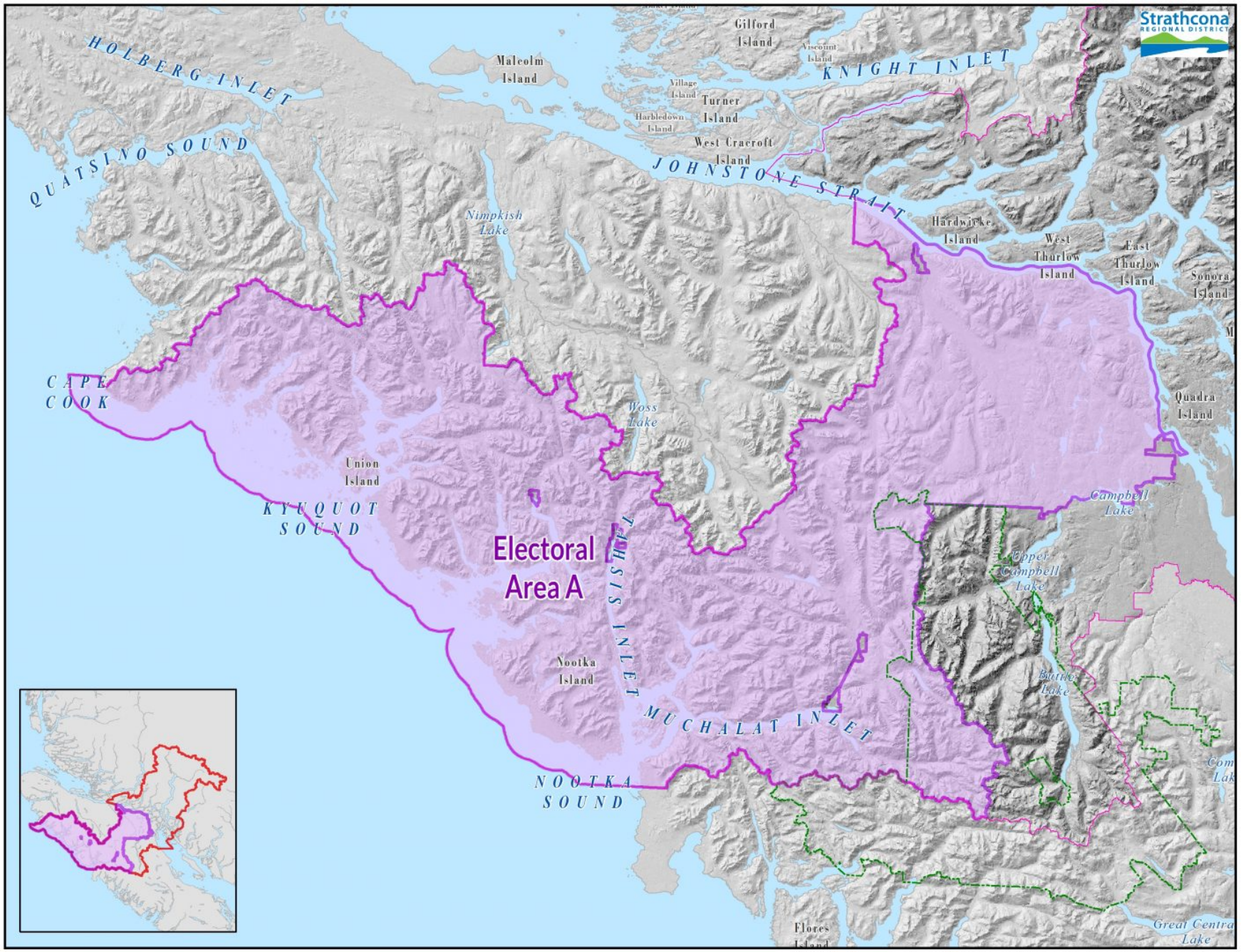
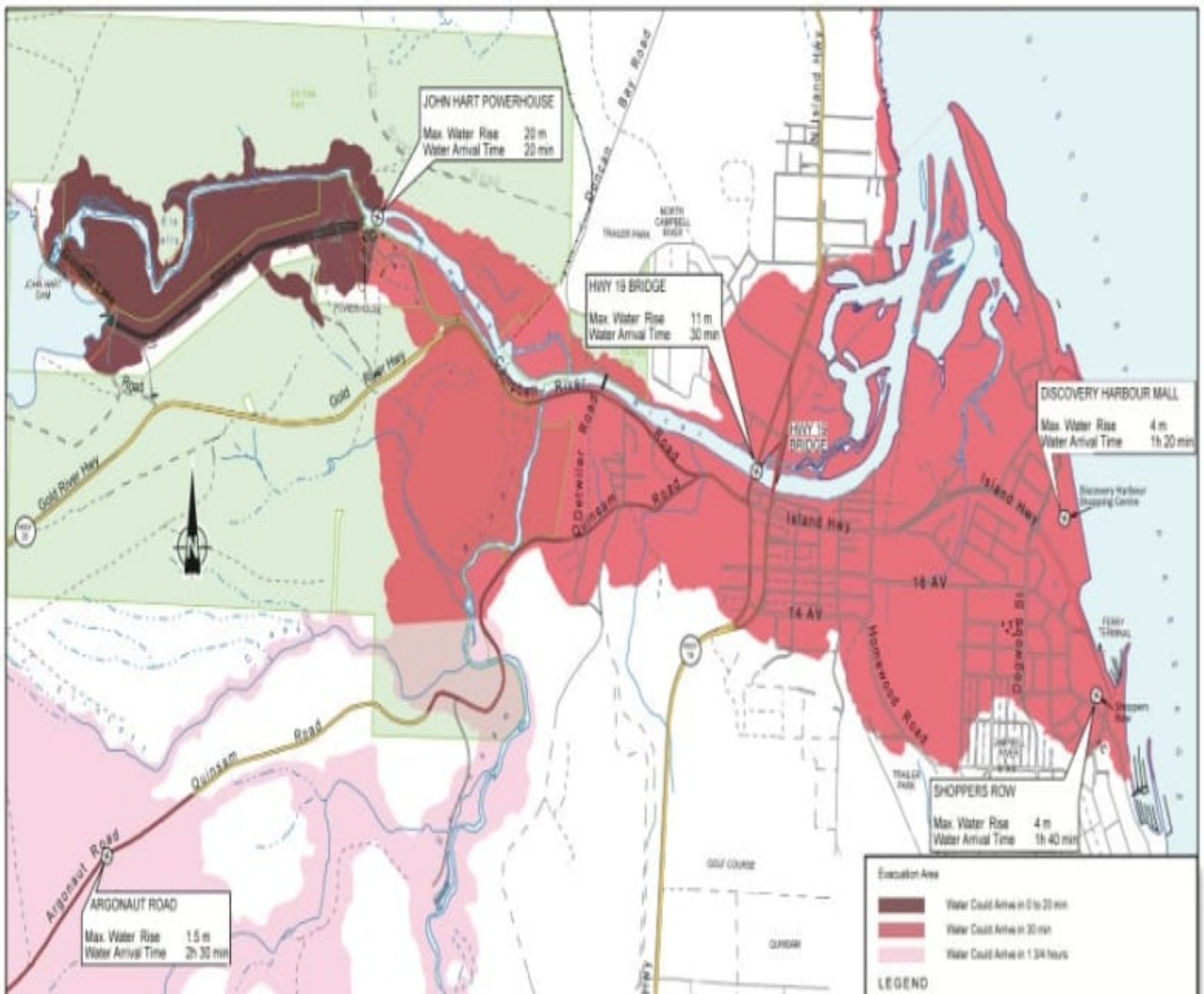
Championing Earthquake Safety and Risk Reduction

- **Shaun Koopman – Protective Services Coordinator – Strathcona Regional District**
- **Tiegan Hobbs – Seismic Risk Scientist – Natural Resources Canada**
- **Kathryn Forge – Executive Director, Planning and Risk Reduction - Emergency Management British Columbia**
- **Henry Seywerd – Program Manager Earthquake Early Warning/Canadian Hazard Information Service – Natural Resources Canada**
- **Teron Moore – Public Safety Program Manager – Innovation Centre, Ocean Networks Canada**
- **Sahar Safaie – Founder and Principal Consultant, Sage on Earth Consulting Ltd.**
- **Jessica Shoubridge – Director – Earthquake Engineering Research Institute**



There are no high-resolution model results for specific sites on the northwest coast of Vancouver Island and this area requires our attention.

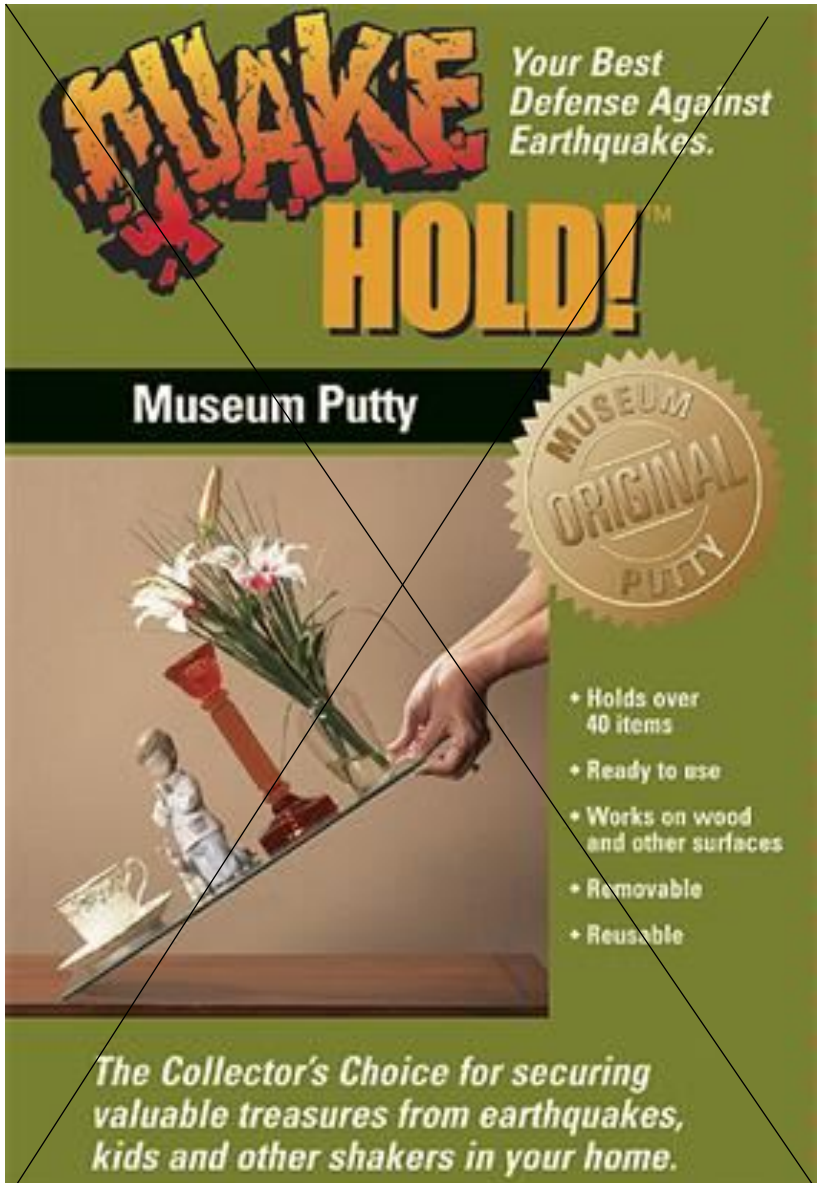
UBCM 2020 CEPF Flood Planning Grant.



