KEEPING OUR SYSTEM SAFE

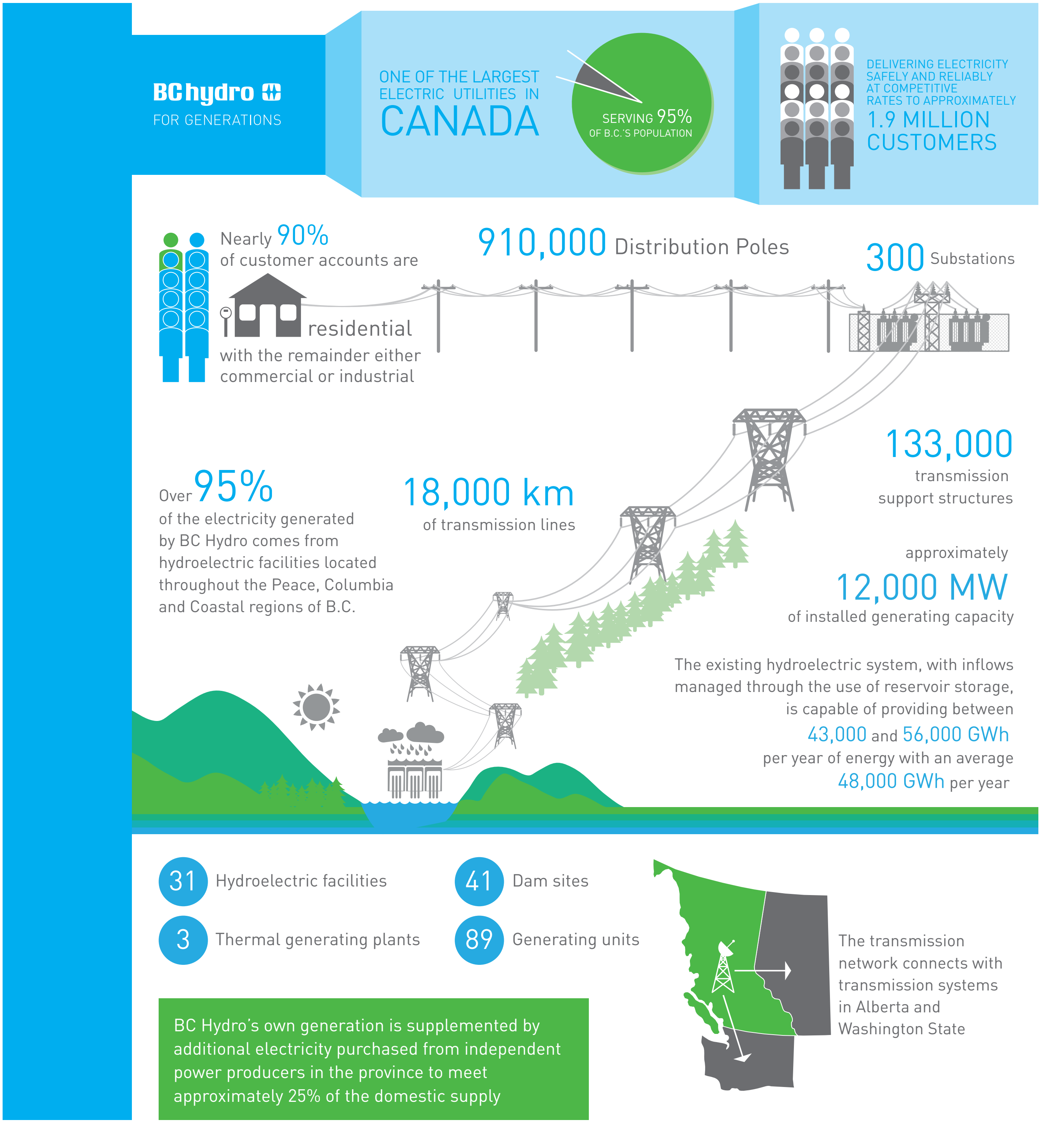
DAM SAFETY AT BC HYDRO

FOR GENERATIONS

DECEMBER 2014

ABOUT BC HYDRO

BC Hydro was established over 50 years ago to generate and deliver clean, reliable and competitively priced electricity to homes and businesses throughout British Columbia. The electricity generated by our dams and delivered by our transmission and distribution infrastructure has powered B.C.'s economy and quality of life for generations. With prudent reinvestment and careful planning, BC Hydro is positioned to safely deliver clean, reliable power for the long-term benefit of the growing province.



INTRODUCTION

The purpose of this document is to describe BC Hydro's long-standing dam safety program, provide a summary of a recent seismic hazard assessment of our dams, and outline some of the actions we are taking to ensure all of our dams and facilities remain safe, including new initiatives based on the findings of the seismic assessment.

BC Hydro operates some of the largest dams in the world. Today, we maintain and operate 79 dams at 41 locations across the province and have been assessing seismic hazards at these facilities for decades.

BC Hydro's top priority is the safety of the public and our employees, including the safe operation and maintenance of our dams and generating stations, transmission and distribution lines, and other facilities.

Our dam safety program—which is based on provincial regulations, guidelines published by the Canadian Dam Association and international best practices—has been modelled by other jurisdictions in North America and around the world.

We use thousands of instruments and devices to collect and report automatically on the performance of our dams, most of which are visually checked weekly and receive more extensive inspections twice a year. Some small dams are inspected less frequently.

Our dam safety management system goes through extensive external and internal reviews every five years and we also submit annual reports to the Province of British Columbia and commission independent reviews of the dams every seven to 10 years.

A 2013 independent external audit by two international experts in dam safety found that BC Hydro has a strong dam safety program and a robust risk assessment process consistent with international best practices.

Over the next 10 years, BC Hydro will be investing approximately $1.9 billion in dam safety and seismic upgrades to its facilities.


Jordan River


John Hart


Strathcona

BC HYDRO'S DAM SAFETY PROGRAM

The objective of BC Hydro's dam safety program is to manage the safety of all our structures that retain the reservoirs and control the passage of water that flows through, around, and beyond our dams.

