical, electrical, protection and control, and communications equipment required for local and remote operational capability.

The first stage of construction comprising upgrades on the Stave Lake end of the tunnel and discharge facilities continued in Q3 of F2024 with work outside of the tunnel. This included upgrading the slopes above the surge tower, upgrading the surge tower structure, and preparing the back-up power and communications site. The remaining in-tunnel scope that forms part of the first set of works is planned to be completed during the summer 2024 tunnel outage.

For the second set of works, at the Alouette Lake end of the tunnel, the project continues to consult with First Nations, engage with key stakeholders, and work with regulators to advance based on a reservoir management approach that balances the risk of impacts to the reservoir with the risk of impacts to the Alouette River.

6.0: Quarterly Dam Safety Report

John Hart Dam Seismic Upgrade Project

Construction on the John Hart Dam Seismic Upgrade Project continued through Q3.

- On the North Earthfill Dam, the double-walled silt curtain was fully installed, in-water excavation of the upstream riprap was completed, and dredging of loose materials that will enable the placement of the compacted upstream berm progressed.
- On the Concrete Main Dam, work to raise the spillway's left training wall and to upgrade the dam roadway structures between the spillway and the North Earthfill Dam commenced.
- On the Middle Earthfill Dam, construction of the new plastic concrete cut-off wall progressed. The wall is built by excavating a vertical-walled trench, as deep as 37 metres, between concrete guide walls on the crest of the dam. To prevent the trench from collapsing, it is excavated in panels and clay bentonite is used to fill the gap. A pipe is lowered to the bottom of the trench and the plastic concrete is pumped in, pushing the bentonite upward and out. Construction continues in this way, panel-by-panel. By the end of January, the wall was approximately 50 percent constructed and is scheduled to be completed in the spring of 2024.



Figure 8 Construction on the John Hart Dam Seismic Upgrade Project. Left: Construction of a panel of the plastic concrete cut-off wall, showing the specialized excavating equipment in use (November 2023). Right: Looking upstream toward the North Earthfill Dam work site (January 2024).

Lake Buntzen 1 – Penstock Exterior Recoat

The objective of this project is to extend the life of the penstock at the Lake Buntzen 1 facility by recoating the exterior steel surfaces, refurbishing the steel and concrete pedestals, and replacing the dresser coupling bolts. Construction commenced for this project in F2024 Q3.

On the upper portion of the penstock, site preparations including contaminated materials management and grounding and bonding mitigations were completed, scaffolding was erected, and recoating started on November 15, 2023. The lower, steeply sloped portion of the penstock required greater efforts for site preparation activities, including asbestos management, and grounding and bonding mitigation solutions. Penstock corridor preparation activities are now substantially complete. Scaffold erection and recoating activities will commence in F2024 Q4.

6.0: Quarterly Dam Safety Report

Seton – Bypass Project

The objective of the Seton Bypass Project is to construct an alternative water conveyance pathway that diverts flows from the Seton Canal to the Fraser River, bypassing the generating unit. The hydraulic bypass will improve operational flexibility and water management in the Bridge River System and will enable maintenance of Seton's aging generating unit – as well as its future replacement – without increasing spill risks down the environmentally sensitive Seton and Lower Bridge Rivers.

The project has completed Feasibility Design and is proceeding to Preliminary Design. The project's Preferred Alternative is characterized by a tunnel that branches off from the Seton Canal immediately upstream of the forebay to the generating station and discharges into the Fraser River at the powerhouse tailrace. See Figure 9 at right.

The tunnel's design flow will be 120 m³/s, capable of fully replacing the generating unit's discharge, and will feature a fish diversion dam immediately upstream of the canal headworks. An application for a Certificate of Public Convenience and Necessity is being prepared for submission to the British Columbia Utilities Commission at the end of 2024.



Figure 9 Alignment of the proposed Seton Bypass tunnel.

Terzaghi Spillway Chute Access Improvement

The objective of this project is to mitigate the rockfall hazard sufficiently to allow detailed in-chute inspection of the Terzaghi Dam spillway structure, drain maintenance, concrete repairs, and, if required, subsequent capital projects to improve the spillway. Key design characteristics of the spillway structure resemble those associated with the recent spillway failure at Oroville Dam, making inspection and further assessment of the spillway a high priority for Dam Safety.

The project has completed the Feasibility Design Report, but a series of events have delayed the project's progression into Definition Phase. In the early summer of 2023, rockfall activity impacted the auxiliary structures adjacent to the Terzaghi spillway and the project was requested to investigate additional treatment and protection options for that area, where BC Hydro employees are often working. Later in the summer of 2023, the Casper Creek Wildfire burned around Terzaghi Dam and over the slope that is the subject of the project, requiring the development of a strategy for clearing trees that were impacted by the fire as part of the procurement strategy. Most recently, the rockfall event that is discussed under "New Issues" will require the project team to support the short-term response to clear the spillway and restore it to service, as well as to assess the impact of the rockfall on their design and procurement approach.

