# BC Hydro Briefing Note

## Issue Site C Preliminary Market Consultation

## Background

- The Peace River Site C hydroelectric project is a potential third dam and generating station on the Peace River in northeastern B.C with an interim capital cost estimate of $5.1 to $6.6 billion. BC Hydro is currently in the Project Definition and Consultation stage of the Site C project.

- As part of Stage 2, the Site C project team is investigating procurement options for the design, construction, and operations of the Site C project. This review is in accordance with provincial guidelines for capital projects (the Ministry of Finance's Capital Asset Management Framework).

- In order to focus efforts on assessing various procurement options the Site C project team will require information from market participants regarding their technical, labour and financial capacity, ability to take and manage risk and views on timeline and structure of possible bid structures.

- BC Hydro has an extensive capital program and stays in regular touch with market participants. The Site C project, however, is of a higher capital cost and higher scale and complexity as compared to other capital projects underway at BC Hydro.

- For above reasons, BC Hydro intends to interview a selection of market participants in order to gather information regarding market preferences around the Site C project.

- This market consultation is consistent with overall consultation with Stage 2 which involves stakeholders and communities, in parallel with First Nations consultation.

## Objectives

- This market consultation is expected to be an exchange of information between the Site C team and market participants in order to inform the market about the characteristics of the Site C project, as well as inform BC Hydro about the market capacity, experience and interest in the delivery of this project.

- The specific objectives for the market sounding are as follows:

1. To provide early notification and preliminary information to potential participants on the Site C project

2. To explore the viability of procurement options for the Site C project and explore what aspects of the project can be packaged for optimal risk sharing with the private sector.

**Methodology**

- The Site C project team has engaged Pricewaterhouse Coopers (PWC) as its financial advisor on the procurement process, and will work with PWC in order to conduct the market consultation.
- Interviews will be conducted with different companies to provide their perspectives on their potential participation.

- A decision was made to interview a sample of companies within each category to ensure different perspectives are taken into account.

- At this time it was determined that it would be premature to contact other financial institutions such as rating agencies or insurers. Further, we determined that it is unnecessary to interview potential plant operators at the current time, as the most likely scenario is that BC Hydro would continue as the operator of the facility should it proceed.

- At the request of the Independent Contractors and Businesses Association, BC Hydro is also adding construction associations to its list of participants for market consultation.

- A project summary and a list of questions will be sent to invitees ahead of time in order to allow the companies to prepare.

- BC Hydro selected the following companies based on a review of experience with large hydro projects and/or perceived interest in infrastructure projects of this size.

**Proposed Participants**

Developers/Sponsors
Macquarie
SNC Lavalin
Electricité de France

Financial Investors
BCIMC
Brookfield Power
Caisse

Construction Contractors
Peter Kiewit and Sons
Flat Iron
Impregilio

Turbine and Generator Suppliers
Mitsubishi
Voith Siemens
Alstom
Andritz

Transformers and Switchgear Suppliers
Hyundai
ABB

Lenders
Dexia
Fortis
BNP Paribas

Associations:
ICBA
BC Construction Association
Northern Construction Association
Vancouver Regional Construction Association

**Market Consultation Questions**

- Below is a sample of some of the questions that will be asked during market consultation. These are draft and will be finalized in the upcoming two weeks.

1. Do you see any issues related to market capacity for this project?
2. Are you interested in the development of a project of this size?
3. What other roles would you be interested in?
4. Do you have the capacity to undertake a deal of this size alone? If not would you partner with others?
5. Have you worked on other hydro projects of this scale?
6. What do you believe to be the best model for procuring this project?
7. Would you be interested in a long-term performance-based contract option for this project?
8. What components of the project would you expect to be included in a performance-based contract? (i.e. design / build / finance / operate / maintain etc.)

9. If operations or maintenance was included in the contract, what would be a reasonable concession term?
10. What do you consider to be a reasonable time frame to allow proponents to submit a fully committed bid?
11. Would you be prepared to bid on a project prior to final regulatory approval?
12. What do you believe to be the most likely financing structure for this project?
13. What other competing projects are you considering in the same time frame?
14. What are the challenges you see in this project?
15. Would a construction period of 7 years be an issue?
16. How detailed should the project design be at the procurement stage for you to bid?
17. Will you assume geotechnical risks? How will you manage this risk?
18. What do you see as some of the key challenges you may have on this project?
19. What other roles would you be interested in?
20. Do you see any issues with the financing market capacity for this project?
21. What is your debt capacity for this project? What kind of coverage ratios would you require?
22. What do you see as the most likely financing structure for this project?
23. How much time do you need to complete due diligence and obtain full credit approval?
24. What other competing projects are you considering in the same time frame?

**Schedule**

| Task | Date |
|---|---|
| Finalize market sounding documents<br>• Project Brief<br>• List of questions<br>• List of invitees | June,2008 |
| Send invites to potential participants | June 2008 |
| Conduct market sounding meetings | July – August 2008 |
| Prepare summary report | August - September 2008 |

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# BC Hydro Briefing Note

**Issue: Peace River Site C Hydro Project – 2009 Environmental and Engineering Field Program**

This briefing note provides an overview of the study components for the environmental and engineering field and study program taking place in 2009 for the Site C project. The study list below outlines those studies or investigations which generally include some field work in the Peace region.

| Study Name | Study Rationale | Field Presence / Schedule | Contractor |
|---|---|---|---|
| **ENVIRONMENTAL STUDIES** | | | |
| **1. Stone Sheep Survey** | New Study. Stone Sheep surveys and pellet analysis, assess for potential presence in project area. Issue raised by Blueberry River First Nations. | Mar - July: 3 visits to record sheep at 15 sites between Hudson's Hope and the Moberly River. Helicopter drop off 2-3 crew. | Keystone |
| **2. Peace River Fish Telemetry Studies** | Continued Study (2005 – 2009). Fish tracking program to gather fish movement data, to understand fish and habitat use, and movement past the potential dam site. | Late Spring – Fall: Monthly and bi-weekly overflights of rivers with fixed wing plane. Monthly field access to fixed stations along river banks (by boat, foot or helicopter). Location same as last year, mainly Pine River. | AMEC |
| **3. Peace River Tributary Fish Studies (juvenile spawners)** | Continued Study (2005, 2006, 2008, 2009). Assess tributary fish and habitat usage, to understand how the project would affect | Seasonal sampling (late spring, summer, fall, early winter) for 1 week / season. Boat or shore access, walking along river bank, in stream nets. | Mainstream |

| Study Name | Study Rationale | Field Presence / Schedule | Contractor |
|---|---|---|---|
| | key habitats and fish life stages. | | |
| **4. Archaeology Archival Work: - Digital Catalogue - Recorded Site Location Verification** | New Study. Develop digital catalogue system. Verify previously identified site locations, by checking original field maps and correcting BC database. | none | RFP underway |
| **5. Archaeology Potential Model** | New Study. Will define level of work for stage 3 field inventory (% of area and sampling intensity). | none | RFP underway |
| **6. Bat Surveys** | Continued Study (2005, 2006, 2008, 2009). Tag and track bats focus on listed northern myotis. Data gap identified in TAC discussions. | July: Land based walking around following bat signals, same as last year | Keystone |
| **7. Climate Study** | Continued Study (2008 – 2009). Wind station installation and data collection. | Monthly: collect wind data from stations | RWDI |
| **8. Recreation / Angler Survey** | Continued Study (2008 – 2009). Survey of recreation users to understand current recreation use patterns. | Monthly through Oct 2009: Visitor surveys at sites along the Peace River and Pine River. Helicopter flights (counting anglers) | LGL |

| Engineering Studies | | | |
|---|---|---|---|
| **9. North Bank Pore Pressure Pump Test** | Continued program<br><br>Completion of pump test initiated in 2008 to assess pore pressure dissipation and confirm design standard. | Late May to October<br>North Bank at proposed Site C Dam site | SNC Lavalin / KCBL<br><br>Beck Drilling<br><br>Local Contractor Support |
| **10. South Bank Rebound Testing** | Continued program<br><br>Work initiated in 2008, additional core samples are required for long term tests. | June to August<br><br>South Bank at proposed Site C Dam site | SNC Lavalin / KCBL<br><br>Beck Drilling<br><br>Local Contractor Support |
| **11. Landslide Instrumentation Monitoring** | Continued program<br><br>Condition assessment of the historic instrumentation in the valley was completed in 2008 and monitoring was re-established.<br><br>Continued monitoring of historical instrumentation is planned for 2009 | Monitoring existing instrumentation<br>Helicopter pickup and drop off required for some sites on South bank.<br><br>May/June and September/October | SNC Lavalin / KCBL<br><br>Ian Harder Associates |