BC Hydro's dam safety department currently has over 30 professional and technical staff that are responsible for the following aspects of dam safety:

- Surveillance
- Investigations
- Risk analysis and prioritization
- Project initiation and oversight
- Regulatory compliance and reporting

For decades, BC Hydro has been evaluating the safety of our dams and upgrading our facilities where deficiencies are identified.

We do this by reviewing the normal wear and tear on our dams, identifying and measuring any unanticipated challenges, and making the necessary improvements and repairs as soon as practicable. This approach involves constant monitoring and estimation of risks, incorporating changes to international and Canadian current practice, along with ongoing reviews and remedial actions that are prioritized.

Some of the many instruments and tools we use to monitor our dams include:

- Approximately 3,000 piezometers to measure water levels in slopes, dams and foundations
- Almost 2,000 weirs, flumes and drains to measure seepage through and around a dam
- About 5,000 measurement points using inclinometers, extensometers and survey monuments to measure potential movement of the dams and slopes
- Over 100 devices to monitor reservoir elevation
- Almost 200 devices such as rain gauges, thermometers, anemometer to measure weather conditions
- About 3,000 other instruments to measure groundwater temperature, water turbidity and ground motion due to earthquakes

Many of these instruments are connected to an Automated Data Acquisition System that monitors and provides notification if measurements are outside the normal range.

Relief well upgrade at Bridge River

Kootenay Canal inspection

MONITOR, ASSESS, ACT … REPEAT

The instruments and tools we use to monitor our dams are just one source of information in the assessment of the overall condition and safety of our dams.

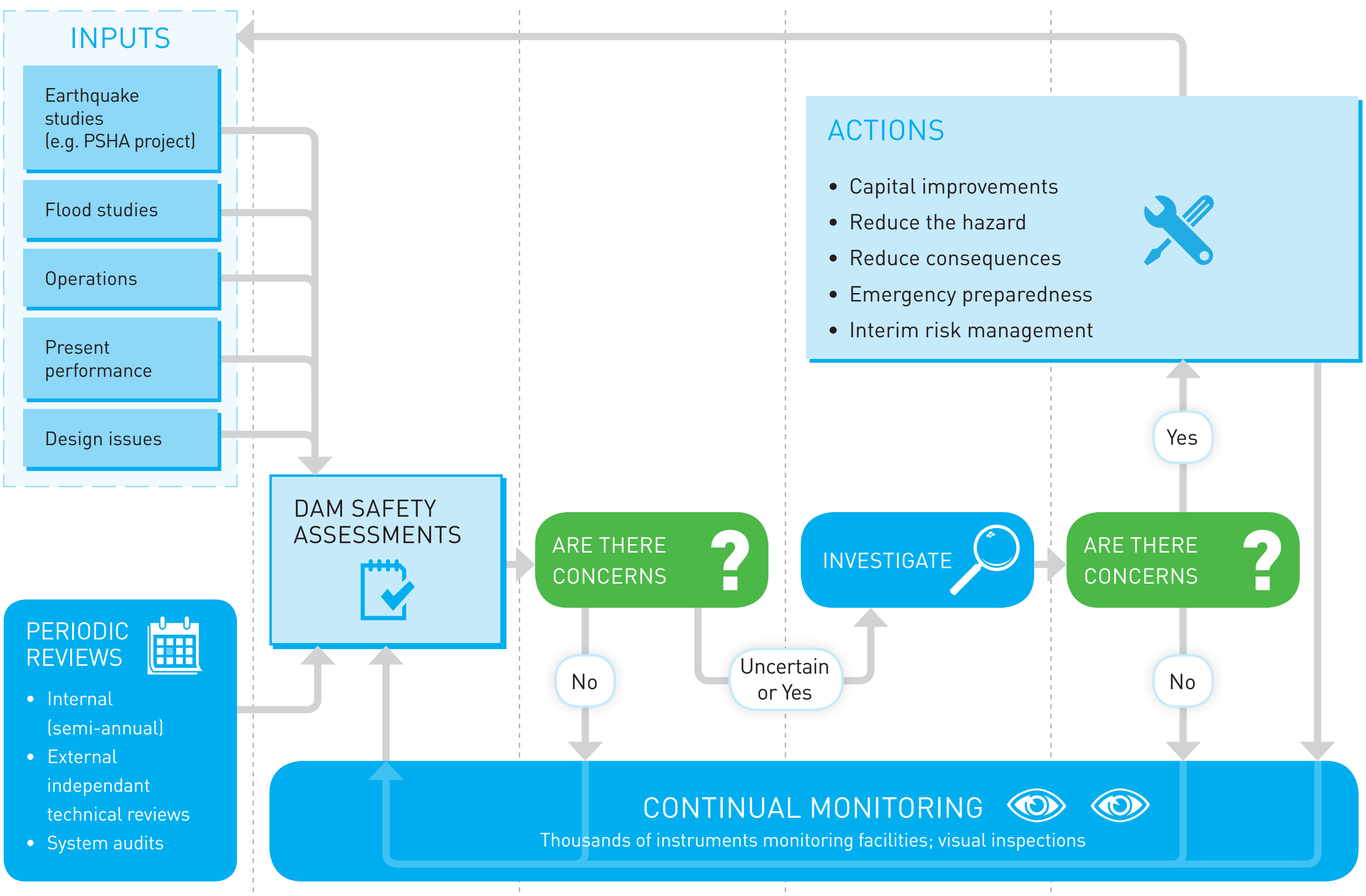
Other inputs include how and when a dam was built, its present condition, its expected performance during floods and earthquakes, and how the dam is currently performing (as described in the chart below). System audits, internal assessments and external reviews by dam experts also get factored into this assessment.

If those assessments show that a dam is operating satisfactorily, we keep monitoring on a regular basis. If we identify a potential problem, we continue to monitor while we investigate the severity of the problem and possibly implement interim measures. If there are still concerns, we take action.

Potential actions include reducing the hazard or consequence of a potential safety issue, investing in capital improvements, as well as enhancing plans for emergency preparedness.

All of these actions are considered in our seismic preparedness planning to ensure that our dams and water passages are kept safe. This document will now focus on earthquakes in B.C., how earthquakes could impact our dams, and introduce a recent six-year seismic hazard study, called the Probabilistic Seismic Hazard Analysis (PSHA).