BC Hydro $700 million on Vancouver Island dam safety upgrades.

Strathcona Dam project is still in the planning stage.

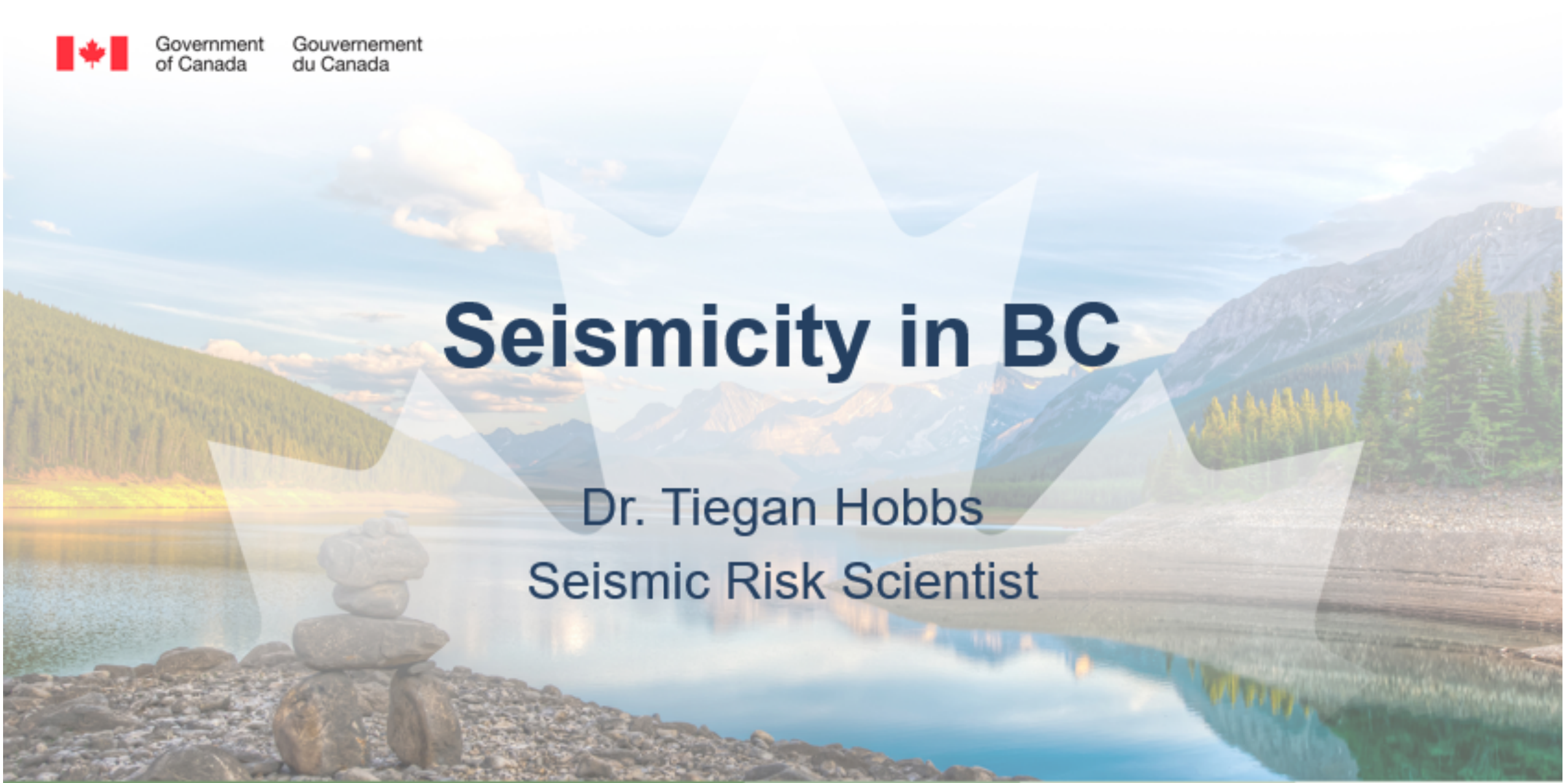
Seismic safety household items NOT available in hardware stores.



Lack of consistent and sustainable funding for seismic safety initiatives

- **July 1, 2014 the State of California amended Section 2705 of the Public Resources Code to increase seismic fee for building permits to provide for increased mapping of faults and strong-motion sensors.**