**BC Hydro Key Contact**
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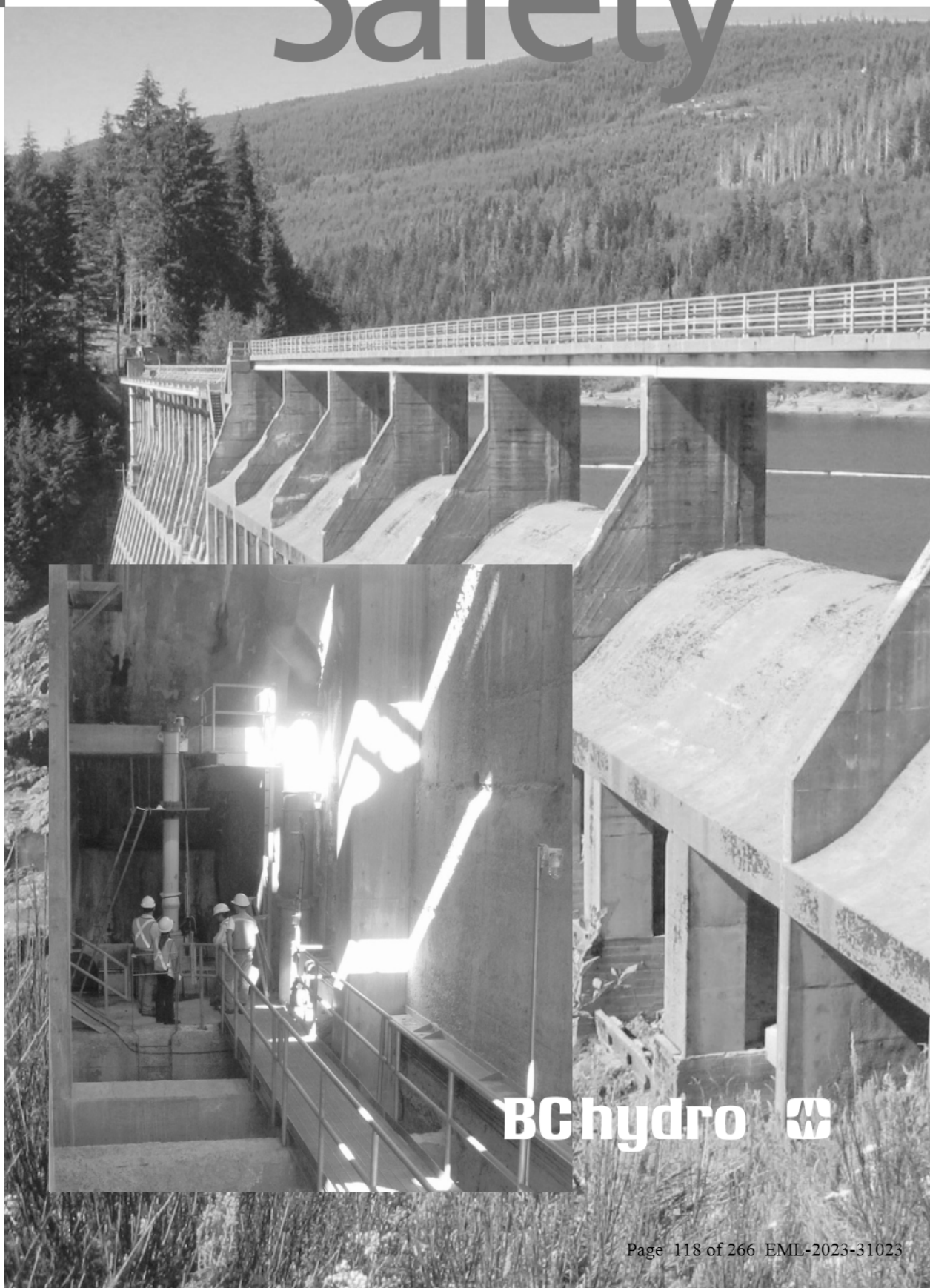
2007 — 2008

# Dam Safety

APRIL 2008

ANNUAL REPORT



Jordan River

BC hydro

# Dam Safety Program
# Annual Report 2007/2008

Prepared by:

Raymond A. Stewart
Director of Dam Safety

April 2008

# Executive Summary

BC Hydro owns, operates and maintains 74 dams at 41 sites across British Columbia. The dam safety program provides oversight for management of the wide range of risks associated with these dams. Governance of dam safety was strengthened in 2006 with integration of dam safety into the broader responsibilties of the Chief Safety, Health and Environment Officer, who also acts as Director of Dam Safety. We continue to improve surveillance processes, analytical and assessment methods, and decision-making, as part of BC Hydro's robust dam safety management system.

The matter of continual escalation of the traditional industry "standards and practices" for dam safety that have focused on severe floods and more recently earthquakes, remains an important area for improvement of dam safety practices. The extreme event standards approach does not capture higher probability events that combine to cause failures, nor does it address human error and management system failures under relatively normal operating conditions.

To address these problems, which exist at an industry-wide level, BC Hydro continues to provide leadership at national and international levels in the development of a more rational and balanced risk-informed approach to dam safety management that deals with the problem of natural hazard escalation and also addresses other very important matters of dam safety risks not normally included in dam safety practices.

The initial gains in risk reduction from the spillway gate reliability improvements initiative have been sustained and some immediate physical risk reduction measures were completed for the Campbell River system. However, the reduction in risk, while substantial, did not achieve the level of residual risk that is "as low as reasonably practicable" (ALARP). This problem arises because of a lack of ALARP-focused systems engineering capability in the industry. To address this problem, BMT Isis, a specialist consulting firm with expertise in safety assessment, risk-based concept design and Safety Case preparation for hazardous systems that include hydraulic control, was engaged to explain how the ALARP condition can be achieved, and to provide the framework to achieve this objective for the spillway gate reliability improvement initiative.

The full extent of the dam safety deficiencies resulting from degradation of the spillway gate systems has been defined. The extent of other dam safety concerns due to a historical shortfall in civil maintenance, particularly of ancillary structures, is emerging, and additional investigations will be forthcoming to address these issues. The expected performance targets for the future will be set within a risk assessment framework.

With the agreement of the Comptroller of Water Rights, the detailed review of the National Building Code's seismic guidelines was expanded to provide a state-of-the-art and scientifically robust characterization of the seismic hazard in British Columbia. This study will provide the necessary information that is not available from the National Building Code and it will provide a stable basis for characterizing dam safety seismic hazards in the foreseeable future.

The contractor for the Coquitlam Dam failed to meet the project completion schedule and BC Hydro was forced to maintain its compensatory operational risk controls over the winter and spring period.

Coquitlam, Ruskin, Strathcona, John Hart and La Joie remain the higher risk dams. The risks at Coquitlam and Ruskin dams are being managed by reservoir operation controls. The risks at Strathcona, John Hart and La Joie dams are managed through diligent surveillance. Knowledge uncertainties, many of which are associated with original design and construction features, represent the dominant background risk at other dams such as Mica and WAC Bennett.

# Contents

# Introduction

*BC Hydro's dams*

BC Hydro owns, operates and maintains 72 dams at 41 dam sites throughout British Columbia, as a major part of its generating system. The dam facilities are listed in Appendix A. Coursier Dam was decommissioned in 2003, and the Jordan forebay dam was removed in 2005.

BC Hydro is accountable to the government of British Columbia, and in particular to the Comptroller of Water Rights, for ensuring the safety of BC Hydro dams in accordance with the British Columbia Dam Safety Regulation (B.C. Reg. 04/00 Deposited February 11, 2000).

BC Hydro's commitment to dam safety is outlined in Corporate Policy Statements on Safety and Risk Management. The management system is documented in the Dam Safety Management Manual.

# Governance and Organization

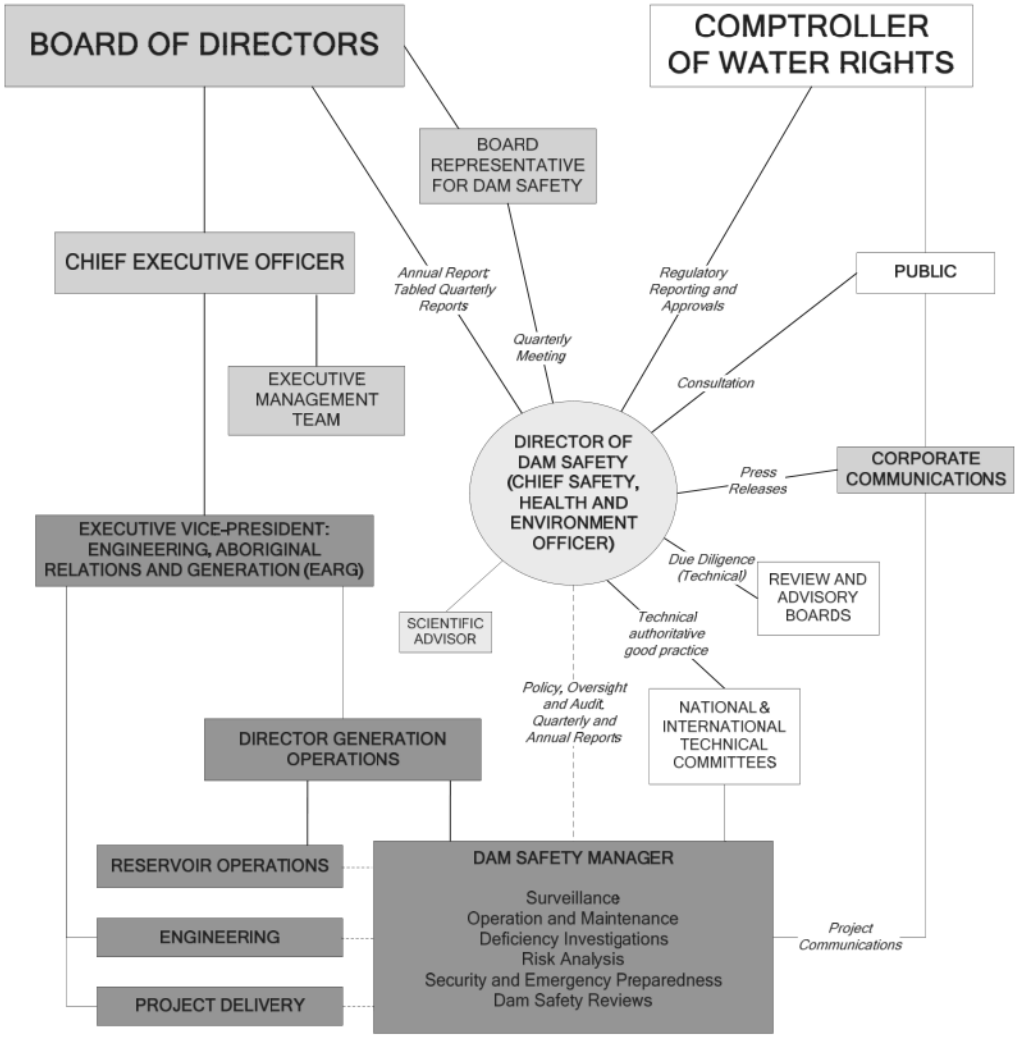
*Governance*

Governance and implementation of dam safety at BC Hydro is shown on the chart below. Mr. Raymond Stewart has a dual role of Director of Dam Safety and Chief Safety, Health and Health and Environment Officer. He reports through the President and Chief Executive Officer (CEO) to the Board of Directors.

*Director of Dam Safety*

The Director of Dam Safety sets policy and provides scientific direction and corporate oversight to the Dam Safety Program.

The Director of Dam Safety met quarterly with Mr. W. Saponja, the assigned Board of Directors representative for dam safety, prior to tabling the quarterly reports to the full Board of Directors. An annual report is prepared for the Board of Directors.