FLOW OF INFORMATION



UNDERSTANDING EARTHQUAKES

Canada experiences approximately 4,000 earthquakes a year. More than half of these occur in British Columbia and surrounding areas.

B.C.'s Lower Mainland and Vancouver Island typically experience about 400 earthquakes a year.

British Columbia is in a geological setting where the structure of the earth's crust is complex. The province experiences five kinds of seismic events, two of which come from the Cascadia Subduction Zone (see image). This zone is the potential source of a "mega-thrust" earthquake (magnitude 9), like the Tohoku quake that triggered a catastrophic tidal wave along the northeastern coast of Japan in 2011.

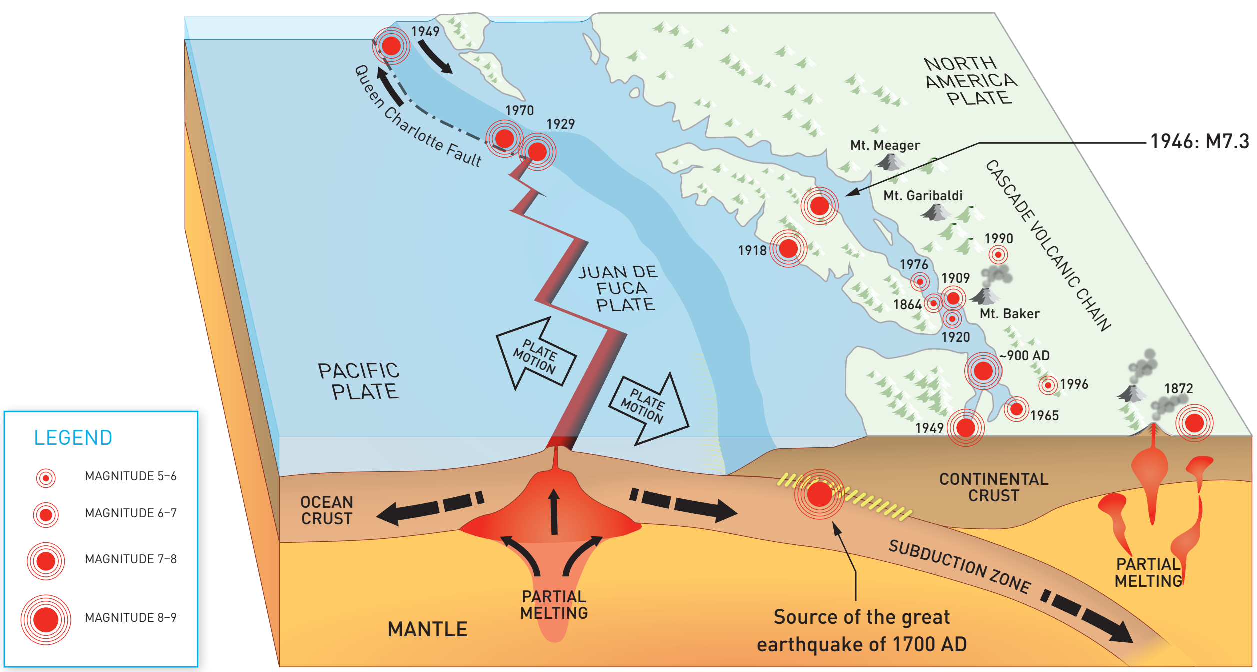
The Cascadia Subduction Zone is a 1,000-kilometre offshore fault along the Pacific Coast from northern Vancouver Island to Northern California. This is where the relatively thin Juan de Fuca oceanic plate is pushed underneath the western plate of North America.

This subduction zone can produce smaller intra-slab earthquakes. B.C. can also experience shallow active crustal earthquakes and stable continental earthquakes, like those in eastern Canada. Volcanic earthquakes can also occur near the Cascade Mountain range.

Using the expertise of seismologists, physicists, geologists and engineers, BC Hydro worked to identify where major seismic activity could occur, develop prediction models and determine resulting seismic ground motions at BC Hydro dam sites.

These models have helped us assess and rank seismic upgrades at our facilities, and will also help BC Hydro, emergency responders and the public to be better prepared for a major earthquake.

CASCADIA SUBDUCTION ZONE



ON THE FAULT LINE

Just as each area of British Columbia has its own unique seismic profile based on geological conditions, each of our dams also has its own unique reaction to seismic activity, based on the type of dam, the material used to construct it and geology of the area.

We have studied dams and modelled their performance for years, and we continue to learn more about the ability of our facilities to withstand seismic events, including a major earthquake.

A major earthquake is one that would produce "severe" to "extreme" shaking and cause considerable damage to ordinary buildings, such as broken or falling walls and other significant damage to structures and buildings (see the Mercalli Index on page 14 for more information).