Government of Canada | Gouvernement du Canada

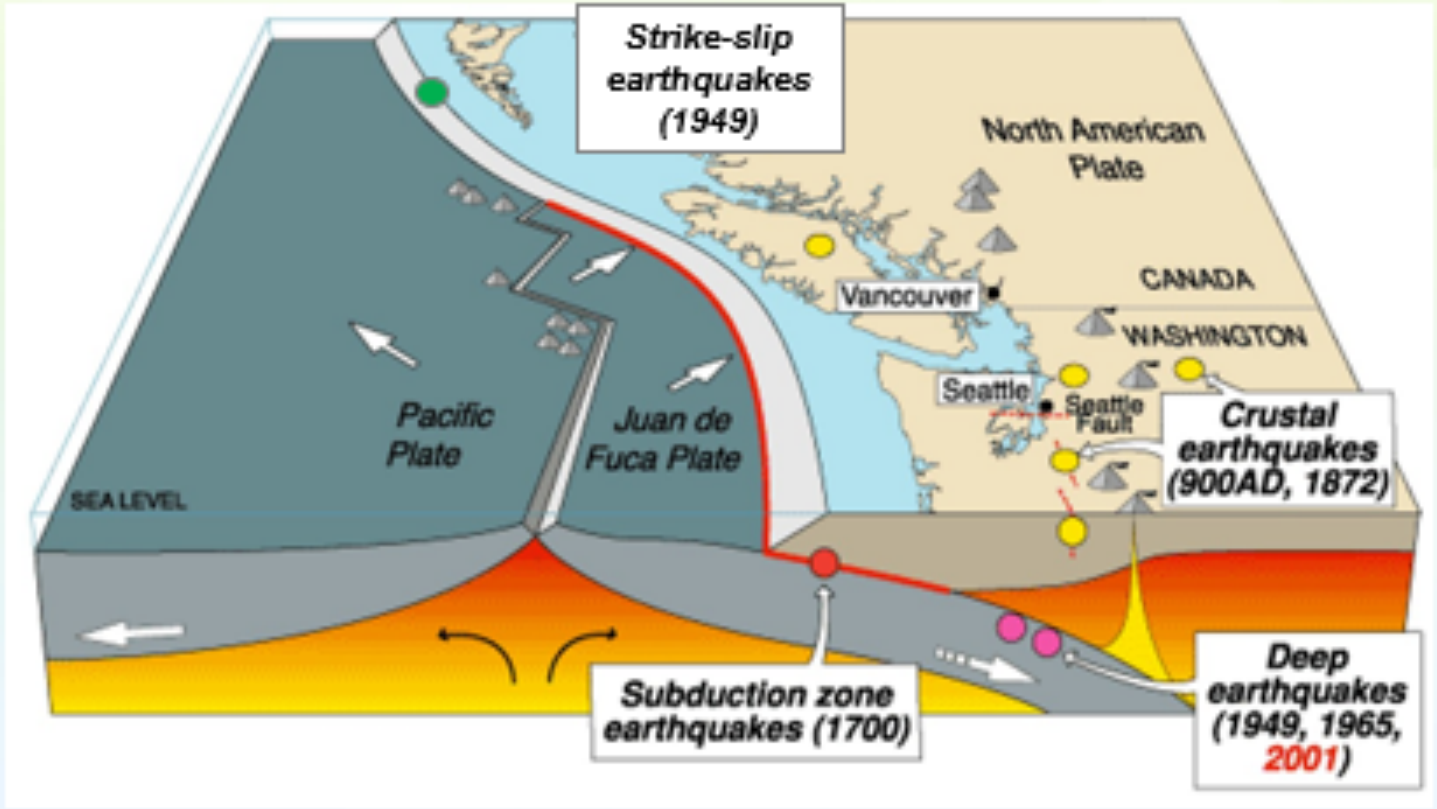


Seismicity in BC

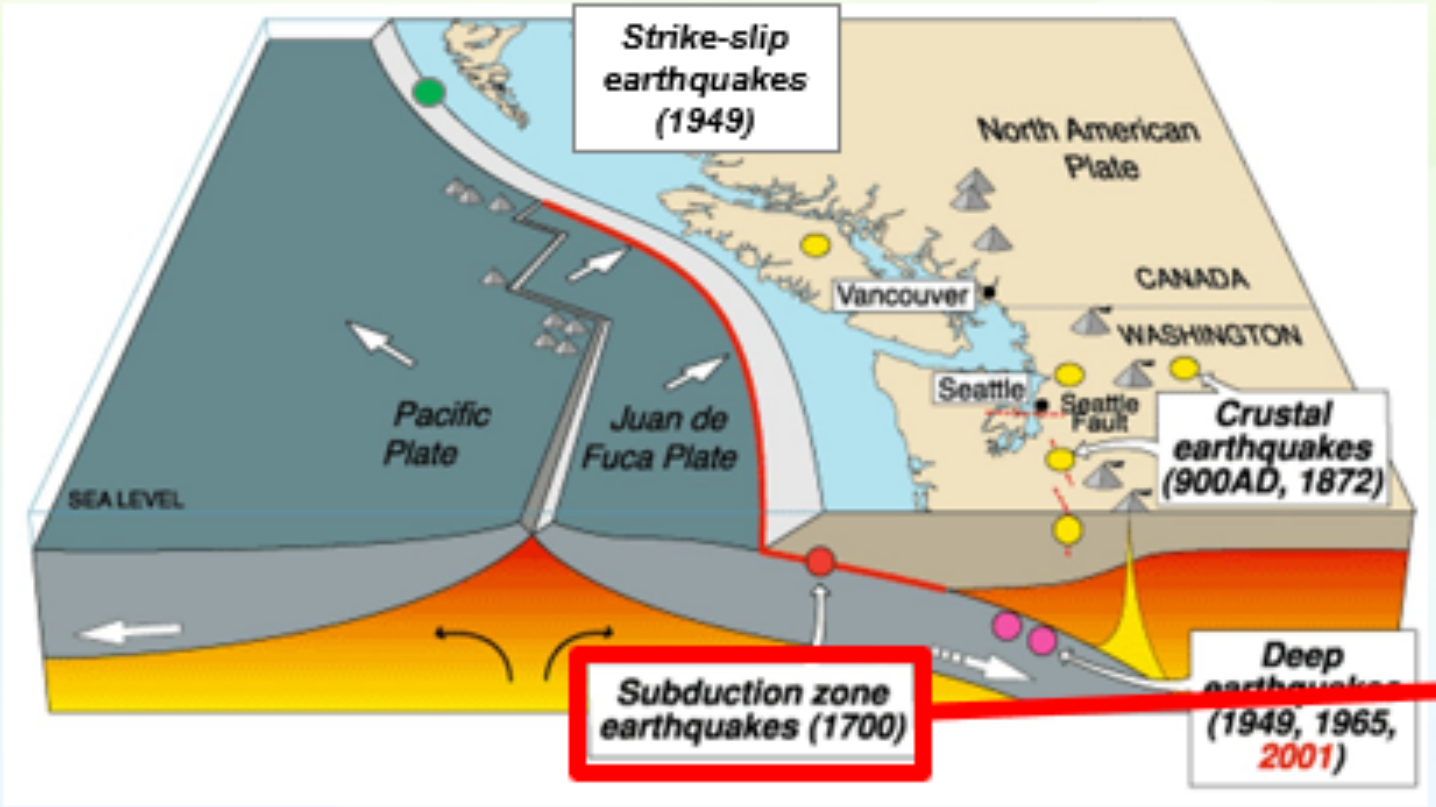
Dr. Tiegan Hobbs
Seismic Risk Scientist

Canada

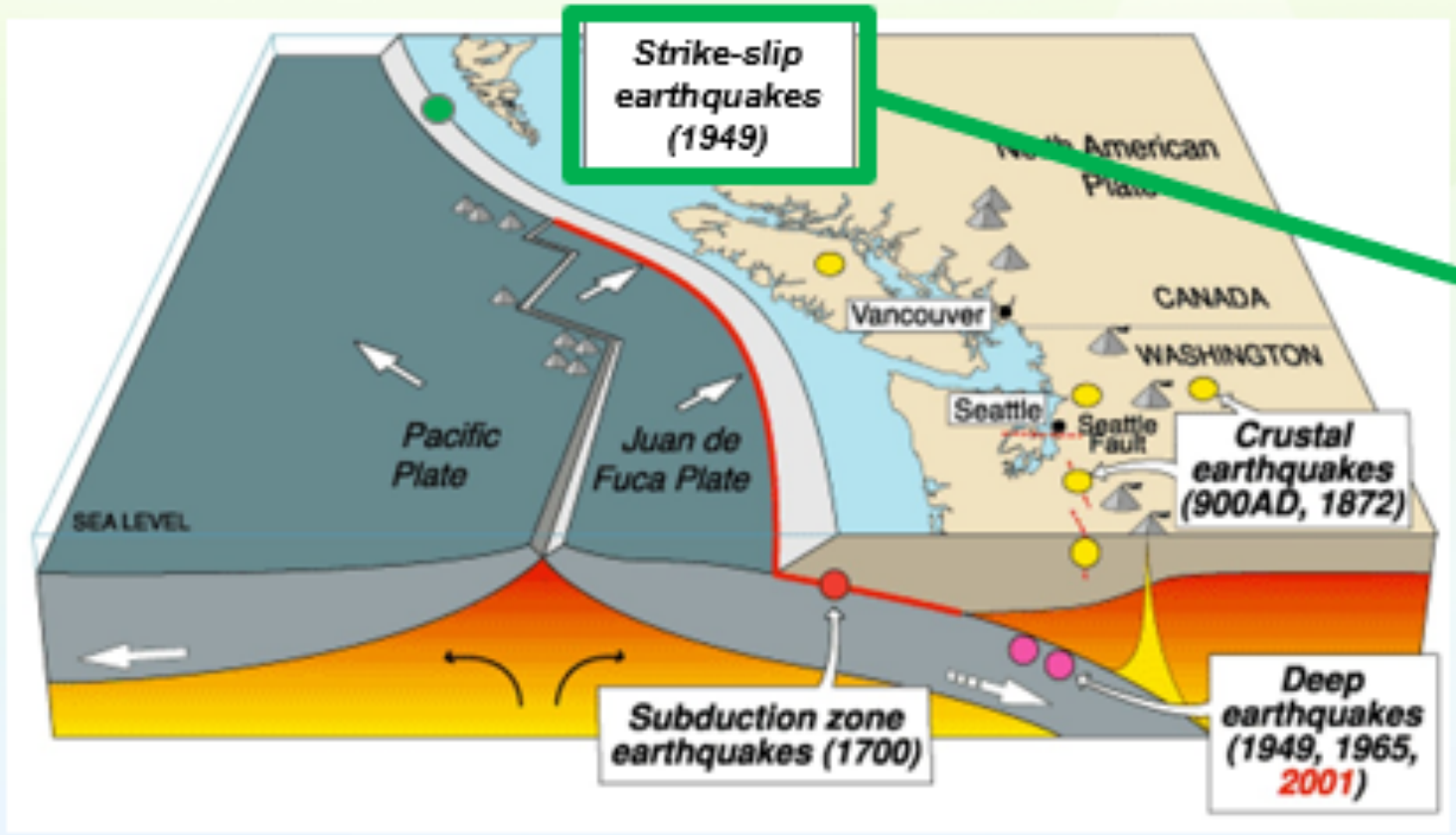
Types of Earthquakes



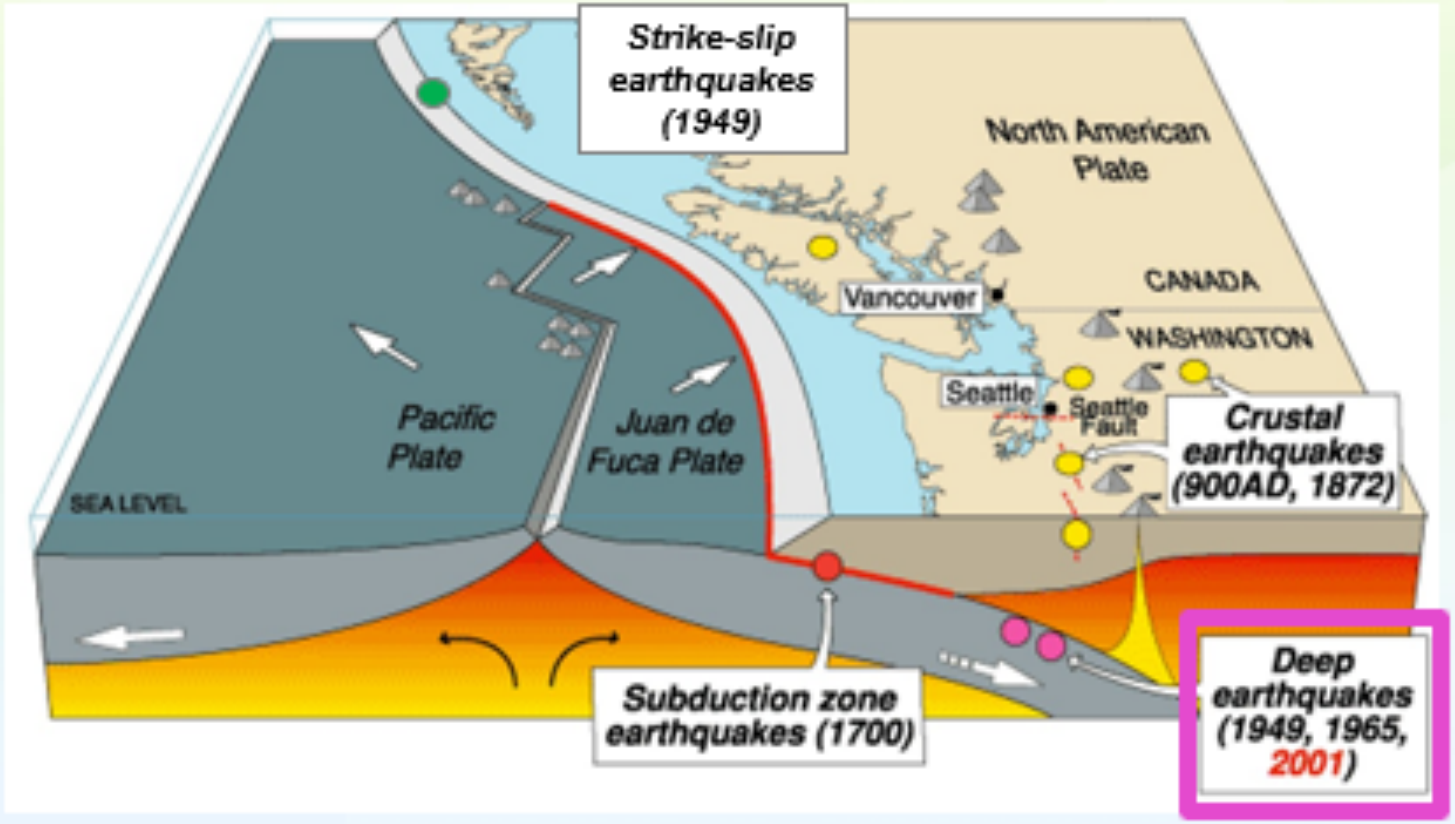
Types of Earthquakes



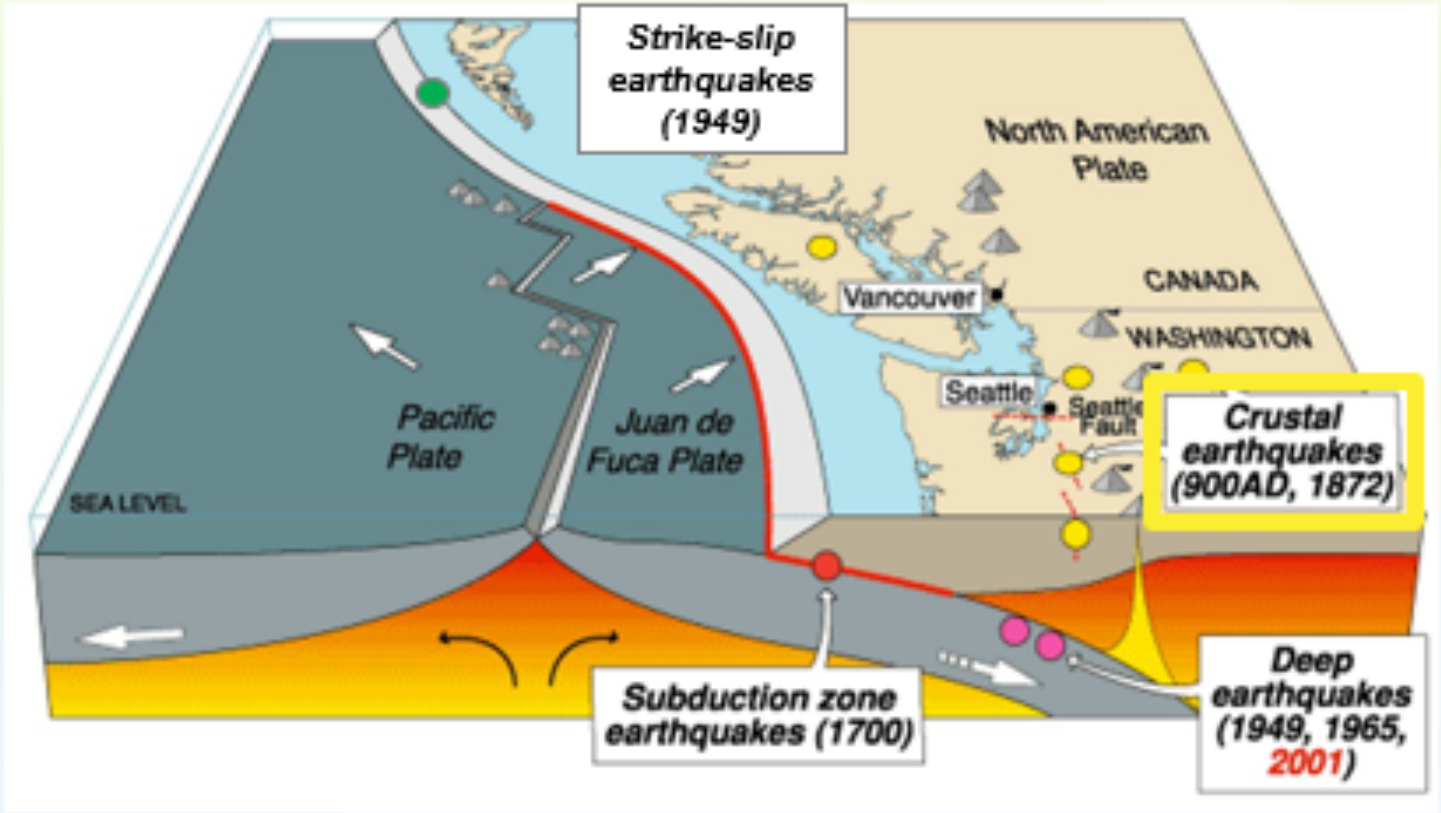
Types of Earthquakes



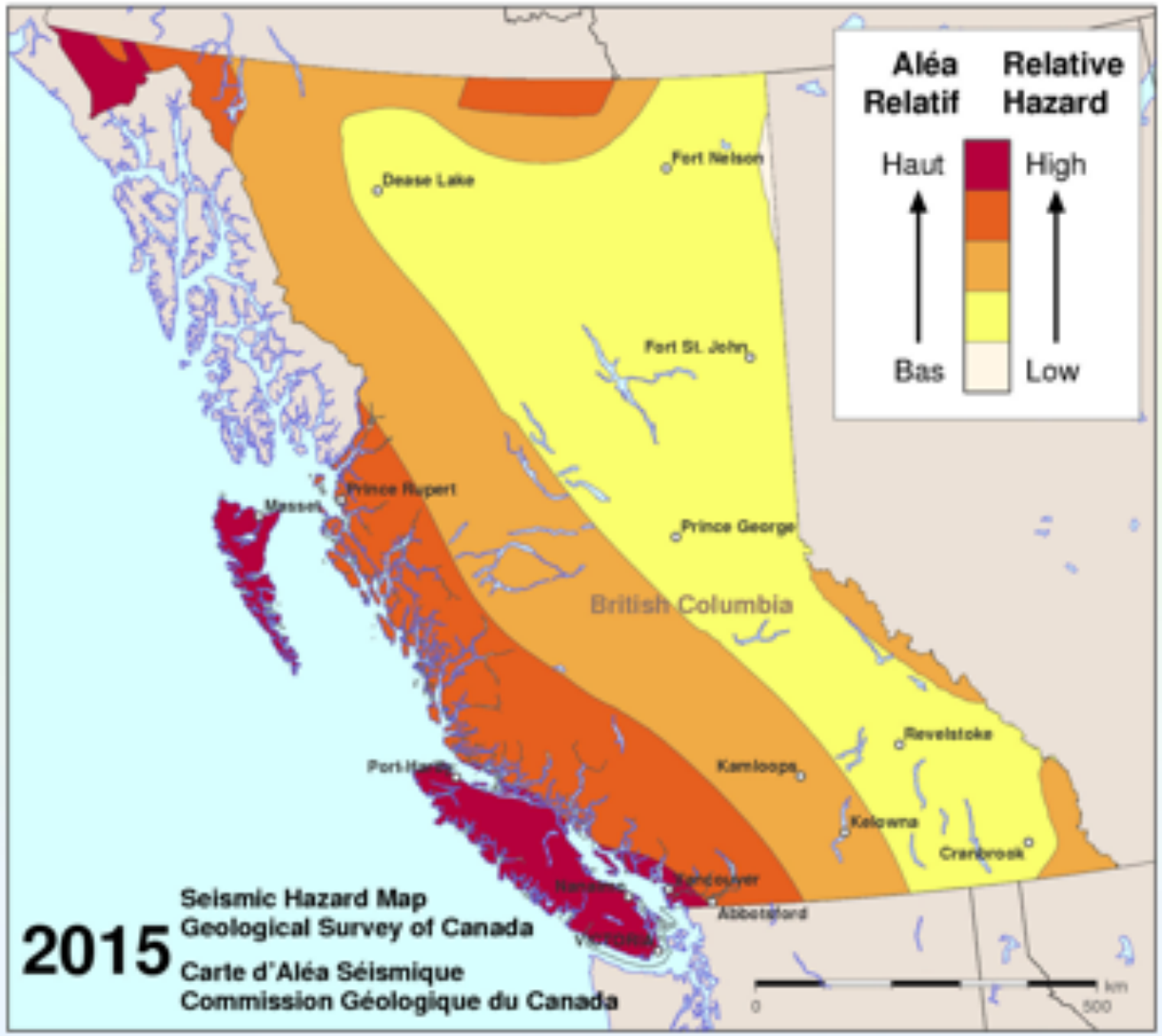
Types of Earthquakes



Types of Earthquakes

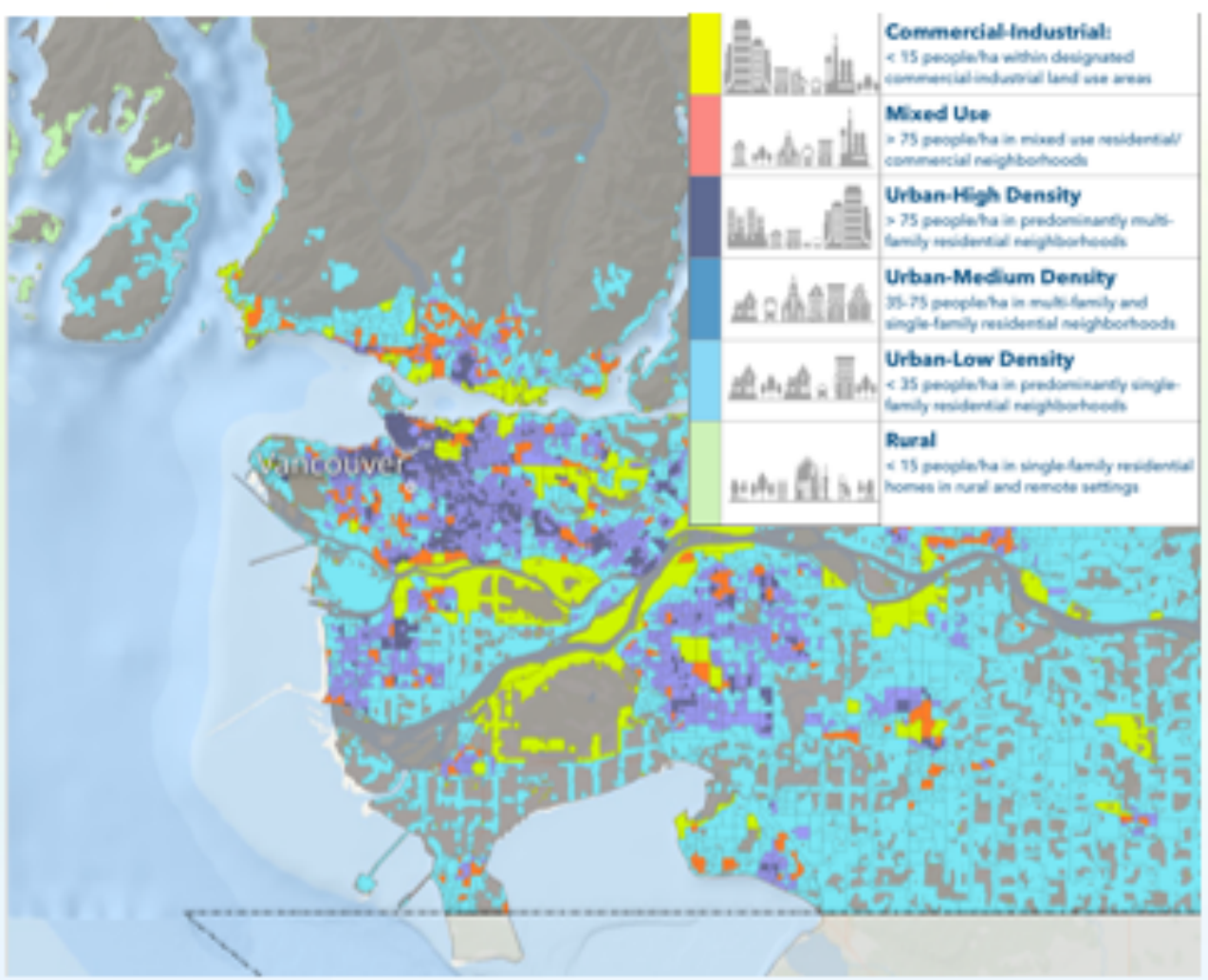


Natural Resources Canada | Ressources naturelles Canada