*Advisory Boards*

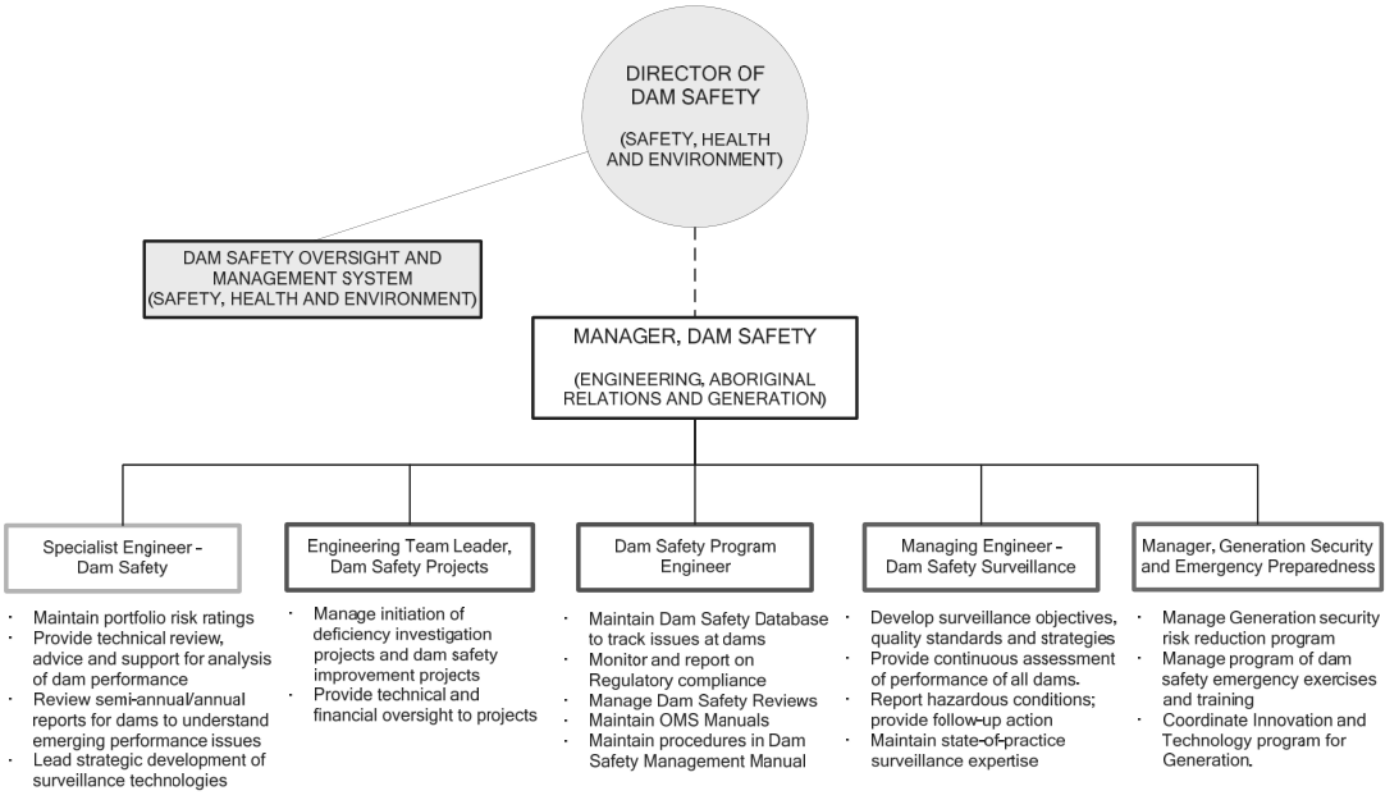
The Director of Dam Safety convenes Advisory Boards to provide independent interpretation of the engineering and scientific information used to inform decision-making, or to provide guidance on decision-making concerning complex or unique matters of societal risk. Up to three or four independent subject-matter experts of international repute, with complementary expertise suited to the type of issue under consideration, make up the Boards.

In 2007-2008, Advisory Boards met for the Strathcona seismic and seepage upgrades and for the seismic hazard model project.

*Dam Safety Program*

The Dam Safety Program is implemented by the Dam Safety group of Engineering, Aboriginal Relations and Generation (EARG) with a staff of about twenty. This includes five dam safety area engineers resident in the generating regions, who are involved in all dam safety activities at the dams. Coordination and support related to instrumentation systems, regulatory requirements, risk management, and the program of dam safety investigations and capital upgrades, are provided by staff at Edmonds who report directly to the Manager of Dam Safety.

The Director of Dam Safety, through the office of Safety, Health and Environment, provides corporate oversight, policy, scientific guidance, review and audit of the dam safety program.



# Dam Risk Management

*Management System*

The dam safety management system is described in detail in the Dam Safety Management Manual, which is updated periodically on the BC Hydro Intranet.

Dam risks are generally identified through surveillance activities or the periodic independent expert dam safety reviews for each dam. Once a potential or actual deficiency is identified, it is entered in the dam safety database, and then tracked through to resolution. A key aspect of the risk management process is prioritization of the deficiencies.

*Risk Profile*

The Consolidated Risk Index (see figure) shows the current risk measure and estimated future changes in risk at each dam that has an identified active or future dam safety improvement project. The portfolio risk is the aggregate total of all the individual dams.

The term “risk” is used here in a general sense; it is not a measure of the probability of failure multiplied by the consequences. Although desirable, dam risks cannot yet be reliably quantified.

The risk shown is a measure of the degree of non-conformance to current practices, multiplied by a weighting factor which increases with the consequence category for the dam.

The risk profile cannot account for any future deficiencies that may be uncovered during routine surveillance, during the periodic dam safety reviews, or during other dam safety activities. As new deficiencies are identified, and as existing deficiencies are addressed, the risk profile is adjusted and reported quarterly.

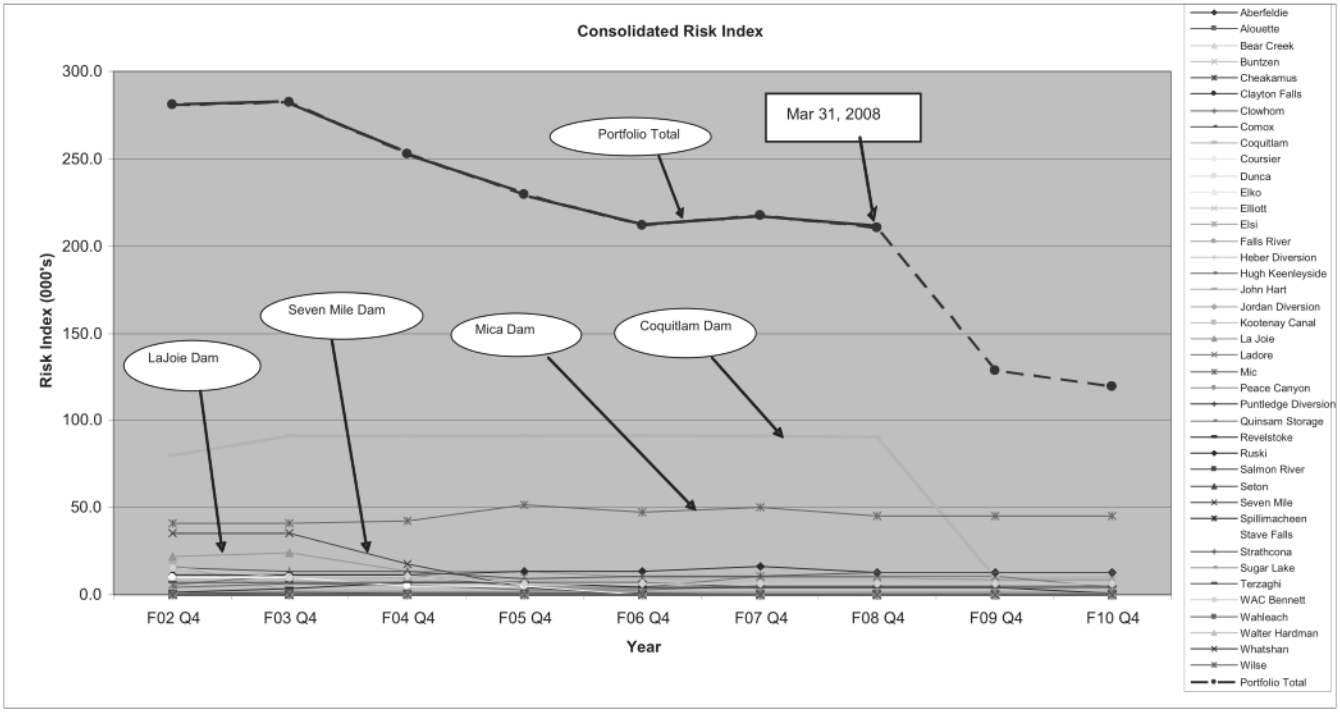
The risk estimates are heavily weighted by the consequences of dam failure; that is consistent with the use of the “precautionary principle” in catastrophic loss risk management. Therefore the dams with very large consequences dominate the risk profile.

*Dam Risk Matrix*

The BC Hydro dam deficiency prioritization system develops a deficiency rating for each dam which is a surrogate for probability of future poor dam performance. This is an aggregate rating based on all known issues or departures from state-of-practice or current standards.

When the deficiency rating is plotted against the estimated consequences of failure, a measure or index of risk results. The Risk Matrix below represents the current (2008 March 31) status for all the dams with identified actual deficiencies and potential (as yet unconfirmed) deficiencies. Changes from 2007 April 1 are highlighted in colour, with explanation following.