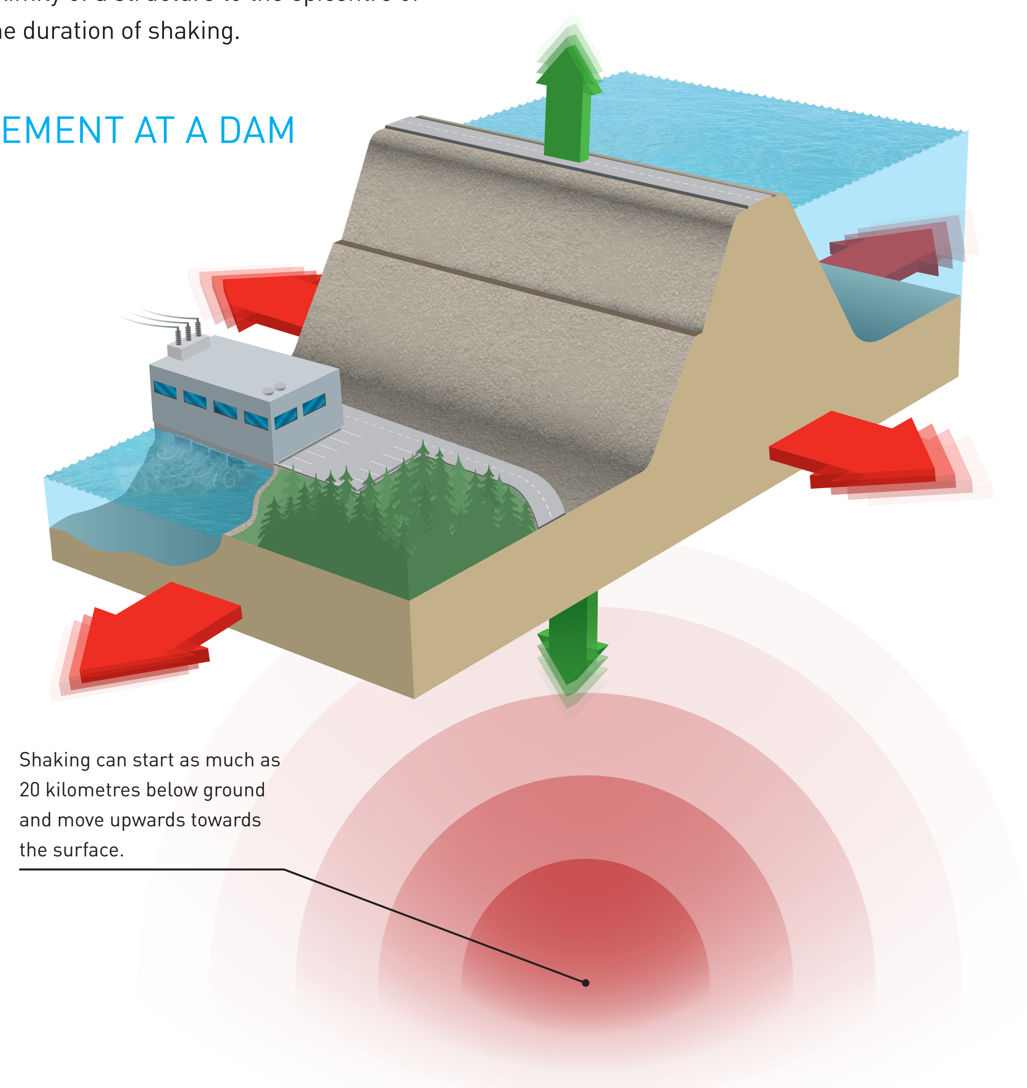
Damage caused by an earthquake isn't just about magnitude, it's also about the proximity of a structure to the epicentre of the earthquake and the duration of shaking.

As illustrated below, a major earthquake can cause movements to a dam that are lateral and vertical. Shaking can start more than 20 kilometres below ground and move upwards towards the surface.

B.C. experienced a magnitude 6.7 earthquake near Port Hardy in April 2014. However, there was no reported damage to BC Hydro facilities as a result of this earthquake because of the combination of the magnitude and the distance from our facilities.

The PSHA study has given BC Hydro a powerful new tool to calculate seismic hazards in British Columbia. We have a better understanding of the potential impact of major earthquakes and we are using the information to better assess and focus on seismic upgrades at our facilities.

GROUND MOVEMENT AT A DAM



SEISMIC HAZARD ASSESSMENT

In collaboration with international experts, BC Hydro completed a six-year seismic hazard assessment (PSHA) of the entire province. BC Hydro is the first non-nuclear utility in North America to elevate the seismic hazard assessment of its dams using processes similar to those used by the U.S. Nuclear Regulatory Commission (SSHAC).

The study was undertaken by BC Hydro staff, a team of world-class specialist consultants, and scientists from the Geological Survey of Canada and the United States Geological Survey.

The model gives BC Hydro a better understanding of the intensity of ground movements that occur at our facilities in the event of an earthquake.

BC Hydro is using this new information to take action and address areas of concern.

WHAT THE RESULTS MEAN FOR B.C.

The PSHA study addressed a basic but important issue: how to determine the ground movement that a major earthquake might exert upon a structure (such as a dam) at a specific location in British Columbia.

The research team sifted through years' of anecdotal reports and detailed seismic records for B.C. and other similar regions around the world.

For the first time, the study results provided BC Hydro with a comprehensive and common approach to assessing seismic hazards for the entire province.

The study confirms that in the Peace and Columbia regions of the province, where we have most of our generating capability, the risk of potential damage to our facilities due to an earthquake has generally remained stable or decreased.

In some circumstances, the expected level of shaking in a high-magnitude earthquake hasn't changed, but the duration of shaking could be longer leading to an increase in the hazard.

For example, the PSHA determined that the dams on the Campbell River would be subject to extended shaking. The Jordan River dam on the west coast of Vancouver Island would experience both longer and stronger shaking.

Looking ahead, the PSHA is not only a better method to calculate seismic hazards at existing BC Hydro facilities but it will help us with the construction of new projects—like the proposed Site C project on the Peace River. It will also help us prioritize upgrades to our facilities and determine what level of seismic withstand may be required.

The table on the following pages summarizes the PSHA results (compared to previous models) for BC Hydro's dam locations and includes information about past, ongoing or upcoming safety and seismic upgrades at our facilities.

WHAT ABOUT SITE C?

The Site C Clean Energy Project is a proposed third dam and hydroelectric generating station on the Peace River in northeast B.C.