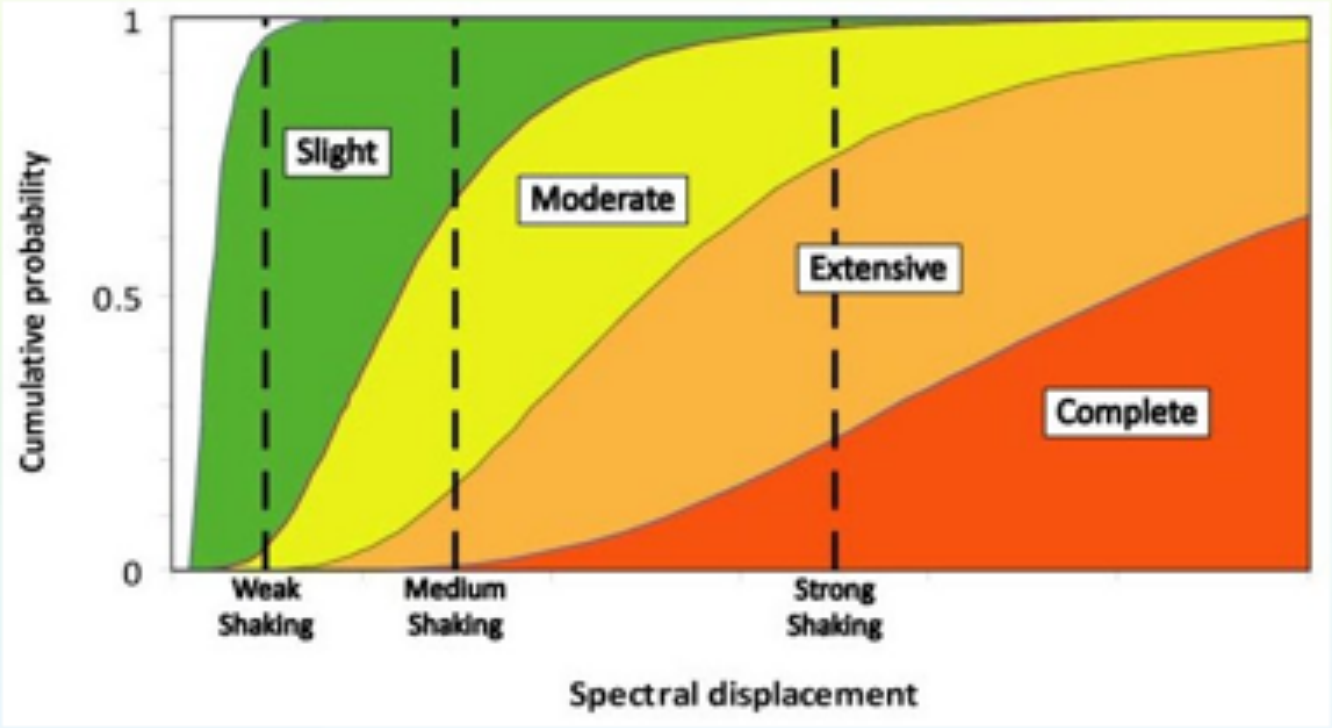
National Seismic Hazard Map

National Seismic Risk Profile

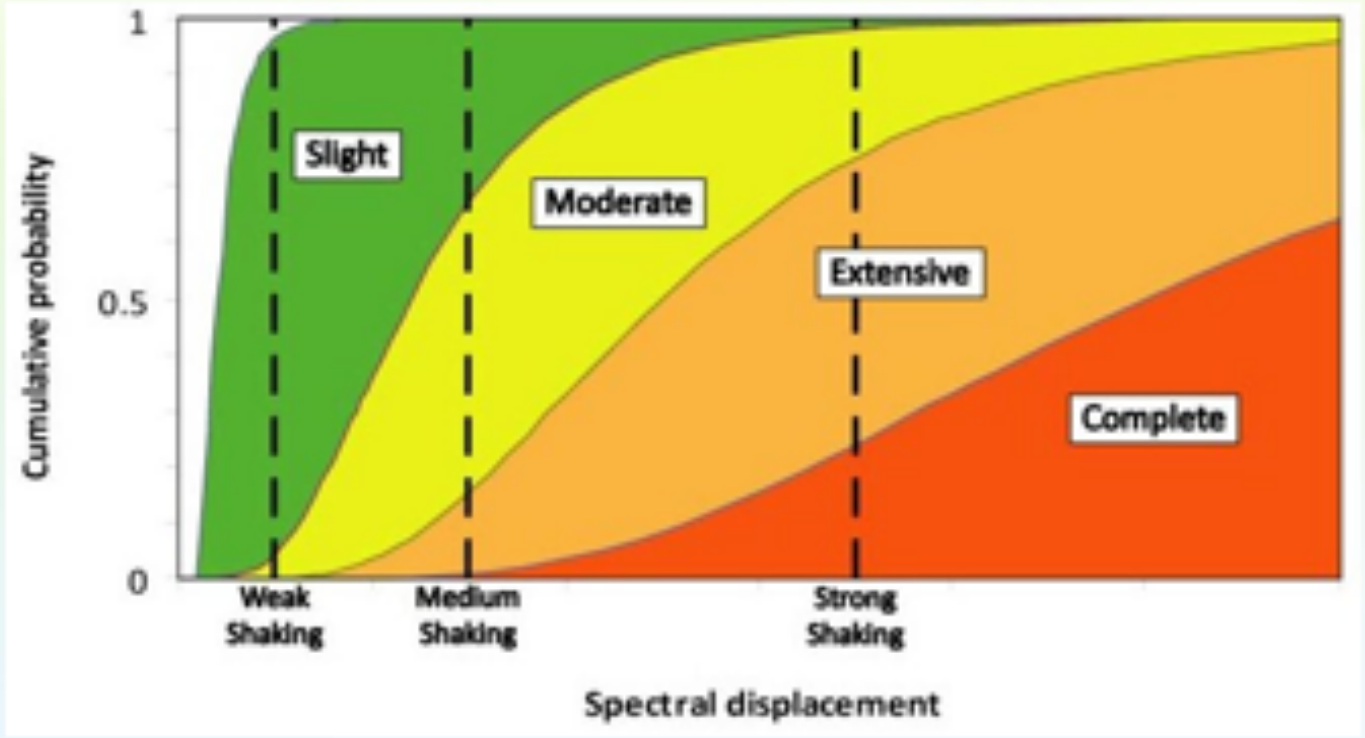


© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2017

National Seismic Risk Profile



National Seismic Risk Profile



Natural Resources Canada | Ressources naturelles Canada

Canada

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Emergency Management BC
Seismic Initiatives

Kathryn Forge
Executive Director, Planning and Risk Reduction
Emergency Management BC
Kathryn.Forge@gov.bc.ca