# CONSOLIDATED RISK INDEX



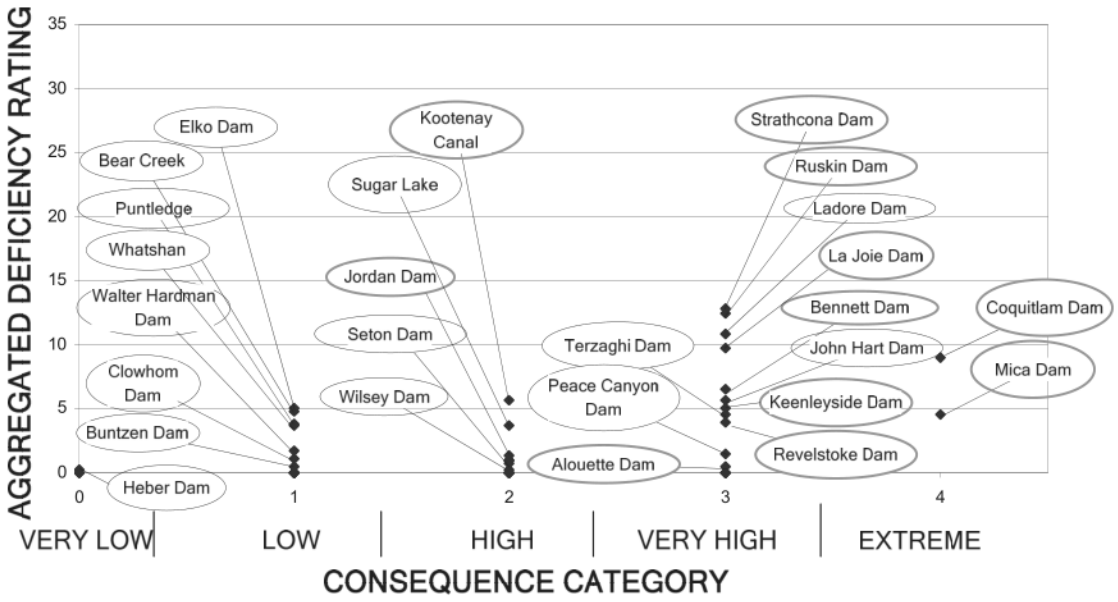

**How to interpret the Risk Index:**

The risk index for each dam is the qualitative assessment of future poor dam performance from all causes, multiplied by a dam consequence factor. The consequence factor increases logarithmically from the very low consequence category (factor = 1.0) to the extreme consequence category (factor = 10,000). The effect is to highlight the very high consequence (catastrophic loss risk) dams for priority risk management.

This risk index chart should be used in conjunction with the risk matrix, following, to appreciate the currently identified range of dam risks and how they compare to each other in the total portfolio.

## RISK MATRIX

(Risk status, at 2008 March 31, of dams with identified performance deficiencies)




***Legend:***

Active project — Active deficiency investigation or capital upgrade project

No active project — No active deficiency investigation or capital upgrade project

***How to Interpret Risk Matrix:***

The vertical axis is an assessment of future poor dam performance from all causes; the higher up the scale, the more likely is poor performance. The horizontal axis indicates severity of consequences of dam failure, increasing to the right.

Priority attention is paid to dams in the upper right. The management goal is to move the position downwards for each dam. When risks from defined issues at a dam are fully mitigated, the dam is removed from the chart. A dam may reach a background risk that cannot be easily reduced further. Dams are added or the position is adjusted when new risk information is obtained.

Minor changes to risk rating (1 unit or less) occur during the year and are not normally reported.

*Risk Reduction Projects*

The planned projects (including the ones already in progress) that are estimated to exceed $2 million are listed in the table below. Exclusive of the gate reliability upgrades and security program, a total of $474 million is estimated for these projects. However, some of these costs are very uncertain as the definition phases has not yet been started.

## SUMMARY OF MAJOR PROJECTS

**(Exceeding $2 Million to F2011)**

| Dam | Estimated cost ($ Million) Best Est. | Range | Major Upgrade Items | Estimated Project Start (Fiscal Year) | Reduction in Risk Index x 1000 |
|---|---|---|---|---|---|
| System-Wide | - | 175-325 | Gate reliability upgrades (10 high priority sites) | In-progress | n/a |
| System-Wide | 1.5 | 1.5-3 | Automatic data acquisition at numerous sites | In-progress | n/a |
| System-wide | 4 | 4-8 | Flood simulation at numerous sites | In-progress | n/a |
| System-wide | 5.7 | 5-7 | Seismic hazard assessment | In-progress | n/a |
| Coquitlam | 66 | 66 | New embankment dam | In-progress | 80.0 |
| La Joie | 70 | 70-190 | Leakage reduction and seismic upgrades | F10 | 8.2 |
| La Joie | 6 | 6 | North conduit seismic improvements | In-progress | 1.5 |
| Kootenay Canal | 18 | 18-40 | Forebay seepage embankment upgrades | In-progress | 0.4 |
| Revelstoke | 6 | 6-8 | Downie Slide - reservoir slope drainage | In-progress | n/a |
| Ruskin | 170 | 170-270 | Seismic and seepage upgrades | In-progress | 8.9 |
| Strathcona | 90 | 90-200 | Seismic and seepage upgrades | In-progress | 9.0 |
| W.A.C. Bennett | 34 | 34-70 | Rip-rap upgrade | F11 | 3.0 |
| W.A.C. Bennett | 2.5 | 2-6 | Observation well grouting | F10 | 1.5 |

*Deficiency Investigations*

An examination of ongoing and future deficiency investigations provides some insight into potential issues which may have to be addressed in the future if they are confirmed as deficiencies. These issues include those listed below:

## SUMMARY OF CURRENT AND FUTURE DEFICIENCY INVESTIGATIONS

| | Dam | Possible Issues |
|---|---|---|
| *Deficiency Investigations Underway* | Mica | Dam performance |
| | Alouette | Seismic performance |
| | Cheakamus | Seismic performance |
| | Jordan | Seismic performance |
| *Future Deficiency Investigations* | Sugar Lake | Abutment seepage |
| | WAC Bennett | New seismic and flood standards |
| | Columbia Basin | New flood standards |
| | Puntledge | New seismic and flood standards |
| | Seven Mile | Review of auto spill procedures |
| | Deferred* | Pending new seismic standards |

* Clowhom, Duncan, Hugh Keenleyside, John Hart, Kootenay Canal, Ladore, Peace Canyon, Revelstoke, Seton, Terzaghi

*Design Earthquakes*

BC Hydro is carrying out an assessment of current practices and uncertainties around seismic hazard models and seismic performance goals for large dams. In order to provide the appropriate scientific rigour and to draw upon the very limited number of specialized experts in this field, the project plan has been extended to the winter of 2009-2010.

In the meantime, following extensive discussions with the Comptroller of Water Rights, new seismic assessments at dams where the dams already meet high seismic standards are being deferred until we have completed the overall seismic reassessment.

*Spillway Gate Reliability*

Since 2005, BC Hydro has commenced a systematic review and upgrade of all spillway gates required for flood control. The program focuses on modernizing the gate systems and improving their safety and reliability for normal operation. A total of 111 spillway gates and valves will be upgraded at 22 dam sites as part of this program.

The first phase upgrade of gate systems at 3 high-priority sites was completed in 2008. Engineering design is being carried out on the other seven high-priority sites (Cheakamus, Terzaghi, Seton, Stave Falls, Hugh Keenleyside, Duncan and Ruskin). Implementation is planned to commence in 2008-2009.

Engineering design is also being carried out to upgrade the reservoir level monitoring infrastructure. This is required to enhance gate reliability, reservoir operation capability and dam safety, and will be carried out at all BC Hydro dam sites. Pilot implementation is planned at Cheakamus and Clowhom in 2008. As early improvements, reservoir level sensors have been added at 6 sites in 2007.

Since August 2006, the spillway gates have been regularly tested, with gates at higher criticality sites tested monthly. The tests have helped verify availability, detect equipment and operational problems, and provide regular training to plant staff in spillway gate operation. Progress in 2007-2008 included the following activities:

- *John Hart, Ladore and Strathcona Dams;* the spillway gates at Strathcona, Ladore and John Hart dams have been refurbished for normal operation.
- *Seton Dam;* major repair work has been carried out on the single spillway gate at Seton Dam.
- *Mica, Seven Mile and Stave Falls Dams;* hoist cables of 8 spillway gates at the three sites have been replaced.
- *Duncan Dam;* early attention refurbishment was carried out on the spillway gate hoists to reduce friction within the system.
- *Peace Canyon Dam;* seal heaters will be replaced in April 2008.
- *Falls River Dam;* as interim risk management, an operational variance has been approved by the Comptroller of Water Rights to waive the installation of flashboards.
- *Whatshan Dam;* interim risk mitigation measures are being developed prior to modification of the flood discharge facilities.
- *Elko Dam;* an interim risk management plan is being developed prior to determining the modifications required to the spillway gates.

# Regulatory Activities

The key requirements of the BC Dam Safety Regulation include the following activities.

*Site Surveillance*

A total of 1528 inspections were completed for the 41 dam sites. This represents 97 percent of the required inspections, compared to the regulatory target of 90 percent.

*Formal Dam Inspections*

Annual surveillance inspections and reports have been completed for all 41 dams for Fiscal 2008.

*Instrumentation and Surveys*

Dam instruments have been read and recorded, and surveys have been completed throughout the year in accordance with the schedule submitted to the regulator.

*Gate Testing*

Spillway gates required for passing the design floods have been inspected and tested, and exceptions are noted in the annual report for each dam. A program for assessing and improving spillway gate reliability is underway for the system (See Dam Risk Management – Spillway Gate Reliability for details).

*Emergency Plans*

All emergency plans and planning guides have been reviewed and revised during Fiscal 2007 in accordance with the Regulation.

*Operation, Maintenance and Surveillance (OMS) Manuals*

The OMS manuals (41) have been reviewed and are in the process of being updated as necessary.

*Dam Safety Reviews*

These periodic comprehensive and detailed reviews of dam performance and assessment against current standards are required on a 5 to 10 year schedule for dams where the consequences of failure are high. Dam Safety Reviews were conducted for Strathcona and Elko Dams in 2007-08 and the findings will be incorporated into the dam safety management system.

*Meetings with Dam Safety Regulator*

The Director of Dam Safety met with the Comptroller of Water Rights, together with key staff, on January 15, 2008, to discuss matters of mutual interest. The topic of escalating seismic and flood design standards, in general, was addressed, as was BC Hydro's current investigation into alternative means to manage flood risks in the Campbell River system.

*Surveillance Highlights*

Performance-based surveillance reviews, using the fault tree methodology, are being conducted for BC Hydro dams to focus surveillance activities on site-specific potential failure modes for each dam. In F2008, the process was applied to Mica, Clowhom, John Hart, Wahleach and Hugh Keenleyside Dams.

Surveillance staff work closely with plant staff to address operational issues which impact dam safety, and with teams undertaking investigation or improvement projects. Among the surveillance issues addressed during F2008 are the following.

- *Kootenay Canal Dam*

  Over the years, cracking and leakage has occurred in the concrete slabs lining the canal, with the latest cracks found in February 2007. Temporary

repairs to the cracked slabs upstream of the right intake were completed by May 2007. The work was coordinated by Kootenay Canal staff and involved installation of steel reinforcement and pouring of concrete underwater using divers. The work was safely completed during a single nightshift. Ongoing performance monitoring of the canal is being covered by routine surveillance activities that include the Automated Data Acquisition System with real-time data assessment and alarm capabilities.