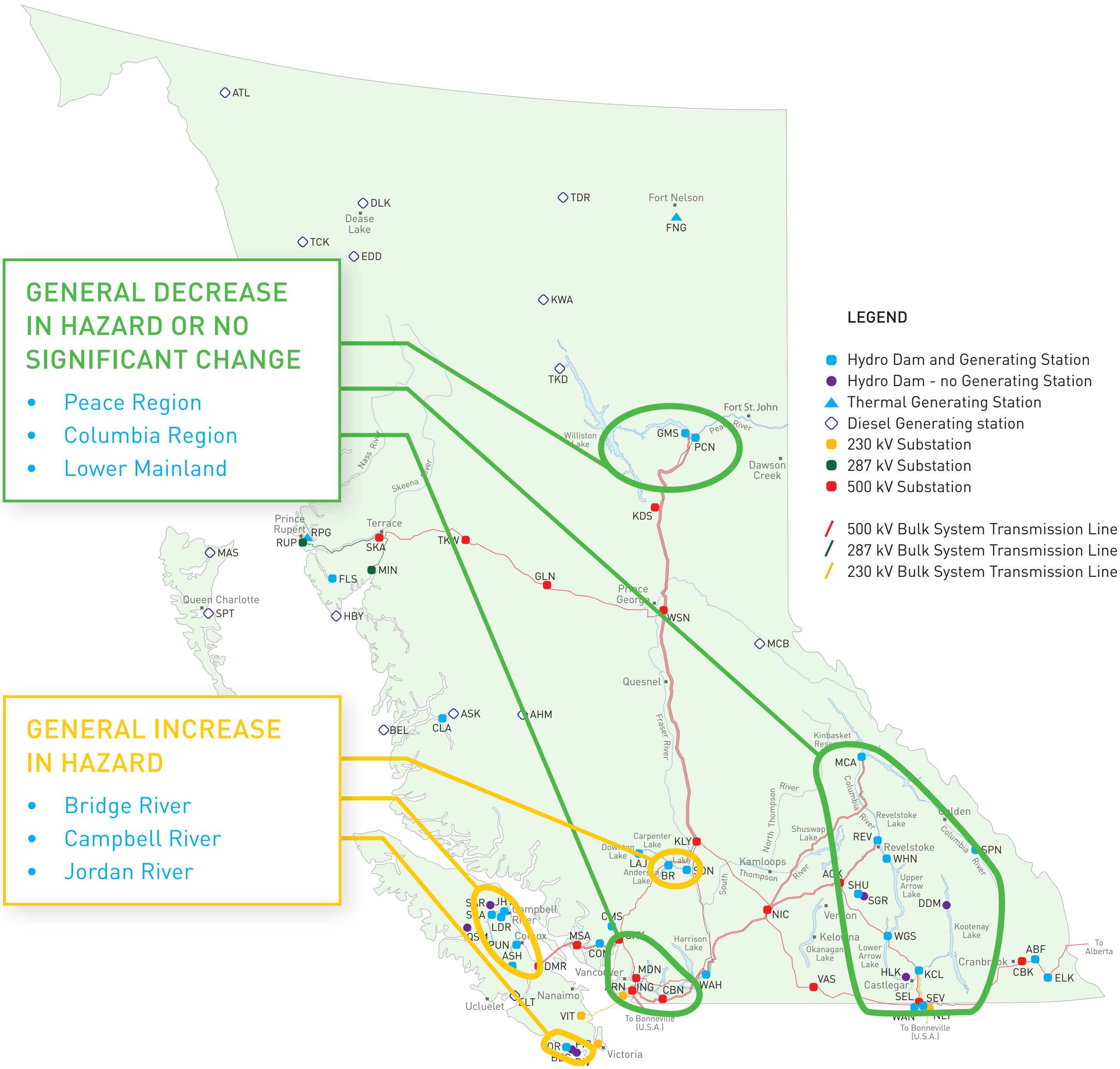
Site C's dam design takes into account the full range of earthquake magnitudes that are considered possible in the Peace region. This includes low-probability scenarios of larger earthquakes than the highest magnitude event on record in the Peace.

Site C would be designed, constructed and maintained in accordance with international and Canadian safety practices to withstand major events, including unlikely extreme earthquakes and floods. The project is designed to the highest recommendations of the Canadian Dam Association.

A seismic hazard assessment for Site C was completed in 2009. The PSHA study shows no significant change in seismic hazard for the Site C dam site.

Site C received environmental approval from the federal and provincial governments in October 2014. The project requires an investment decision by the Province and regulatory permits and authorizations before it can proceed to construction.