UN Sendai Framework on Disaster Risk Reduction

Emergency Program Act Modernization

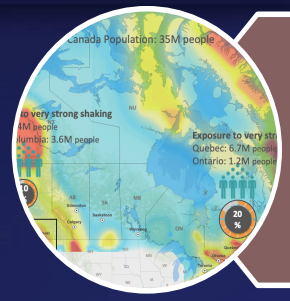
Preventing creation of new disaster risk

Reducing existing disaster risk

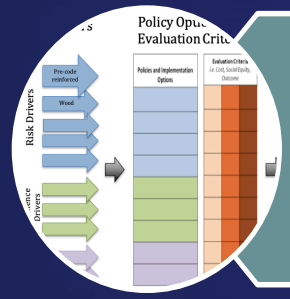
Managing residual risk

Risk informed measures that are integrated and inclusive of whole-of-society

Disaster Risk Reduction Pathways Project: incentives for mitigation and adaptation investments



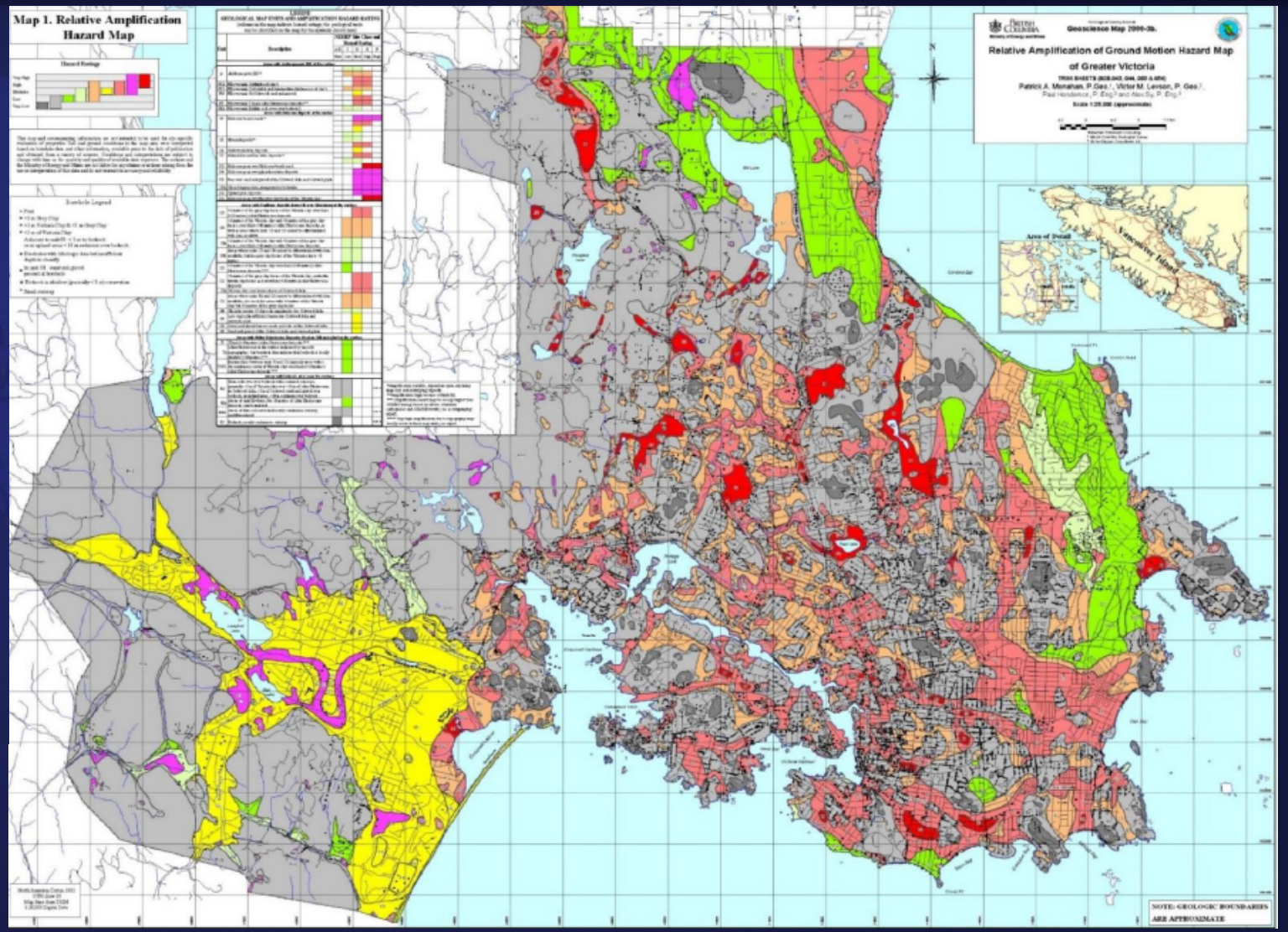
Objective 1. Increasing capabilities to model systemic risk, recovery, and resilience