Site investigations were completed in 2007 for design of a permanent fix to the leakage and cracking issue. Remediation options being considered include a membrane, downstream toe berms, concrete patching and grouting under the slabs. Removal and reconstruction of the affected slabs, which would require a canal dewatering, is also under consideration.

- *Ruskin Dam*

  Regular surveillance detected increased seepage from the left abutment area of Ruskin Dam in December 2006. The leakage was found to originate from the G3 penstock (tunnel) and the penstock was dewatered for inspection and eventual repair.

  Repairs to the tunnel were completed and an automated instrumentation array installed to monitor tunnel and left abutment performance. Following test filling in May 2007, Unit 3 was returned to service and has been operating satisfactorily. All observations indicate that both pressures and seepages around the tunnel and within the left abutment area are consistent with successful repair of the tunnel lining.

  Investigations into the tunnel leakage found the condition of the slope adjacent to the penstock to be a concern.

- *WAC Bennett Dam*

  The performance of WAC Bennett Dam was within usual thresholds during F2008. The performance and surveillance of WAC Bennett Dam has been reviewed annually by an independent expert, to comply with an order from the BC Comptroller of Water Rights. The last review was completed in April 2007. Future reviews are proposed to be carried out every three years, or as required, based on continuous surveillance.

# Security and Emergency Preparedness

*Security Upgrades*

Installation of physical security systems was completed at Mica, Revelstoke and WAC Bennett Dam (GM Shrum Generating Station). Operational documentation is underway and final commissioning will be completed when the snow melts in the spring.

Multi-year contracts for supply and installation of security systems, motorized and non-motorized gates, and fencing were awarded in F2008.

Performance of the existing hydraulic bollards installed for security at Mica and Revelstoke is under review. Included in the review will be recommendations for continuous crash-rated barrier systems to be installed at other critical generating facilities.

*Cyber Security*

The North American Electric Reliability Corporation (NERC) sets reliability standards that are mandatory for American utilities. In 2007, through its energy policy, the government of B.C. committed us to compliance with these standards. As part of an overall compliance program, BC Hydro is verifying the scope of work and cost estimates for compliance with the new Cyber Security standards for Critical Infrastructure Protection. Site specific reviews of cyber vulnerabilities were carried out at Burrard Thermal and Buntzen Generating Stations and the Shift Office.

*Emergency Planning Exercises*

A major functional emergency preparedness exercise on the Columbia Basin was conducted with participation from BC Hydro, Columbia Power Corporation, Fortis BC, US Bureau of Reclamation, US Army Corps of Engineers, and the National Weather Service. In British Columbia the downstream response agencies participating in the exercise included the Provincial Emergency Program Victoria and Nelson Regional Offices, the cities of Revelstoke, Nakusp, Nelson, Castlegar and Trail and the three Regional Districts bordering the Columbia River. In the United States, the state and county agencies also participated.

The exercise provided a training opportunity in terms of flow coordination and emergency decision-making and response for the 119 participants. The findings of the exercise relate to improving the visual communication of the impact of high flows (hydrographs, GIS polygons, etc.) and addressing confusion related to the metric/imperial units of measurement between the two countries.

# Project Activities at BC Hydro Dams

The safety status of BC Hydro dams is assessed through ongoing surveillance, periodic Dam Safety Reviews and deficiency investigations. When necessary, capital improvement projects are then carried out.

The dam safety capital improvement projects are listed in Table 1 and Deficiency Investigations are listed in Table 2 in Appendix C. The major projects are summarized below.

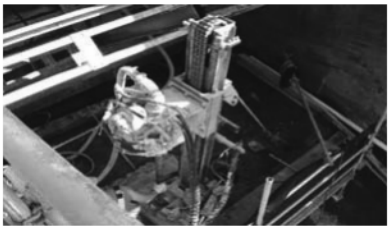
## Projects Completed in Fiscal 2008 – Capital Improvement

*Walter Hardman Dam – Seepage Monitoring Weirs*

- ***Walter Hardman Dam – Seepage Monitoring Upgrade***

The Walter Hardman facility includes a dam on Cranberry Creek that diverts water into a diversion channel containing several control structures, and into Cranberry Headpond. A single penstock delivers water from the headpond to the 8 MW capacity generating station situated on the west shore of the Arrow Lakes Reservoir about 1 km away. More specifically, there are two through-going conduits in the headpond embankment dam, each with a concrete valve chamber at the downstream toe of the dam. In the past, seepage has been observed near these chambers, but they were not monitored.

Construction of a collection system and two weirs to improve surveillance of the seepage flows through the dam at the valve chambers was completed in November 2007.

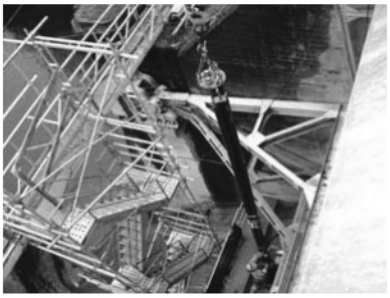


*Ruskin Dam – Drilling in anchor hole in Bay 1*

- ***Ruskin Dam – Crest Block Anchoring***

Ruskin Dam retains the Hayward reservoir which supplies water to the 105 MW generation station near the downstream toe of the dam. The dam is a concrete gravity structure located near Mission in the Lower Mainland.

Installation of anchors in the spillway crest block was completed in November 2007. Passive anchors were installed at each of the seven spillway bays This mitigates the risk of failure of the crest block during the design seismic event.



*Ruskin Dam – Bay 7 Anchor Installation*

## Active Projects – Capital Improvements

*Coquitlam Dam – Zone 1 fill placement excavation, Oct 2007*

*Coquitlam Dam – Zone 1 Impervious Core at El. 150 m, Oct 2007*

### ➢ *Coquitlam Dam – Seismic Upgrades*

The Coquitlam Dam seismic upgrade consists of construction of a new earthfill dam downstream of the existing dam. The restricted reservoir continues to mitigate the seismic risk while the seismic upgrades are under construction.

Planned progress on construction in Summer/Fall 2007 was not achieved due to a late start and periods of very low productivity. As a result, the Contractor suspended the work when poorer weather conditions started in October. The embankment dam advanced to El. 150 m, about 11 m below final crest elevation. Work that was not sensitive to weather (post-tensioned anchors, instrumentation and limited site reclamation) continued during Winter. Start-up of the embankment construction is currently under discussion with the Contractor and completion is targeted for August 2008.

*Ruskin Dam*

### ➢ *Ruskin Dam – Seismic Upgrades*

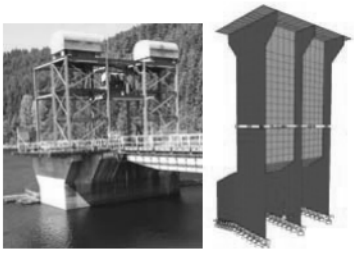
Hayward Reservoir at Ruskin Dam continues to be operated at the low end of the normal operating range as an interim risk mitigation measure.

Detailed analysis of dam performance, in progress, indicates that the lower portion of Ruskin Dam may not require seismic upgrades (anchoring).

The development of long-term dam upgrade options continues, including seismic upgrades to the spillway section dam and right abutment. Work to evaluate the new cut-off option for the right abutment was added to the scope. An Advisory Board meeting will be held during the first week of April 2008.

Work is underway to evaluate mitigation options to address the environmental issues at Ruskin. The scope and impact of this additional work on the overall project schedule is yet to be determined.

*Strathcona Dam*



*Strathcona Dam – Intake tower, conceptual view of isolator option*

### ➢ *Strathcona Dam – Dam Safety Upgrades*

The seismic upgrade work will include the installation of isolators and anchors in the intake tower, construction of a reverse filter berm at the downstream slope of the dam, and anchoring at the spillway and training walls. The project is currently in definition phase, with preliminary design of the upgrade options expected to be completed by Q2 of F2009. An Advisory Board meeting to review the options and preliminary designs was held in December 2007. Recommendations from their report are being incorporated into the designs.

The field investigation program, completed in November 2007, found potentially loose material; additional investigation is required to fully understand the nature and impact of this loose material. This investigation is expected to be completed by Q1 of F2009. If required, the impacts of the new information on the project scope will be evaluated after completion of the field investigations.

Project completion is targeted for F2013. This date will be reviewed, pending the results from the 2009 field investigations work.

*La Joie Dam – North conduit, setting up for drilling for conduit supports*

### ➢ *La Joie Dam – North Conduit Improvements*

The North Conduit at La Joie Dam serves as the low level outlet (LLO) for the facility while the South Conduit is used for power generation. The LLO consists of a 2.7 m diameter steel conduit installed inside a 4.3 m diameter concrete-lined tunnel excavated in rock, supported on discrete concrete saddles.

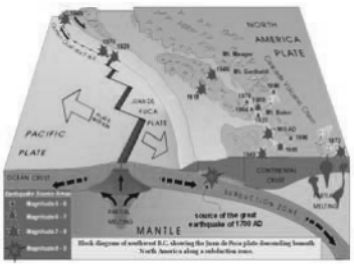
Previous studies have concluded that the steel conduit could fail in the design earthquake if the conduit is full of water, compromising its ability to control the reservoir post-earthquake. Capital work was recommended to upgrade the seismic withstand of the North Conduit to improve the ability to control the reservoir in the event of an earthquake damaging the dam.

Installation of steel ring supports was completed in September 2007. Construction of a walkway beside the conduit, permanent access, drainage and other ancillary works have been postponed to Spring/Summer 2008 due to winter weather. Installation of heaters on the hollowcone valves are required to prevent freezing of the valves in winter when the conduit is full. Refurbishing of the valves and installation of the heaters are planned for Q1/Q2 F2009. Until this work is completed, the conduit will be left dewatered and the risk index for this item will not be reduced.

*WAC Bennett Dam*

### ➢ *WAC Bennett Dam – Instrumentation Improvements*

To further improve the dam safety surveillance/monitoring system, additional instrumentation upgrades are underway. Installation of the crest settlement monitoring devices at the observation wells, connection to the ADAS and alarms was completed. Work continued on the development of the prototype in-place crosshole seismic monitor. The feasibility of converting two of the existing drillholes into standpipe piezometers will be evaluated in Q1 of F2009 with field work planned for Q2/Q3.