CHANGE IN SEISMIC HAZARD



SUMMARY OF SAFETY AND SEISMIC UPGRADES AT BC HYDRO DAM SITES

Dam Site (region)*	Year Completed	Change in Seismic Hazard (PSHA vs Previous Models)		Summary of Dam Safety and Seismic Upgrades Completed and Planned
		Decrease or no significant change	Increase[1]	
Aberfeldie (C)	1922	✓		1953 – Dam replaced | 1999 – Dam anchored for seismic and flood loadings • No further action required at this time.
Alouette (LM)	1926	✓		1984 – Original dam replaced | 1993 – Spillway and low level outlet upgraded • Seismic upgrades to the headworks and surge tower are planned within the next few years. Plant currently out of service. No action required for the dam at this time.
Bear Creek (VI)	1912		✓	1971 – New low level outlet tower constructed – improvements to flood routing capacity | 1974 – Berm added to improve stability/ seepage control | 1993 – Spillway channel lowered to reduce consequence of failure following an earthquake • See Action Plan page 13
Buntzen (LM)	1902	✓		1965 – Dam rehabilitated • Seismic upgrades are planned for the tunnel portal within 10 years. No action required for the dam at this time.
Cheakamus (LM)	1957	✓		1981 – Earthfill dam raised and protected with concrete cap; seismic upgrades to the wing dam | 1985 – Work to improve stability of the dam and flood routing capacity, including anchoring of main and wing dams | 1988 – Seismic upgrades to dam, including placement of rockfill berms and dynamic compaction | 2010 – Upgrades to the spillway gates • Upgrades to the dam safety monitoring system and seismic upgrades to the spillway and to the dam retaining wall planned within 10 years. No action required for the dam at this time
Clayton Falls (LM)	1958	✓		• No action required at this time.
Clowhom (LM)	1958	✓		1998 – Upgrades to the spillway gates • Upgrades to the spillway gate controls planned in the near future, with general gate upgrades planned in about 10 years. No action required for the dam at this time.
Comox (VI)	1912		✓	1957 – Reconfiguration of the dam including new spillway and sluiceway | 1982 and 1989 – Upgrades to the dam to improve seismic withstand • A study will be prioritized in future work plans to assess the performance of the dam given the increase in seismic hazard. Seismic upgrades to the dam are more than 10 years away.
Coquitlam (LM)	1913	✓		1980 – Seismic upgrades | 1985 – Upgrades to flood routing capacity | 2006 – New dam completed downstream of original dam • No further action required at this time.
Duncan (C)	1967	✓		2010 – Upgrades to the spillway gates • Upgrades to the dam safety instrumentation are underway. Upgrades are expected within 10 to 20 year timeframe to seismic withstand and riprap.
Durack Brook (P)	1968	✓		2014 – Pond was drawn down due to general condition of the dam. • Dam will be decommissioned.
Elko (C)	1924	✓		1950 – Major modifications to the dam | 1974 – Major rehabilitation work • Plant currently out of service. Total site redevelopment under consideration.
Elliott (VI)	1971		✓	• See Action Plan page 13.
Elsie (VI)	1958		✓	2003 – Seismic upgrades to the two larger dams • A study will be prioritized in future work plans to assess the performance of the dams given the increase in seismic hazard.
Falls River (LM)	1930	✓		1983 – Improvements to the sluiceway and intake; anchoring of the dam | 1992 – Major rehabilitation including improving the flood routing capacity and stability of the dam • Major improvements to various site components likely required within 10 years.
Hugh Keenleyside (C)	1968	✓		2011 – Instrumentation improvements • Improvements to right abutment downstream area to be implemented. Upgrades to the spillway gates are underway. Anchoring of low level outlet piers to improve post-seismic operability expected within 10 to 20 years.
John Hart (VI)	1947		✓[2]	1988 – Seismic upgrades to dams and spillway | 2005 – Upgrades to the flood routing capacity | 2007 – Upgrades to the spillway gate system • Underway: new powerhouse and seismic upgrades. Seismic upgrades to the dam and spillway are planned within 10 years. See Action Plan page 13.
Jordan Diversion (VI)	1913		✓	1971 – Extensive rehabilitation to the dam and water passages | 1991 – Dam upgraded to address seismic concerns • See Action Plan page 13.
Kootenay Canal (C)	1975	✓		2009 to 2014 – Improvements to the canal including installation of carpi liner in the canal to reduce leakage • Upgrades to the dam safety instrumentation are planned within the next few years. Some upgrades expected within 10 years to the headworks structure, penstocks and an excavated overburden slope adjacent to the powerhouse.
La Joie (LM)	1951	✓		1972 – Timber facing replaced with shotcrete | 2007 – Seismic upgrades to the north low level outlet tunnel penstock supports and instrumentation | 2013 – New release valves installed to increase reliability in water control • Ongoing: general upgrades to the water passages. Reservoir maximum operating level to be lowered in 2015 to reduce the likelihood and consequence of failure. See Action Plan page 13.
Ladore (VI)	1949		✓[2]	1987 – Seismic upgrades to the spillway piers and gates | 1991 – Seismic upgrades to Loveland Bay Saddle Dam | 2007 – Upgrades to the spillway gate system • Upgrades to spillway gates to enhance seismic withstand and post-earthquake operability are planned within 10 years. A study is underway to assess the performance of the dam given the increase in seismic hazard. See Action Plan page 13.

* Columbia (C) Lower Mainland/Coastal (LM) Peace (P) Vancouver Island (VI)

[1] Increase defined as >15% and >0.05g change in Peak Ground Acceleration (see Glossary).
[2] Decrease in peak value, but a much longer expected duration of ground shaking.

Dam Site (region)*	Year Completed	Change in Seismic Hazard (PSHA vs Previous Models)		Summary of Dam Safety and Seismic Upgrades Completed and Planned
		Decrease or no significant change	Increase[1]	
Mica (C)	1973	✓		1988 – Stability improvements at Dutchman's Ridge | 1986, 2000, 2005, 2012, 2013 – Instrumentation improvements in various areas • Upgrades to the dam safety instrumentation are underway. Seismic upgrades to the discharge facilities within 10 years. General improvements to instrumentation at Little Chief and drainage at Dutchman's Ridge slide areas. Some remediation of leaky casings in the dam expected within 10 years.
Peace Canyon (P)	1979	✓		2004, 2005 – Seismic improvements to the spillways back-up power system • Upgrades to the spillway gate controls are planned within the next few years. A study is currently underway to reassess the general stability of the spillway structure. No further action is expected.
Puntledge Diversion (VI)	1912		✓	1954 – Dam, intake and powerhouse replaced • A study will be prioritized in future work plans to assess the performance of the dam given the increase in seismic hazard. Possible dam upgrades within 10-20 years.
Quinsam Diversion (VI)	1957	✓		• No action required at this time.
Quinsam Storage (VI)	1957	✓		• No action required at this time.
Revelstoke (C)	1984	✓		1980 – Anchors and drains installed in right abutment rock slope | 1982, 1999, 2008 – Drainage improvements and additional instrumentation in Downie Slide and other areas | 1993, 1996 – Instrumentation upgrades in Checkerboard Creek slide area • Improvements to the left bank rock slope are planned within the next few years. General improvements to drainage in both the concrete dam and Downie Slide area within 10 years. Some remediation of leaky casings in the dam expected within 10 years.
Ruskin (LM)	1930	✓		1991 and 1996 – Powerhouse slope and dam abutments were upgraded to address seismic concerns | 1997 – Seismic upgrades to the spillway gates | 2005 – Maximum reservoir level drawn down 1.6m to partially mitigate seismic risk | 2007 – Seismic upgrades to the dam including anchors in the crest block | 2013 – Seismic upgrades completed on the right abutment • Underway: seismic upgrades to the main dam, spillway and left abutment. No further action required at this time.
Salmon River (VI)	1958	✓		• Upgrades to the Salmon Diversion facility including addressing fish passage issues are planned within the next few years. No further action required at this time.
Seton (LM)	1956		✓	2010 – Upgrades to the spillway gate system • Upgrades to the dam safety instrumentation and seismic upgrades to the aqueduct are planned within 10 years. A study will be prioritized in future work plans to assess the performance of the dam given the increase in seismic hazard. See page 13.
Seven Mile (C)	1979		✓	2002 – 2005 Dam upgraded to improve seismic withstand • No action required at this time. Seismic upgrades completed in 2005 are sufficient for the updated seismic hazard.
Spillimacheen (C)	1955	✓		• No action required at this time.
Stave Falls (LM)	1911	✓		1986 – Main dam anchored to improve stability | 1998 – Seismic upgrades to the spillway gates | 2002 – Dam further upgraded to address seismic concerns, including rockfill stabilizing support for the concrete dam | 2006 – Seismic upgrades to Blind Slough Dam | 2013 – Upgrades to the spillway gates • No further action required at this time.
Strathcona (VI)	1958		✓[2]	1994 – Seismic upgrades to the spillway | 2005 – Upgrades to flood routing capacity | 2007 – Upgrades to the spillway gate system | 2010 – Seismic upgrade to the intake tower • Upgrades to spillway to enhance post-earthquake operability and construct a new low level outlet in about 10 years, followed by seismic upgrades to the dam. See Action Plan page 13.
Sugar Lake (C)	1929	✓		1993, 2000 and 2002 – Dam upgraded to address seismic concerns • Upgrades to the flood discharge system currently under consideration. Possible requirement to upgrade earthen dam abutments within 10 years.
Terzaghi (LM)	1948		✓	1960 – Dam rebuilt downstream of original dam and new power tunnel was constructed | 2010 – Upgrades to the spillway gate system • Study underway to assess the performance of the dam given the increase in seismic hazard. Work to improve the seismic withstand of the BR1 and BR2 intakes is planned in about 10 years. See Action Plan page 13.
WAC Bennett (P)	1968	✓		1996 – Placed a filter on downstream toe of the dam for stability and seepage control as part of sinkhole remediation program • Upgrades to the spillway concrete surface and the spillway gates are underway. Upgrades to the upstream rip rap are planned within the next few years. Improvements to the dam safety instrumentation are planned within the next few years.
Wahleach (LM)	1952	✓		1994 – Dam and spillway upgrades to increase the flood routing capacity • A project to upgrade the seismic withstand of the intake tower is planned within the next 10 years. No action required for the dam at this time.
Walter Hardman (C)	1961	✓		2004 – Upstream storage dam (Coursier Dam) decommissioned to reduce risks | 2006 – Instrumentation upgrade • No further action required at this time.
Whatshan (C)	1951	✓		1998 – New low level outlet gates • General dam safety upgrades are planned in about 10 years.
Wilsey (C)	1929	✓		1992 – Upgrades to the stability of the dam including anchoring and drainage • General upgrades to the dam are planned in about 10 years.