Various – Reservoir Booms Replacement – F2020

Many of the log debris booms around the system are coming to their end of life. Replacements have been sequenced based on the known condition of the existing booms and the criticality of the boom to facility operations. This project is the first grouping to be advanced as a program of replacements, which includes WAC Bennett, Mica, Sugar Lake, Cheakamus, Stave Falls, Clowhom, and Terzaghi Dams.

6.0: Quarterly Dam Safety Report

In F2024 Q3, the debris boom at Terzaghi was replaced with a new style steel boom. This boom replacement was particularly timely for two reasons: the existing log boom was identified as being in very poor condition and the 2023 wildfires around Carpenter Lake are expected to cause a larger than normal debris load in 2024. The new debris boom will be an essential part of the debris management strategy.



Figure 10 The new reservoir boom on Carpenter Lake. The intake structures for Bridge River 2 (at front) and Bridge River 1 (at back) are visible on the right side of the reservoir. Terzaghi Dam is just beyond the top of the photograph.

Dam Safety Investigations

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

Cheakamus Dam Hydraulic Assessment

The Cheakamus Dam Hydraulic Assessment was initiated in 2021 to characterize flood-related dam safety issues at the Cheakamus Dam and its associated structures and spillway channel and to make recommendations for any future upgrades to mitigate the associated risks. The scope of the investigation included:

- Updating the Safety Evaluation Flood, including analysis of the dam’s available freeboard while routing the flood;
- Analysis of the flood passage using computational fluid dynamics to determine the potential impacts of the flood passage to dam structures and the spillway channel; and
- Structural and geotechnical analysis of the stability of the dam and associated structures under flooding.

6.0: Quarterly Dam Safety Report

The Investigation was completed in Q3, with the final report expected in Q4. The investigation concluded that:

- No overtopping of the earthfill dam is expected for any of the updated Safety Evaluation Flood scenarios.
- Saddle Dam No. 1, the wing dam and the concrete main dam (see Figure 11 at right) all meet sliding and overturning criteria under the Safety Evaluation Flood scenarios with no loss of containment expected.
- Riprap at the base of the wing dam, the concrete main dam, and the Highway 99 embankment could be washed away as water flows through the emergency overflow channel during extreme floods.
- The spillway's right wing wall would be vulnerable to failure during extreme flooding. While it is unlikely that the wing wall's failure would retrogress to the dam and cause loss of containment, the modelling was not able to rule out that possibility.

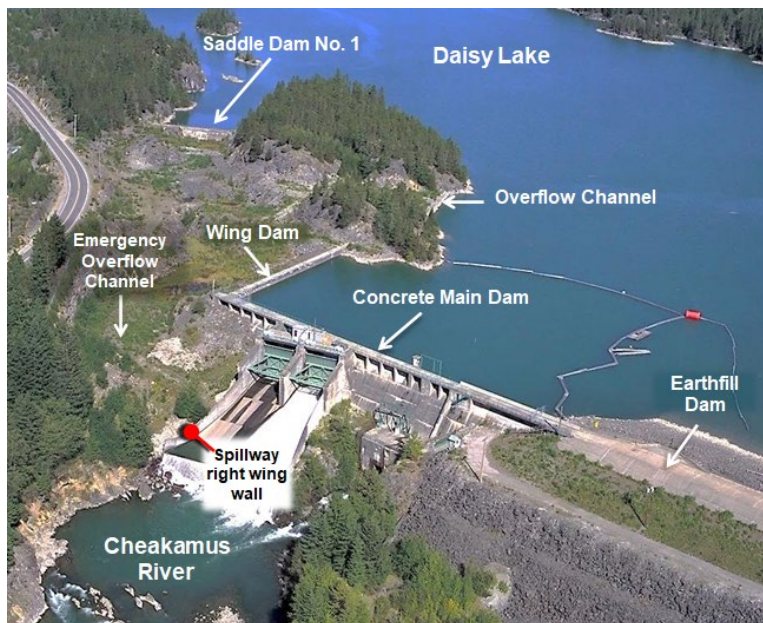


Figure 11 Aerial View of the Cheakamus Dam and Daisy Lake, identifying elements investigated in the Cheakamus Dam Hydraulic Assessment.

The Investigation's final report will recommend closing three Potential Deficiencies and two Non-Conformances in the Dam Safety Issues Database and to update three other Non-Conformance issues.

The Investigation's findings will further be used to inform the scope of an upcoming capital upgrade project for the Cheakamus Dam, the main objectives of which are to address seismic deficiencies of the earthfill dam and spillway piers as well as seepage and the potential for internal erosion of the earthfill dam. That project is planned to be released in F2026.