*Seismic hazard in British Columbia*

### ➢ *Seismic Hazard Model (System-wide)*

BC Hydro has identified a need to develop a system-wide seismic hazard model capable of generating seismic ground motion parameters required for engineering design and evaluation of our dams.

Despite extensive advances in seismic knowledge in recent years, there are still major gaps worldwide in the understanding of the mechanisms that cause earthquakes and of the processes that govern how earthquake energy propagates from its origin beneath the earth surface to the sites of interest. As a result, this uncertainty in the prediction of likelihood of earthquake occurrence and seismic ground motions has caused fluctuation of earthquake criteria and apparent inconsistencies between sites.

The seismic hazard assessment project will develop a robust and defensible seismic hazard model, apply the model to update the assessment of seismic hazard for BC Hydro's 41 dam sites and develop a BC Hydro policy document containing seismic design requirements for BC Hydro's dams. The project scope has been revised based on recommendations from the Advisory Board meeting held in July 2007. The revised scope is significantly larger and over a longer schedule.

The first two of several workshops involving seismic hazard specialists were held in Vancouver in February and March 2008. BC Hydro staff presented the work carried out to date, and workshop participants identified modeling issues, data requirements and data evaluation needs. Project completion is scheduled for F2010.

*Aerial view of Downie Slide*

### ➢ *Revelstoke Dam – Downie Slide*

A program to upgrade the drainage facilities at Downie Slide, located midway between Revelstoke and Mica dams, began in October 2007. It consists of a drilling program to install drainholes to relieve slowly-rising groundwater pressures in parts of the slide. Thirteen drainholes were completed in F2008 with four to six additional holes to be drilled. The project is scheduled for completion in Q1 of F2009.

Monitoring of the drilling and drainage effectiveness and overall stability of the slide while crews are on site is being achieved in real-time with the Automated Data Acquisition System.

*Before and after lighting upgrade, in adit*

### ➢ *Hugh Keenleyside Dam – Instrumentation Improvements*

A project to improve instrumentation at Hugh Keenleyside Dam is in the identification phase.

*Stage I upgrade work*

*Stage II Sonic site investigations*

➢ ***Kootenay Canal – Slab Leakage Improvements***

Kootenay Canal, northeast of Castlegar, is about 5 km long, leading to a concrete gravity dam with intakes for the penstocks for the powerhouse below. Several leaks have occurred in the forebay embankment adjacent to the concrete dam, due to settlement of the concrete slabs lining the face of the embankment. A significant leak occurred in 2003, and Stage 1 upgrade work was completed in 2007. Other interim risk management measures consisting of a larger ditch along the toe of the existing forebay embankment and stockpiling of rockfill nearby will be completed in 2008.

Design and preparation of tender documents for the permanent buttressing berm at the forebay area are underway. Construction of the buttressing berm and construction of the concrete slab upgrades have been deferred to F2010 and F2011, respectively, based on resource availability and consideration of the effectiveness of the interim risk mitigation measures and Stage I work.

Until permanent upgrades are implemented, the recently-installed Automated Data Acquisition System (ADAS) will provide real-time data assessment and alarm capabilities on instrumentation installed in the embankment.

## Projects Completed in Fiscal 2008 – Deficiency Investigations

*Campbell River System: Strathcona, Ladore and John Hart Dams*

➢ ***Campbell River System – Flood Risk Mitigation Study***

After construction of lock blocks in 2005 at Strathcona and John Hart dams, the existing spillways in the Campbell River system (Strathcona, Ladore and John Hart Dams) can pass about 72% of the Probable Maximum Flood (PMF).

A number of structural long-term risk mitigation options have been identified to pass the full PMF through the Campbell River system. Additional analyses to better define the cost of the structural upgrade options and the life safety risk management approach were completed in F2008.

➢ ***Inundation Mapping Guidelines***

New mapping and inundation guidelines were completed in October 2007. Concurrent with development of these guidelines, new modelling was carried out for the Cheakamus watershed to create updated inundation maps.

Puntledge Dam

➢ ***Comox/Puntledge Inundation Mapping***

A detailed hydraulic model was developed to assess inundation impacts associated with dam breach scenarios as well as other flood and operational scenarios for Comox and Puntledge dams. Inundation maps were generated showing flood extents.

## Active Projects – Deficiency Investigations

*Cheakamus Dam*

➢ ***Cheakamus Dam – Seismic Stability Assessment***

Cheakamus Dam consists of a main concrete dam, an earthfill dam and three saddle dams that impound the Daisy Lake reservoir. The foundations underlying the earthfill dam consist of debris from the 1855 Rubble Creek slide. In the 1980's, a number of capital upgrades were completed on the Cheakamus Dam to improve its seismic performance.

The objective of this investigation is to assess the seismic performance of the dam in light of updated seismic hazard assessments. Information from a field investigation program is being used to develop the stability models. The dam performance assessment and remedial options are planned to be completed in F2009.

*Jordan Diversion Dam*

➢ ***Jordan Diversion Dam – Seismic Stability***

The seismic performance of Jordan Diversion Dam under updated seismic loads is being assessed, and dam risk mitigation options will be developed if required. The work has been awarded to external consultants. Numerical modeling is currently underway to assess the performance of the dam and determine upgrade options. The modeling and reporting is planned to be completed early in F2009.

*Alouette Dam*

➢ ***Alouette Dam – Seismic Stability***

The performance of Alouette Dam and discharge facilities (spillway, low level outlet and power tunnel) is being assessed for updated seismic loads, and dam safety risk mitigation options will be developed if required.

# Business Summary

The progress of dam safety activities over the fiscal year, compared to the plan, is shown on the table below.

**Dam Safety Program Costs versus Plan**

| | *$ Millions* Plan | Actual |
|---|---|---|
| Surveillance and other program activities (Operation, Maintenance and General Administration - OM&GA) | 4.4 | 4.4 |
| Deficiency Investigations (OM&GA) | 2.7 | 2.3 |
| Capital improvements | 82.4 | 74.8 |

*Operation, Maintenance and General and Administration (OM & GA) Program*

Operation, maintenance, general and administration work was completed as planned, including surveillance, emergency preparedness and management of the Dam Safety Program.

*Deficiency Investigation (DI) Projects*

Nine Deficiency Investigations were underway in F2008 and 86% of schedule milestones for the year were achieved. Four DIs were completed by year end – Campbell River system flood life safety risk mitigation, system-wide inundation mapping guidelines, spillway gate reliability assessment and Puntledge inundation mapping. The other deficiency investigations are planned for completion in F2009.

The deficiency investigation program cost variance of approximately $400K was due to the following:

- Unused project and program contingency
- Some delay in two DIs due to resource constraints: Jordan DI will be completed by Q2 of F2009, and initial findings from the Alouette DI require that additional work be carried out in F2009.

*Capital Program*

The variance on the capital program was $7.6M or within 10% of the plan, due to delay in completion of Coquitlam Dam and the lost construction window for the security improvements program.

# Strategic Issues and Other Initiatives

*Dam Safety Practices and Learned Societies*

- *Canadian Dam Association (CDA)*

BC Hydro staff continued to work with the Dam Safety Committee of the Canadian Dam Association, on the revision of the national *Dam Safety Guidelines,* which were published in September 2007.

- *International Commission on Large Dams (ICOLD)*

D.N.D. Hartford is a member of the Committee on Dam Safety. The ongoing work to develop guidance on Dam Safety Management, representing internationally-accepted practice is progressing as planned.

- *U.K. Construction Industry Research and Information Association*

D.N.D. Hartford's work on the steering group for the project on Whole Life-Cycle Asset Management Across Industry is approaching completion. The Guidance will be published later in 2008.

- *Natural Sciences and Engineering Research Council of Canada (NSERC)*

D.N.D. Hartford is a member of the Strategic Panel on Safety and Security and was also appointed to the Scientific Panel to review the proposed Geodetic Canadian Hazards and Risks Monitoring Network.

- *BMT Isis*

BC Hydro engaged BMT Isis, a specialist engineering consulting company that provides services in Systems Safety Analysis and Engineering, to complete a demonstration project on integrated risk assessment for spillway reliability. This project provides balanced consideration to dam safety, worker safety and public safety, and develops conceptual spillway reliability improvements that reduce all risks to the dam, BC Hydro staff and the public users of the river system, to a level that is as low as reasonably practicable.

This project provides BC Hydro with a framework and set of methods to develop a broad spectrum of risk management solutions for its dams.

*Dam Safety Research*

- *Flood damage analysis in dam safety management*

An International Workshop on Flood Damage Analysis based on BC Hydro's Life Safety Model for flood emergency management was hosted in November 2007. Attendees came from Canada (University of B.C., Ontario Power Generation, Canadian Hydraulics Centre), the Netherlands (Technical University of Delft), the United Kingdom (HR Wallingford) and the United States (US Army Corps of Engineers, US Bureau of Reclamation).

Projects continue at the Technical University of Delft and the University of B.C. to extend the virtual reality modelling capability of the Life Safety Model to include infrastructure damage and environmental impacts models. In addition, the model has been tested in the Thames Valley, England, as part of the European Union's FLOODSITE project. When completed, these models will have the capability to analysis the full spectrum of effects of floods and releases from hydropower plants.

- *CEA Technologies Inc. (CEATI) – Dam Safety Interest Group (DSIG)*

BC Hydro is one of 24 member companies of the DSIG, which sponsors specific research programs in dam safety. Substantial research addressing dam safety needs is being carried out in the areas of reservoir debris management, geophysical techniques to detect seepage in earthfill dams, inundation mapping, spillway reliability and the overall effectiveness of dam safety programs.

*Strategic Cooperation*

BC Hydro's collaboration with GlobVision and the National Research Council project on neural network applications in dam surveillance data analysis was completed and a plan to implement this advanced surveillance data management system is being developed.

BC Hydro negotiations with the Swedish Electricity Industry's Research company Elksorsk, Ontario Power Generation, and Hydro Québec to develop a scientific framework for the analysis of spillway function reliability and availability have been completed and the project is in the initiation phase.