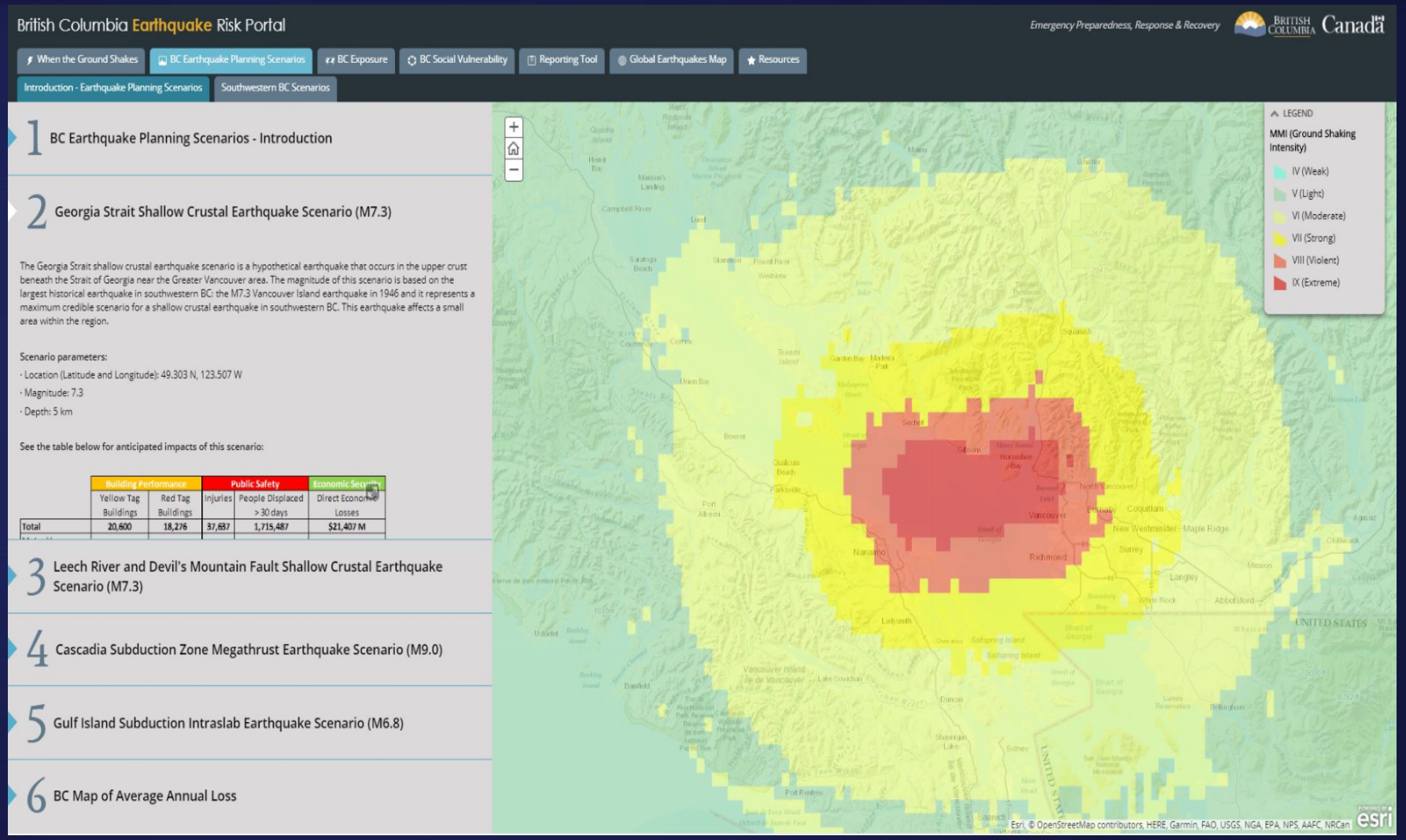
Objective 2. Enabling evidence-based disaster risk reduction

Objective 3. Strengthening governance of disaster risk information and risk management

- Seismic Microzonation
  - Metro Vancouver
- Tsunami Inundation Modelling
  - Community Emergency Preparedness Fund
  - National Disaster Mitigation Program



- BC Earthquake Integrated Risk Assessment
- Earthquake Early Warning



Natural Resources Canada | Ressources naturelles Canada

A National Earthquake Early Warning (EEW) System for Canada

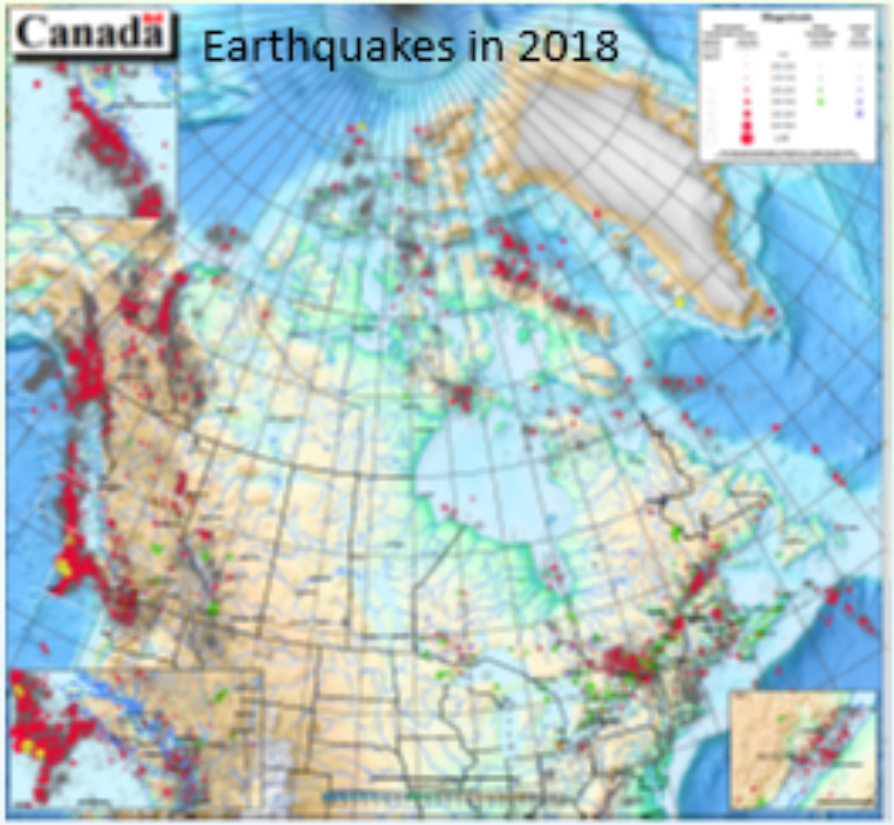
H. Seywerd
Natural Resources Canada
2019-09-24




Canada

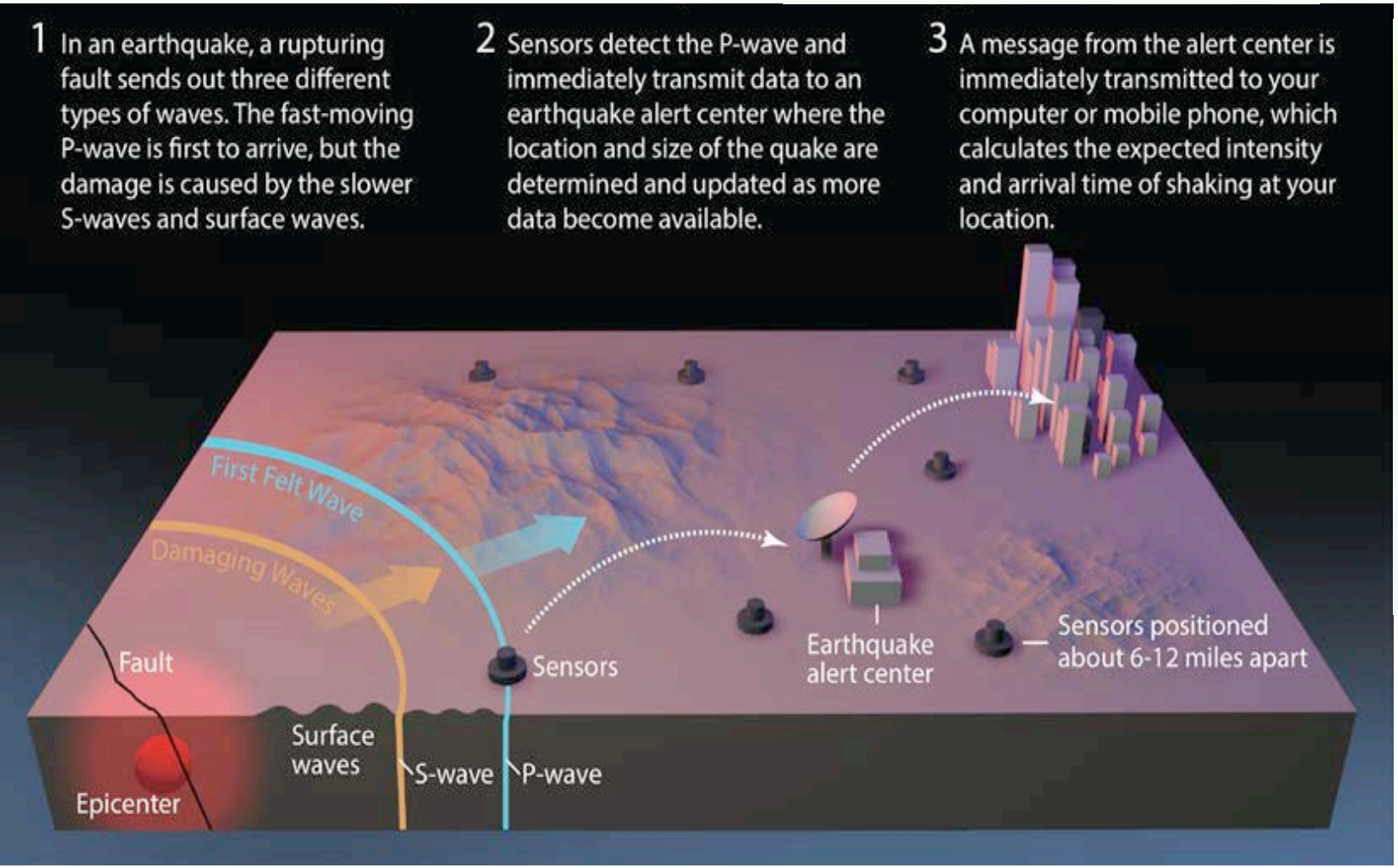
Context: Why EEW?

- Parts of Canada with significant populations are exposed to substantial earthquake risk:
- Insurance Board of Canada study† shows a large but plausible earthquake could result in total direct losses of $75 billion in the West and $60 billion in the East
- EEW can provide seconds to minutes of warning before the arrival of strong shaking to allow protective measures to be taken and reduce the impact of an event.



† Insurance Bureau of Canada, *Study of Impact and the Insurance and Economic Cost of a Major Earthquake in British Columbia and Ontario/Quebec, 2012*

EEW Principles



Limitations:

- Not prediction
- Short warning time (seconds to minutes)
- Blind zone: very little/no warning time close to the epicentre
- System itself does not protect:
  - Automated response
  - Well educated public (Shakeout)

Canada's EEW Program

- Federal Budget 2019 included funding for 'Ensuring Better Disaster Management Preparation and Response', includes Earthquake Early Warning
- Will cover major at risk areas of Canada
- Implementation phase of the EEW program runs from 2019-2024, with operation and sustainment thereafter
- Sensor Networks: 1000+ stations in total
- Processing in multiple distributed data centres
- Cross-border interoperability with US – use of ShakeAlert system
- The authoritative source of alerts and information
  - NPAS system, CI alerts

Network Partnership Opportunities

- Core network to be installed by federal government for protection of FCI
- Cover other areas by complementary network operated by partners
- Partners can include Provinces, Territories, Municipalities, First Nations, and others
- Data treated same as core network
- Program includes a Contributions component to assist partners
  - Cover cost of instruments
  - National system covers costs of data collection, alert generation, and distribution structure
  - Partner to cover cost of communications, installation, as well as operation and maintenance for a period (10 years)
- Training for station installation and maintenance
- Formal call for proposals to come for initial disbursement in fiscal 2020-21

Summary

- National Earthquake Early Warning System underway
- Will protect all major at risk areas of the country
- Covers cross border areas and ensures compatibility with US
- Looking for potential partners, as hosts for stations and for extensions to the core network

- Contact
- Henry Seywerd
- 613-996-3695
- Henry.Seywerd@canada.ca

OCEAN NETWORKS CANADA

Championing Earthquake Safety and Risk Reduction.