* Columbia (C) Lower Mainland/Coastal (LM) Peace (P) Vancouver Island (VI)

[1] Increase defined as >15% and >0.05g change in Peak Ground Acceleration (see Glossary).
[2] Decrease in peak value, but a much longer expected duration of ground shaking.

INVESTING IN OUR SYSTEM

What action is BC Hydro taking to address new information from the PSHA study about the seismic hazard in B.C.?

We have a long-term plan to help reduce the potential downstream risks to people, property and infrastructure in the event of a major seismic event.

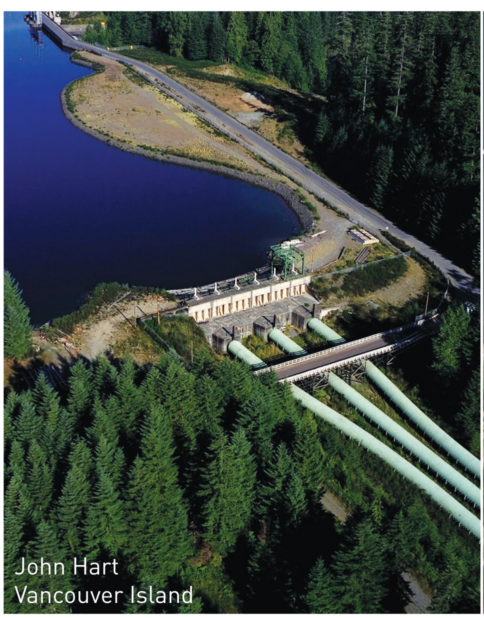
Over the next 10 years, BC Hydro will be investing approximately $1.9 billion in dam safety and seismic upgrades.

Examples of previous improvements and future upgrades at other locations around the province include:

- $400 million on the province-wide Spillway Gates Program (ongoing)
- $19 million to complete the Elsie Dam Safety Upgrade (2004)
- $65 million to rebuild the Coquitlam Dam (2008)
- $20 million on the Strathcona Dam intake tower project (2009-10)
- $4 million on the John Hart North Earthfill Dam Upgrade Project (2011)
- $748 million on the Ruskin Dam Safety and Powerhouse Upgrade (2017 targeted completion)

BC Hydro is also completing a multi-year seismic resiliency assessment to better understand risks and vulnerabilities within our transmission and distribution system in the event of a major earthquake. Long-term capital plans to reduce potential impacts to the transmission system include:

- $171 million on the Vancouver City Central Transmission project, which included building the new Mt. Pleasant substation and two new underground transmission lines
- Initiatives on Vancouver Island for a major cable project between George Tripp and Horsey substations, and new substations at South Wellington and Buckley Bay
- Launching the Downtown Vancouver Reinforcement project to improve the resiliency of the distribution system in Vancouver's downtown


John Hart
Vancouver Island


Elsie Dam
Vancouver Island


Mica Dam
Columbia Region

TAKING ACTION

BC Hydro is prioritizing its capital investments to help address increased hazards identified on Vancouver Island and at Bridge River, located between Whistler and Lillooet.

VANCOUVER ISLAND

The risk of a major seismic event has always been present in British Columbia, particularly on Vancouver Island.

As part of the $1.9 billion we are investing over the next 10 years in dam safety and seismic upgrades, $700 million will be spent on Vancouver Island dam safety upgrades.

This is in addition to the $1-billion John Hart project that will address seismic concerns in the Campbell River area (the Campbell River system includes the John Hart Dam, Strathcona Dam and Ladore Dam).

In fall 2014, BC Hydro also announced the John Hart Dam Safety Upgrade Project is in preliminary stages of design and review, First Nation consultation and community engagement. That project could begin as early as 2019.

Also on Vancouver Island, the Jordan River system includes the Jordan River Diversion Dam and the smaller Elliott and Bear Creek Dams.