# Appendix A:
# BC Hydro Dams

| DAM | TYPE [1] | YR. | HT. (m) | GENERATING STATION | RESERVOIR/HEADPOND | RES. AREA (ha) |
|---|---|---|---|---|---|---|
| Aberfeldie | PG | 1953 | 32 | Aberfeldie | Aberfeldie Headpond | - |
| Alouette | TE | 1926 | 21 | Alouette | Alouette Lake Reservoir | 1600 |
| Bear Creek | TE | 1958 | 19 | Jordan River | Bear Creek Reservoir | 75 |
| Buntzen | PG | 1903 | 16.5 | Buntzen 1 & 2 | Buntzen Lake Reservoir | 185 |
| Cheakamus | TE/PG | 1957 | 29 | Cheakamus | Daisy Lake Reservoir | 4300 |
| Clayton Falls | PG | 1961 | 7 | Clayton Falls | Clayton Falls Headpond | - |
| Clowhom | PG | 1958 | 22 | Clowhom | Clowhom Lake Reservoir | 800 |
| Comox | PG | 1912 | 10.7 | Puntledge | Comox Lake Reservoir | 3000 |
| Coquitlam | TE | 1914 | 30 | - | Coquitlam Reservoir | 1250 |
| Duncan | TE | 1967 | 38.7 | - | Duncan Reservoir | 7150 |
| Elko | PG | 1924 | 16 | Elko | Elko Headpond | - |
| Elliott | PG | 1971 | 27.4 | Jordan River | Elliott Headpond | - |
| Elsie | TE | 1958 | 31 | Ash River | Elsie Lake Reservoir | 658 |
| Falls River | PG | 1930 | 13 | Falls River | Bigs Falls Headpond | - |
| Heber Diversion | ER/T | 1958 | 9.8 | Strathcona | Heber River Headpond | - |
| Hugh Keenleyside | TE/PG | 1968 | 52 | - | Arrow Lakes Reservoir | 51 600 |
| John Hart | TE/PG | 1947 | 34 | John Hart | John Hart Reservoir | 250 |
| Jordan Diversion | CB | 1913 | 39.9 | Jordan River | Jordan Diversion Reservoir | 168 |
| Kootenay Canal | PG/ER | 1975 | 38 | Kootenay Canal | Kootenay Canal Headpond | - |
| La Joie | ER | 1948 | 87 | La Joie | Downton Reservoir | 2400 |
| Ladore | PG | 1949 | 37.5 | Ladore | Lower Campbell Lake Reservoir | 3700 |
| Mica | TE | 1972 | 244 | Mica | Kinbasket Reservoir | 42 500 |
| Peace Canyon | PG | 1979 | 61 | Peace Canyon | Dinosaur Reservoir | 890 |
| Puntledge Diversion | PG | 1912 | 5.5 | Puntledge | Puntledge Headpond | - |
| Quinsam Diversion | PG | 1957 | 15 | Ladore | Quinsam Diversion Headpond | - |
| Quinsam Storage | PG | 1957 | 9 | Ladore | Upper Quinsam Lake Reservoir | 564 |
| Revelstoke | TE/PG | 1984 | 175 | Revelstoke | Revelstoke Reservoir | 11530 |
| Ruskin | PG | 1930 | 59.4 | Ruskin | Hayward Lake Reservoir | 300 |
| Salmon River Diversion | ER/T | 1957 | 5.5 | Ladore | Salmon River Headpond | - |
| Seton | PG | 1956 | 14.4 | Seton | Seton Lake Reservoir | 2460 |
| Seven Mile | PG | 1980 | 80 | Seven Mile | Seven Mile Reservoir | 410 |
| Spillimacheen | PG | 1955 | 14.5 | Spillimacheen | Spillimacheen Headpond | - |
| Stave Falls | PG | 1911 | 26 | Stave Falls | Stave Lake Reservoir | 6200 |
| Strathcona | TE | 1958 | 53 | Strathcona | Upper Campbell Lake, Buttle Lake Reservoir | 6680 |
| Sugar Lake | CB | 1942 | 13.4 | Shuswap Falls | Sugar Lake Reservoir | 2100 |
| Terzaghi | TE | 1960 | 60 | Bridge River 1 & 2 | Carpenter Reservoir | 4800 |
| WAC Bennett | TE | 1968 | 183 | GM Shrum | Williston Reservoir | 117 000 |
| Wahleach | TE | 1953 | 21 | Wahleach | Jones Lake Reservoir | 490 |
| Walter Hardman | TE | 1960 | 12 | Walter Hardman | Walter Hardman Headpond | - |
| Whatshan | PG | 1951 | 12 | Whatshan | Whatshan Lake Reservoir | 1700 |
| Wilsey | VA | 1929 | 30 | Shuswap Falls | Wilsey Headpond | - |

[1] Main dam at site: PG concrete gravity, CB concrete buttress, VA concrete arch, TE earthfill, ER rockfill, ER/T rockfill timber crib.

# Appendix B:
# Dam Safety Advisory Boards for Ongoing Projects

| PROJECT | NAMES | MEETING NO. | DATE |
|---|---|---|---|
| **Coquitlam** | | | |
| | Dr. N. Morgenstern, Alberta | 1 | July 2001 |
| | Mr. A. Williams, Australia | 2 | **June 2002** |
| | Mr. J.L. Ehasz (added in 2004) | 3 | **July 2003** |
| | | 4 | **November 2004** |
| | | 5 | **May 2005** |
| | | **6** | **July 2006** |
| **Ruskin** | | | |
| | Dr. R. Hall, USA | 1 | **September 2002** |
| | Mr. J. France, USA (added in 2003) | 2 | **August 2003** |
| | Mr. Georges Darbre, Switzerland (added in 2008) | 3 | **August 2004** |
| | | 4 | **April 2008** |
| **Strathcona** | | | |
| Seismic Assessment and Flood | Dr. J. France, USA | 1 | January 2003 |
| | Dr. Y. Ghanaat, USA | 2 | January 2006 |
| | Dr. S. Alam, France (added in 2006) | 3 | **December 2007** |
| | Mr. J. Kelly, USA (added in 2007) | | |
| **WAC Bennett** | | | |
| Dam Performance -Surveillance | Dr. E. DiBiagio, Norway (External Reviewer) | 1 | September 2001 |
| | | 2 | December 2002 |
| | | 3 | March 2004 |
| | | 4 | March 2005 |
| | | 5 | March 2006 |
| | | 6 | April 2007 |
| **BC Hydro System** | | | |
| ➢ Probabilisitic Seismic Hazard Assessment | Dr. C.A. Cornell (Deceased Dec 2007) | 1 | July 2007 |
| ➢ Gate reliability upgrades | Dr. Geoff M. Ballard, New Zealand | | 2007 |

BC hydro

FOR GENERATIONS

# Memo

March 24, 2009

To: Honourable Blair Lekstrom
Minister of Energy, Mines and Petroleum Resources

From: Susan Yurkovich
Senior VP, Corporate Affairs

Subject: Follow Up Items from the February 18th Meeting Regarding the Site C Project

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Dear Minister:

At our meeting on February 18, 2009 to update on Site C, we committed to following up and providing you with information on the following three items:

- Preliminary Market Sounding
- Seismic and dam safety issues
- Gravel / construction materials map in the Peace region

Please find below an outline of materials being provided to respond to the items above.

## A. Preliminary Market Sounding

Attached you will find the following documents relating to the Preliminary Market Sounding undertaken during Stage 2 for the Site C project:

- Briefing note, dated June 12, 1008, prepared for the former Minister of MEMPR to describe the Site C Preliminary Market Consultation; and,

- Site C Preliminary Market Consultation Report, prepared by BC Hydro and PriceWaterhouseCoopers, dated October 8, 2008.

The Preliminary Market Sounding was prepared in preparation for, and in advance of, potential commercial negotiations in the future. As a result, this document has had very limited circulation within BC Hydro and within the Site C project team, and has not been circulated within government to date.

## B. Seismic and Dam Safety Issues

At our meeting on February 18, 2009, we provided an overview of the key technical issues associated with the Site C project. One of the issues we discussed was the Maximum Design Earthquake and the applicable seismic standard for the project design.

The attached Dam Safety Program Annual Report for the fiscal year ended March 31, 2008 provides an overview of the BC Hydro dam safety program. The report provides an overview of the oversight and risk management program for the 74 dams at 41 sites across British Columbia that BC Hydro owns, operates and maintains. It describes the standards, practices and approach to managing the dam safety consequences of severe floods and earthquakes. Included in the program are major capital projects which are addressing known deficiencies, current and future deficiency investigations, development of a seismic hazard model as well as the work to improve spillway gate reliability, security and emergency preparedness.

## C. Gravel / construction materials map in the Peace region

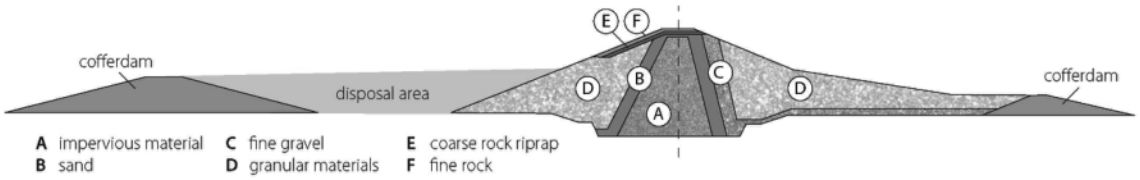
As part of the discussion at the February 18th meeting, we talked about construction materials for the potential dam, and existing gravel supplies in the Peace region.

The balance of this memo provides an overview of updated information on source materials for the potential dam as well as information regarding gravel sources in the Peace.

**PEACE RIVER SITE C PROJECT**
**Overview of Site C Construction Materials Investigations**
**and Gravel Sources in the Peace Region**
**March 23, 2009**

## Source Material for the Construction of the Dam

As currently designed, the Site C dam would be 1,100 metres long, and would be comprised of different zones of gravel, impervious material, riprap and other material. It would also include 300 metres of concrete structures located on the south bank of the river for the spillway and power intakes.




The dam would require an estimated 17.4 million cubic metres of aggregate material (Table 1).

**Table 1: Construction Materials (Dam Site)**

| Material Type | Volume (cubic metres) |
|---|---|
| Concrete Aggregate (for structures) | 190,000 |
| Granular Material (includes dam and cofferdams) | 13,500,000 |
| Impervious Material (for dam core material) | 3,500,000 |
| Riprap (large rock) | 240,000 |
| **Total** | **17,430,000** |

*Granular Material*

Previous studies indicate that the majority of granular materials necessary for construction of the earthfill dam would be available from undeveloped sources in close proximity to the potential dam (refer to attached Figure 1: various locations within the yellow dotted lines). There is the possibility that a small fraction of granular material could be sourced from private land on the North bank.