Earthquake Early Warning – End User Testing

Teron Moore | Fall 2019

A UNIVERSITY OF VICTORIA INITIATIVE

Presentation Overview

1. **EEW Project Overview**
2. **Sensors, science and data (oh my!)**
3. **EEW System Performance**
4. **End-user testing**
5. **Questions?**

EEW Project Scope and Success

INVESTMENT

- **$5M (Emergency Management BC – CapEx, 3 yrs)**
- **$2M (Defense Research and Development Canada – OpEx, 2yrs)**

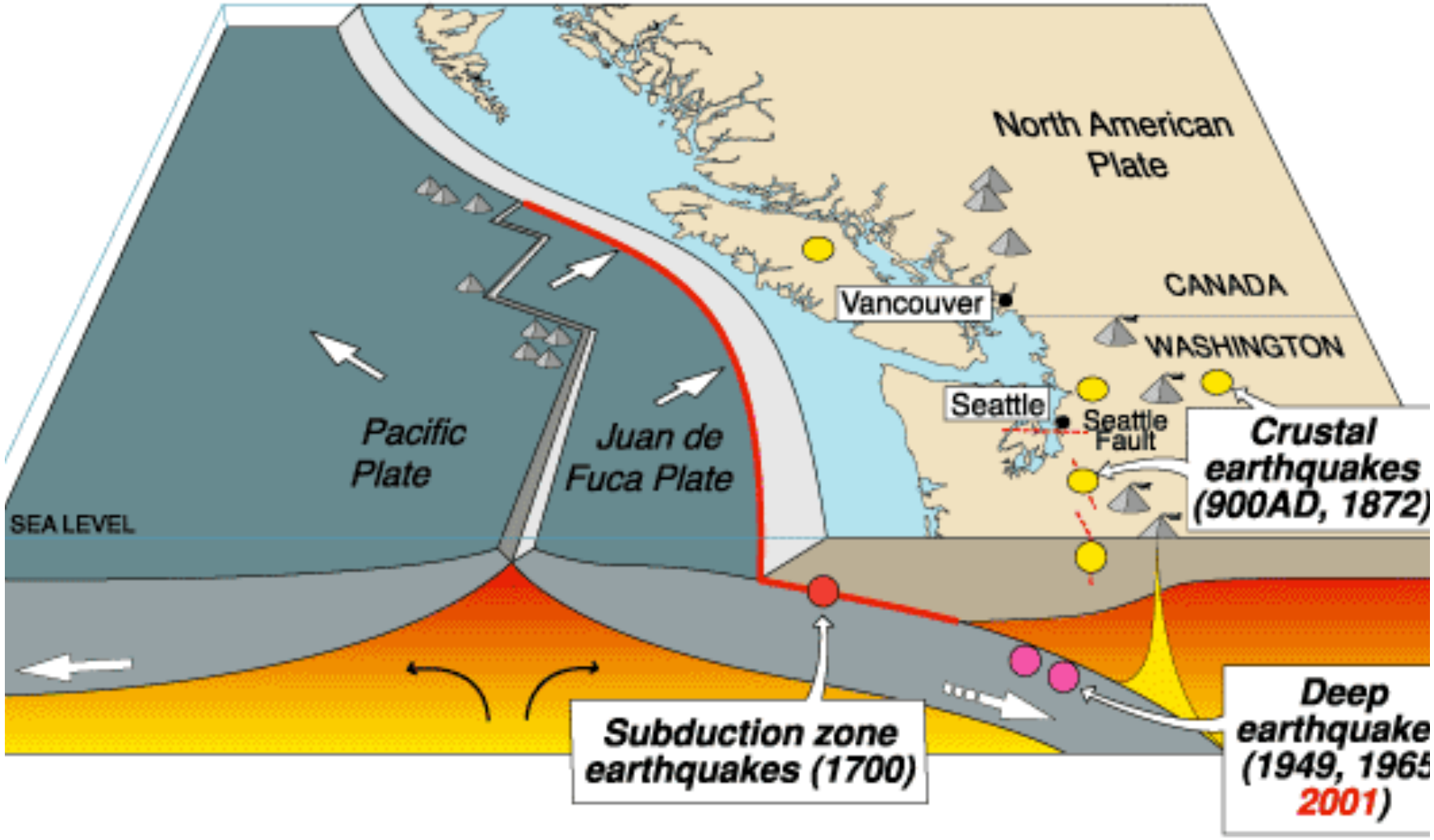
SCOPE

- **Cascadia Subduction Zone**
- **Leveraging existing offshore infrastructure, science, software development and real-time data management capabilities**
- **Integrate with other monitoring where possible**

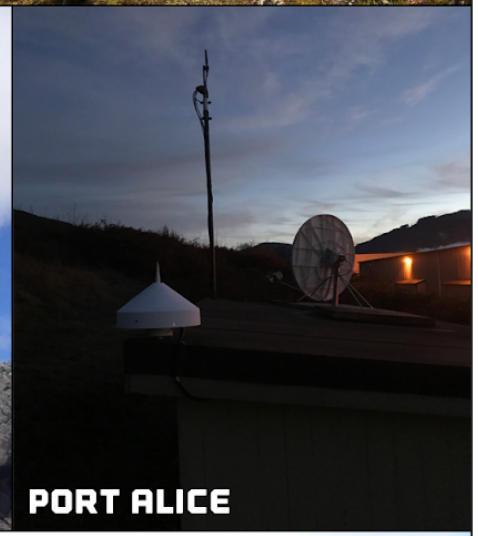
SUCCESS

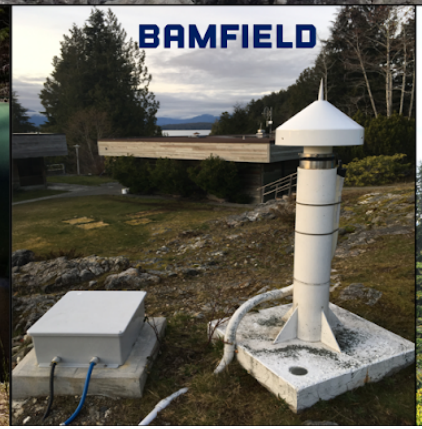
- **~8 offshore and ~36 land-based sites**
- **Capable of achieving live operations**
- **Tested and evaluated with verified operational capabilities**
- **Capable of delivering earthquake notifications to selected End-Users**

Earthquake Sources in British Columbia



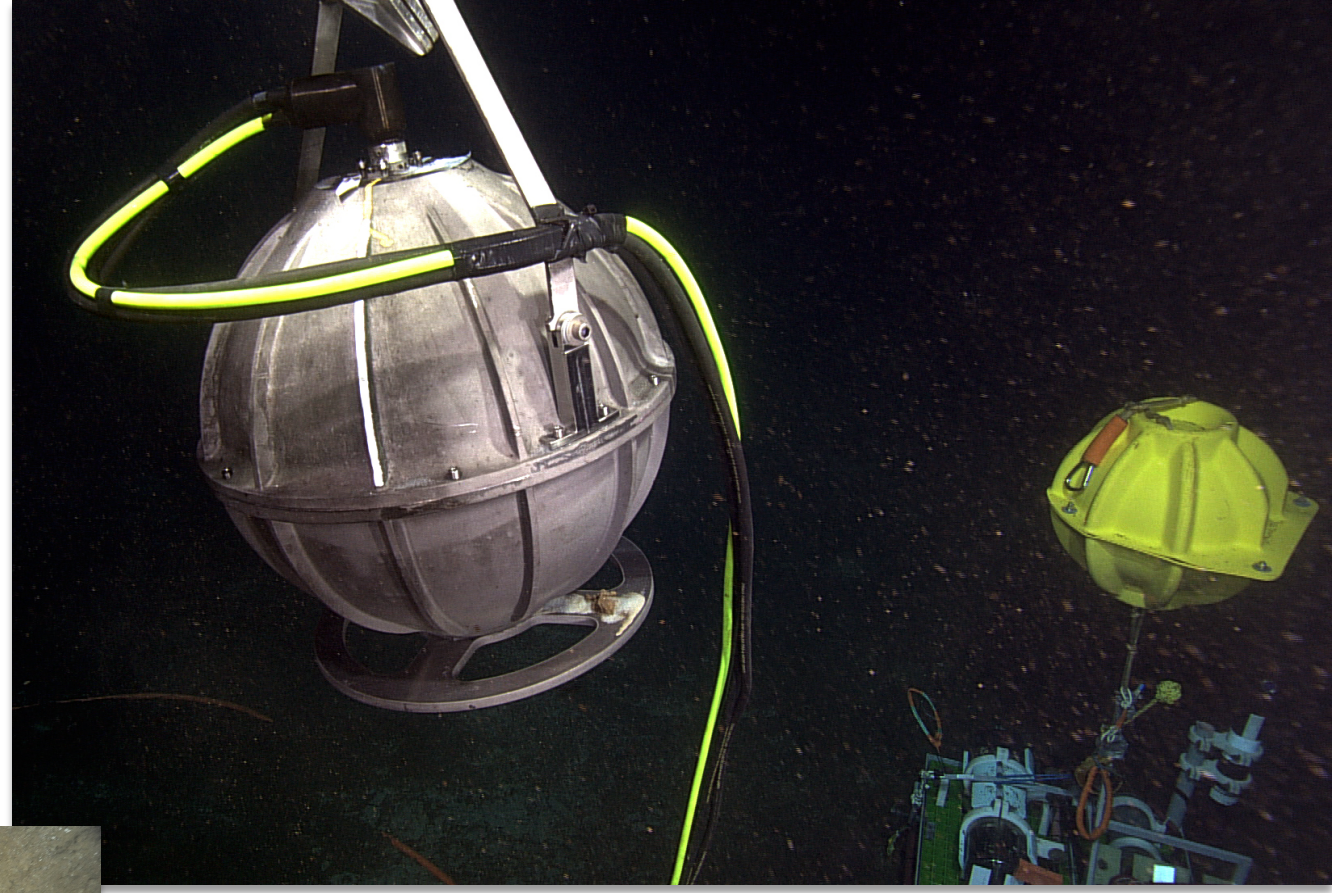

OCEAN NETWORKS CANADA
EARLY EARTHQUAKE WARNING STATION STATUS
Port Hardy
Zeballos
Vancouver Island
Courtenay
BRITISH COLUMBIA
Port Alberni
Nanaimo
Tofino
Victoria
WASHINGTON
Explorer Ridge
Explorer Plate
Sovanco Fault Zone
Nootka Fault Zone
North American Plate
Clayoquot Slope
Cascadia Subduction Zone
Barkley Canyon
Juan de Fuca Plate
Juan de Fuca Ridge
Pacific Plate
Cascadia Basin
Geo-Seismic Sensors:
Installed
Other:
Node
Fibre-optic Cable
Fault Line
Subduction Zone
Spreading Centre
0
Bathymetry (50 m contour lines)
-3500 m
N
W
E
S
50 km
AN INITIATIVE OF
University of Victoria
Data Sources: Plate margins estimated from fig. 2 in Hyndman, 1995, Can. J. Earth Sci.; Digital Elevation Model derived from Smith and Sandwell Global Altimetry, Natural Resources Canada topography, Canadian Hydrographic Service bathymetry.
Last Updated: 25 July 2019
This product has been produced by the Univeristy of Victoria based on CHS data, pursuant to CHS Direct User License No. 2015-0313-1260-V. The incorporation of data sourced from CHS in this product shall not be construed as constituting an endorsement by CHS of this product. This Product does not meet the requirements of the Charts and Nautical Publications Regulations, 1995 under the Canada Shipping Act, 2001. Official charts and publications, corrected and up-to-date, must be used to meet the requirements of those regulations.
British Columbia Canada
Washington - USA