The Jordan Diversion Dam was upgraded in 1991 and the Bear Creek reservoir level was reduced in 1993 to minimize the possible consequences of a dam failure during a major earthquake. New information from the PSHA study puts the Jordan River system at the highest seismic hazard within BC Hydro's system.

BC Hydro plans to meet with residents and local officials in the Jordan River area to review the study's results and plan of action in the event a major earthquake causes the dam to fail.

In addition, future studies are planned for the Comox, Elsie and Puntledge dam systems to assess their respective performance.

BRIDGE RIVER

The dams and related facilities that make up the Bridge River system are safe and well managed. The PSHA study confirmed that there is an increased seismic hazard at Terzaghi Dam and Seton Dam.

A study is underway at Terzaghi to assess the dam's performance, and at Seton a study will be prioritized in future work plans to assess that dam's performance.

Despite the study's findings that there was a slight decrease in the seismic hazard at La Joie Dam, action is still required. Plans are underway at the La Joie Dam to reduce the peak level of the reservoir.

EMERGENCY PLANNING AND COMMUNICATION

BC Hydro has a comprehensive emergency management program and we are always working to improve our processes in the event of major emergency. Following a 2012 Disaster Preparedness Audit, BC Hydro has improved its oversight of emergency management planning, updated earthquake response and recovery plans, and increased training for BC Hydro employees in the event of a major earthquake.

In the short-term, BC Hydro is increasing its emergency planning at its facilities and ensuring that strong lines of communication are in place with local emergency response agencies. We will be working with these groups to ensure that communities understand the location of evacuation areas in the event of a major earthquake that may cause a dam failure.

We also have table-top and role-play sessions with provincial and local emergency management agencies to coordinate emergency procedures. We conduct these exercises every three years and recently completed exercises on Vancouver Island this past fall.

BC Hydro is also working with Emergency Management BC, the City of Campbell River, and the Strathcona Regional District to develop a pilot program to inform residents, businesses and First Nations of the risks associated with a major earthquake.

This program is also being followed with the Capital Region District for the Jordan River system.

BC Hydro will continue to work with government agencies, First Nations, emergency coordinators and first responders to provide information about flood risks and drought management.

SEISMIC STUDY GLOSSARY

Annual Exceedance Frequency
The chance of a specific event occurring in any one year. It is the reciprocal of the average recurrence interval (in years) between the occurrences of a specific event.

Consequence
The total adverse impact inflicted by a natural hazard on people, property, the environment and the economy.

Dam Failure
A condition of a dam when its reservoir can no longer be contained or released in a controlled manner.

Dam Safety
The continuous process of surveying, maintaining and operating all structures and systems involved with the retention and passage of water.

Drawdown
The controlled lowering of the water level in a reservoir.

Inundation Area
The surface area of land that can be potentially covered by reservoir water following an uncontrolled release of the reservoir.

Local Magnitude (Richter scale)
The Local or Richter Magnitude of an earthquake is a number representing the energy released in that earthquake and is defined as the logarithm of the ratio of the amplitude of the seismic waves to the amplitude recorded on a standard Wood-Anderson seismometer placed 100 km from the epicenter. As a result of the logarithmic scale, a difference of a unit magnitude corresponds to 31.6 times more energy and a difference of two magnitude units corresponds to 1000 times more energy.

Natural Hazard
Geological (e.g. earthquakes, tsunamis, landslides, volcanic eruptions, erosion), meteorological (e.g. storms, floods, drought, wildfires) or biological (e.g. epidemic, infestation) events that can have an adverse effect on people, property, environment and economy.

Peak Ground Acceleration
The largest acceleration displayed on an earthquake-generated accelerogram recorded at a given site.

Probabilistic Seismic Hazard Analysis (PSHA)
A procedure first developed by Dr. Allin Cornell in 1968 to calculate the return period of a specified level of ground motion at a site, taking uncertainties into account . A typical PSHA produces seismic hazard curves, uniform hazard spectra and de-aggregated hazard for use in site-specific seismic design.

Risk
The product of the probability of the hazard and the consequences. There is no risk without a hazard or if the hazard has zero consequence.

Seismic Hazard (ground movement)
A natural hazard in the form of ground motions produced by earthquake events.

Seismic Upgrade
The restoration or refurbishment of an engineering structure (such as a dam) that strengthens the structure to better withstand ground movements associated with earthquakes.

Senior Seismic Hazard Analysis Committee (SSHAC):
A committee set up in the 1990s to review the state-of-practice and improve the overall stability of the PSHA process. The committee concluded that most of the differences in individual PSHA results were consequences of differences in the process of information elicitation from experts and from the identification, quantification and incorporation of uncertainty. The recommendations of the committee are now adopted by analysts worldwide.

Significant/Major Earthquake
An earthquake that can potentially cause damage to a well-engineered structure. A major earthquake is a large significant earthquake.

Modified Mercalli Index (Mercalli scale)
This is a scale used for measuring the intensity of an earthquake. On a scale with Roman numerals from I through XII, the index describes the effects of an earthquake on the ground, humans, objects of nature, and man-made structures, with I (lowest) denoting "Not Felt", and XII (highest) denoting "Total Destruction". The values have no mathematical basis and differ based on the distance from the epicenter. Data is typically gathered from individuals who have experienced the quake, and an intensity value is assigned to their location.

The following is an abbreviated description of the levels of the Modified Mercalli intensity:

Intensity	Shaking	Description/Damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

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BC HYDRO

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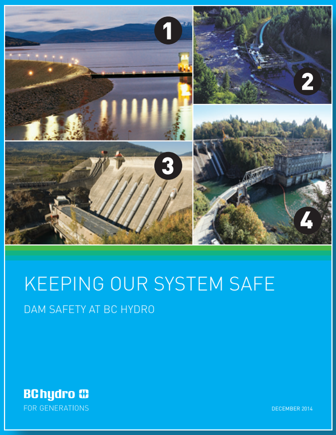

ON THE COVER

1. WAC Bennett Dam, Peace Region
2. Puntledge Dam, Vancouver Island Region
3. Revelstoke Dam, Columbia Region
4. Ruskin Dam and Powerhouse, Lower Mainland/Coastal Region

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