*Impervious Material*

Feasible options of impervious material (Zone A in diagram) are currently assumed to be within 10 km of the dam site on the north bank near Fort St. John on private lands, but have not yet been confirmed.

For perspective, if one site of suitable impervious material (till) were identified with an average thickness of about 10 metres, the area required for extraction (not including roads, stockpile areas) would be roughly the size of the red square area in attached Figure 2.

If the project were to proceed to Stage 3, an early project requirement would be to identify suitable locations and assess the potential environmental and social impacts associated with construction material and related transportation requirements.

**Source Material for the Construction of the Dam, cont.**

The first stage of the investigations would consist of a drilling and test pit program at identified potential source areas to make a preliminary determination of available quantities and to perform laboratory testing on samples to determine suitability for the impervious core.

Until suitable sources of impervious material are confirmed a special allowance is being carried in the project costs to cover more expensive options such as transporting this material from further away, potentially using the rail line.

*Rip-Rap*
Future investigations expected in Stage 3 will also be needed to identify suitable options for rip rap materials. Potential sources include the West Pine Quarry, roughly 130 km (potentially by rail) to the south-west in the Rockies.

**Location of Existing Gravel Pits in the Region**

During Stage 2, a socio-economic baseline study was commissioned to identify pre-existing data sources and remaining data gaps, including land and resources. This study identified total annual regional aggregate consumption in the vicinity of the project footprint at roughly 1 million cubic metres.

The Ministry of Transportation and Infrastructure (MOTI) manages nine pits on Crown lands in the vicinity of the Project (Figure 2), including the large Teko pit southeast of the project area. An overview of these pits is available in the attached Table 2. It is estimated that about 170,000 $m^3$ is extracted from these pits, and about 342,000 $m^3$ is used by MOTI annually in the Fort St. John area.

The potential Site C project would flood three of these pits, or approximately 1.85M $m^3$ of a currently identified known 9.1M $m^3$ reserves (Table 2). It is assumed that the pits would continue to be accessible until the potential reservoir is filled, thus if they were prioritised to be used exclusively until such time, the three pits may be substantially exhausted prior to reservoir filling.

The larger commercial pits are located near Taylor downstream of the proposed dam site, and would be unaffected by the project. Most of the commercial pits have known reserves that would likely support current regional needs in excess of twenty years. The Site C reservoir would flood one private pit (The Goertz pit at the Halfway River – volume of reserves unknown at this time). It is expected that future commercial pit development over the next two decades would likely continue to focus downstream of the proposed dam site near Taylor.

**Estimated Gravel Capability within the Region**

Historic estimates (1976) of the volume of gravel resources between Peace Canyon Dam and the BC/Alberta border suggested there was roughly 1 billion cubic metres of aggregate in the Peace River valley. A current estimate of gravel capability within the potential Site C reservoir area has not been identified at this time.

**Figure 1: Source of Majority of Construction Materials (public)**

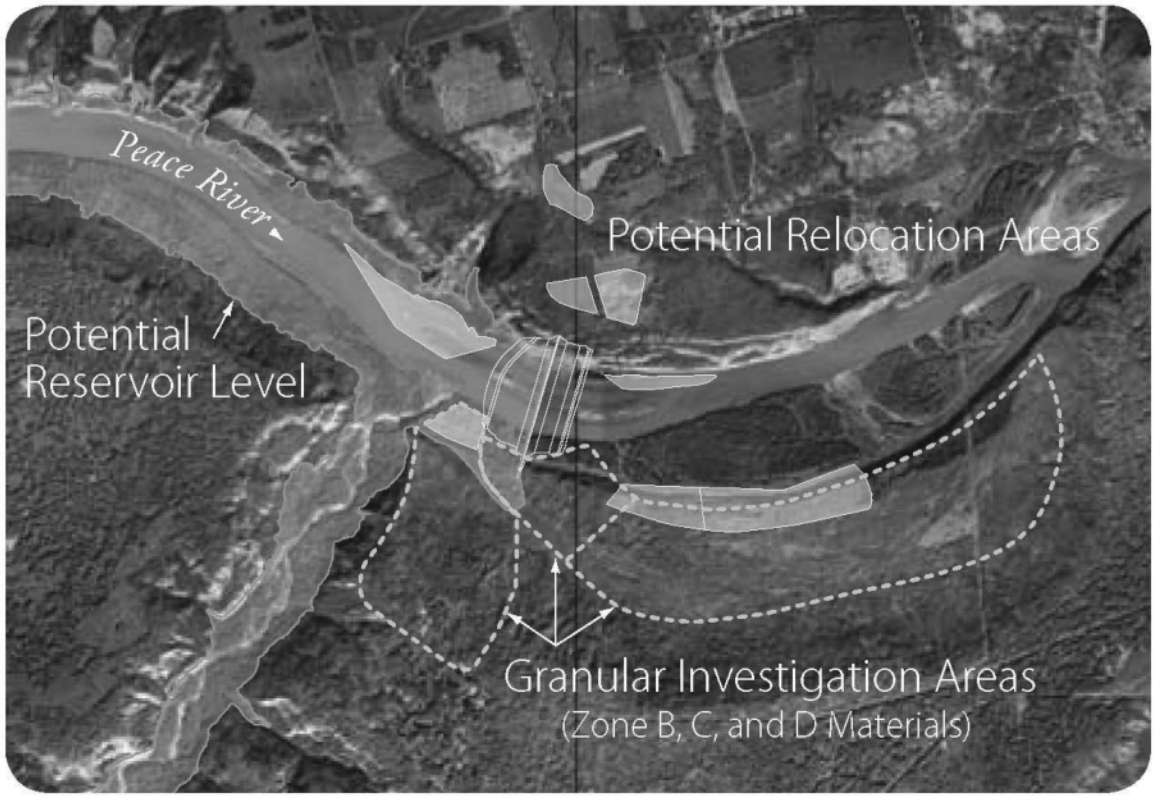



**Figure 2: Potential options of impervious material on North Bank (not public)**

## Table 2: Ministry of Transportation & Infrastructure Aggregate Pits in the Peace

| Pit Name | Estimated Proven Reserves (cubic metres) | MOTI's Comments |
|---|---|---|
| *Flooded* | | |
| Peace View | 1,500,000 | |
| Tompkins | 135,000 | Approx. 40 ha of reserve still remains to be assessed for volume potential. |
| Rieske Pit | 100,000 | |
| **Sub-Total Flooded** | **~ 1,850,000** | |
| | | |
| Unaffected | | |
| Del Rio | Unknown | Important for future use |
| Beryl Prairie | 2.6 million | |
| Benard | 500,000 | Potential for more volumes, only a portion has been assessed. |
| Ardill | Unknown | Close to depletion. |
| Bear Flats | unknown | Poor durability characteristics of the bed rock. |
| Teko | 6.0 million | Source very important to MOTI even though there are challenges with access & hauling. |
| **Sub-Total Unaffected** | **> 9,100,000** | |
| | | |
| **MOTI Reserves** | | |
| Southwick Hudson's Hope | 960,000 | |
| Southwick Notation | 500,000 | Tenure issues with District of Hudson's Hope, |

Source: MOTI

Notes:

1. This relates to how well the physical quality of the deposit meets MOTI's requirements
2. This includes consideration of the quality of the deposit, its location, cost of extraction, size, etc that make it more/less important to the MOTI.

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Withheld pursuant to/removed as

s.12 ; s.13

**From:** De Champlain, Rhonda EMPR:EX
**To:** MacLaren, Les EMPR:EX (Les.MacLaren@gov.bc.ca); McNeil, Kevin EMPR:EX (Kevin.McNeil@gov.bc.ca); Cho, Gayle EMPR:EX (Gayle.Cho@gov.bc.ca); Eaton, Cindy EMPR:EX (Cindy.Eaton@gov.bc.ca)
**Cc:** De Champlain, Rhonda EMPR:EX (Rhonda.DeChamplain@gov.bc.ca)
**Subject:** FW: s.12; s.13
**Sent:** 01/14/2010 17:51:39
**Attachments:** 20100114093527.pdf
**Message Body:**

Attached is a PDF of the above documents signed by Minister Lekstrom.

Minister's Office has delivereds.12

Site C is scheduleds.12

Gayle/Cindy: there are several attachments also for this item (not included in the PDF). These have been sent to your office previously by Les.

Rhonda

---

**From:** Costa, Sarina EMPR:EX
**Sent:** Thursday, January 14, 2010 9:37 AM
**To:** De Champlain, Rhonda EMPR:EX
**Subject:** FW:

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Withheld pursuant to/removed as

s.12 ; s.13

**From:** MacLaren, Les EMPR:EX
**To:** Jardine, Kevin PREM:EX (Kevin.Jardine@gov.bc.ca)
**Cc:** Rowe, Katherine EMPR:EX (Katherine.Rowe@gov.bc.ca); Chang, Olivia Y EMPR:EX (Olivia.Chang@gov.bc.ca); De Champlain, Rhonda EMPR:EX (Rhonda.DeChamplain@gov.bc.ca); Murphy, Shelley EMPR:EX (Shelley.Murphy@gov.bc.ca)
**Subject:** Site C Materials
**Sent:** 11/12/2009 21:12:09
**Attachments:** Site s.12; s.13
s.12; s.13

**Message Body:**

As requested, attached are the materials for the Site C item. The three fact sheets/backgounders have not changed, but I have included them so all of the documents are in one place.

In response to the discussion this morning, the following changes have been made:
s.13

Les

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Withheld pursuant to/removed as

s.12 ; s.13

**From:** Yurkovich, Susan (Susan.Yurkovich@bchydro.com)
**To:** MacLaren, Les EMPR:EX (Les.MacLaren@gov.bc.ca); Reimer, Greg A EMPR:EX (Greg.Reimer@gov.bc.ca)
**Subject:** Materials as requested
**Sent:** 01/12/2010 01:11:55
**Attachments:** s.12; s.13

s.12; s.13

**Message Body:**

Here are the materials as requested. Dan and Bev have both reviewed and approved. The Communications Plan and materials are draft only. I expect to get direction and indication on timing from the Ministers office at some point.

Let me know if you need anything else.

Thanks

Susan

Materials:

s.12; s.13

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Withheld pursuant to/removed as

s.12 ; s.13

Page 261 of 266 to/à Page 266 of 266

Withheld pursuant to/removed as

DUPLICATE