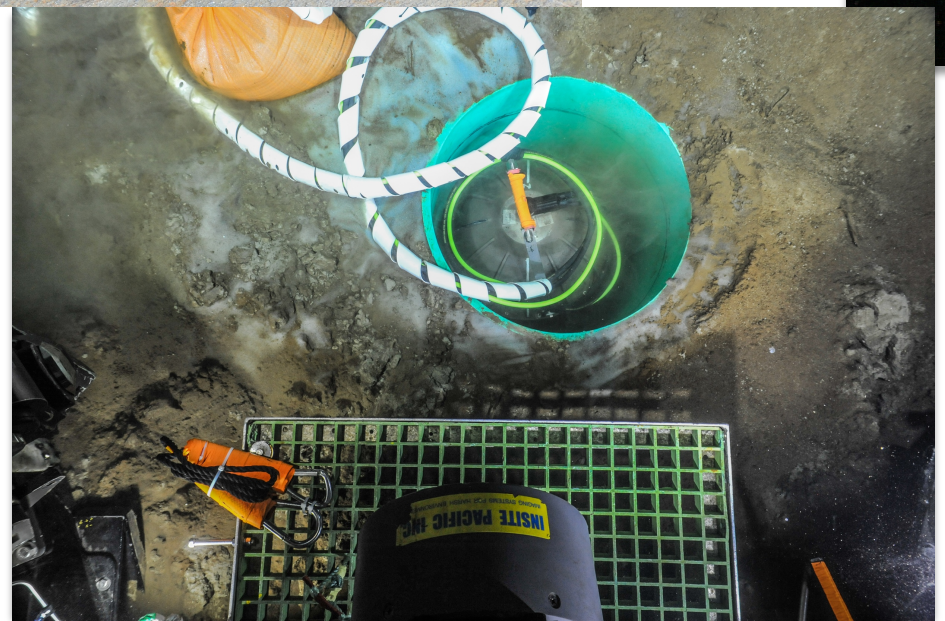




WORLD LEADING DISCOVERIES AT A CRITICAL TIME

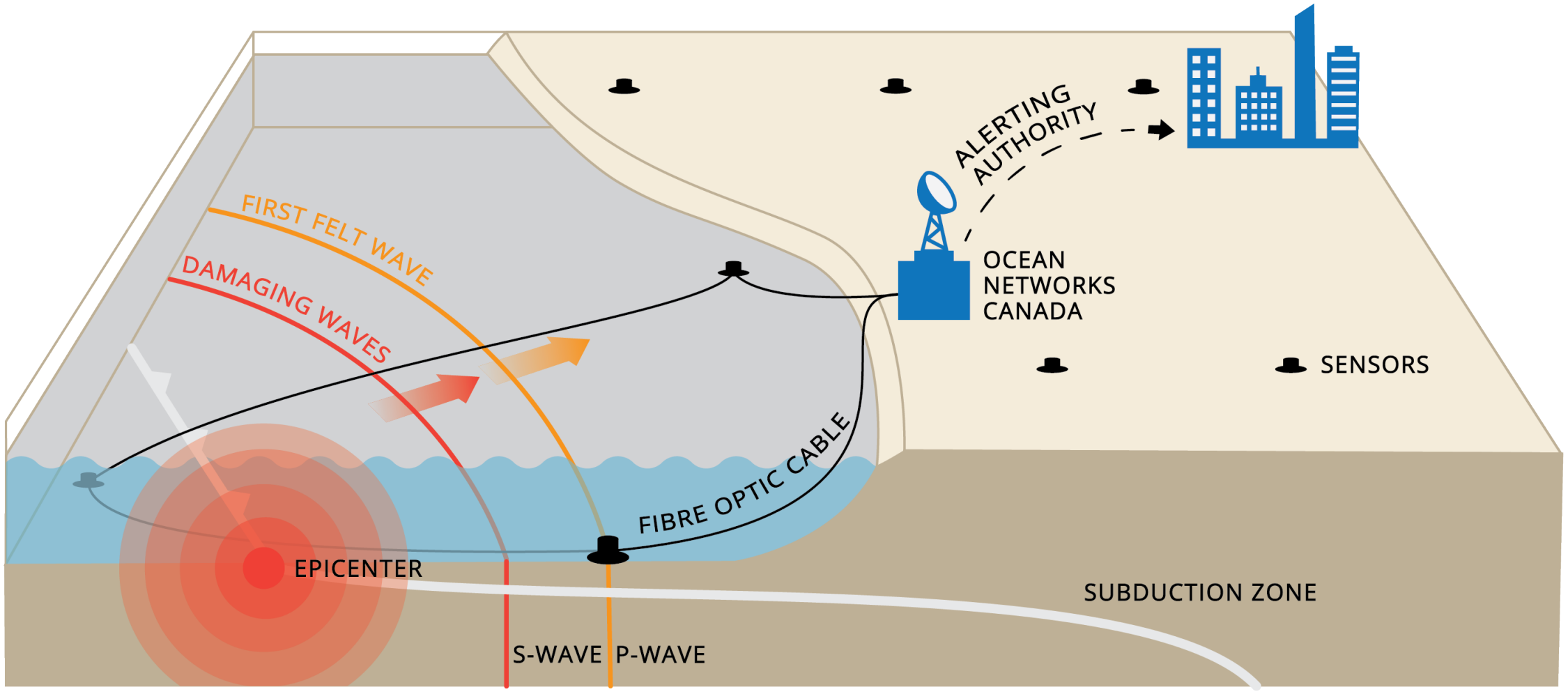
OCEAN NETWORKS CANADA





WORLD LEADING DISCOVERIES AT A CRITICAL TIME

OCEAN NETWORKS CANADA


ALERTING AUTHORITY
OCEAN NETWORKS CANADA
SENSORS
FIRST FELT WAVE
DAMAGING WAVES
FIBRE OPTIC CABLE
EPICENTER
SUBDUCTION ZONE
S-WAVE
P-WAVE

ONC Earthquake Early Warning – System Architecture

Land-based and ocean-based

Sensors
(Accel., GNSS)

P-wave, peak
displacement
detection

Algorithms:

- P-wave detection
- direct combination of displacement and acceleration

ONC Data Centres

Event
Associator

Notification

Algorithms:

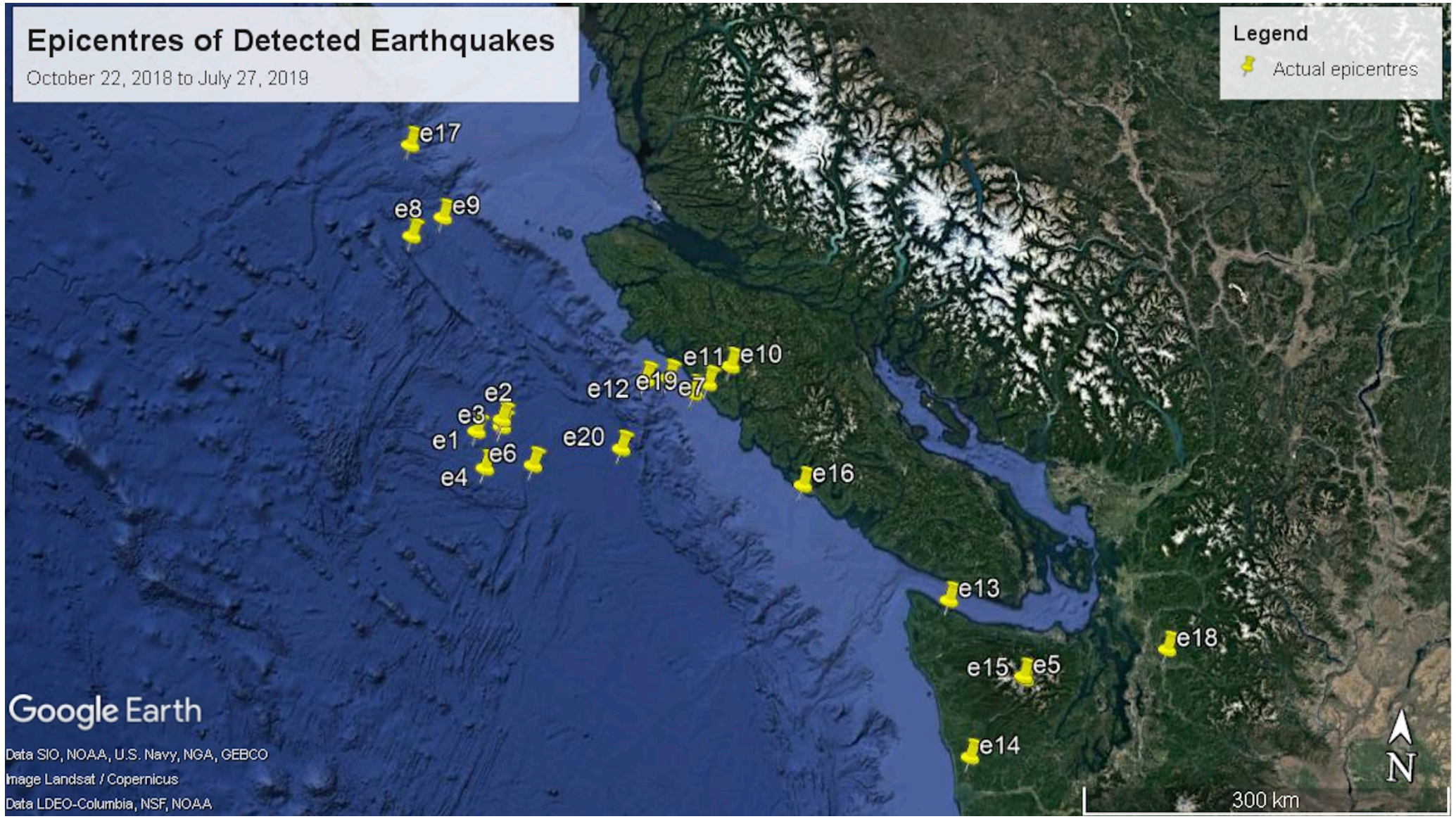
- Epicentre determination
- Magnitude estimate

Client Sites

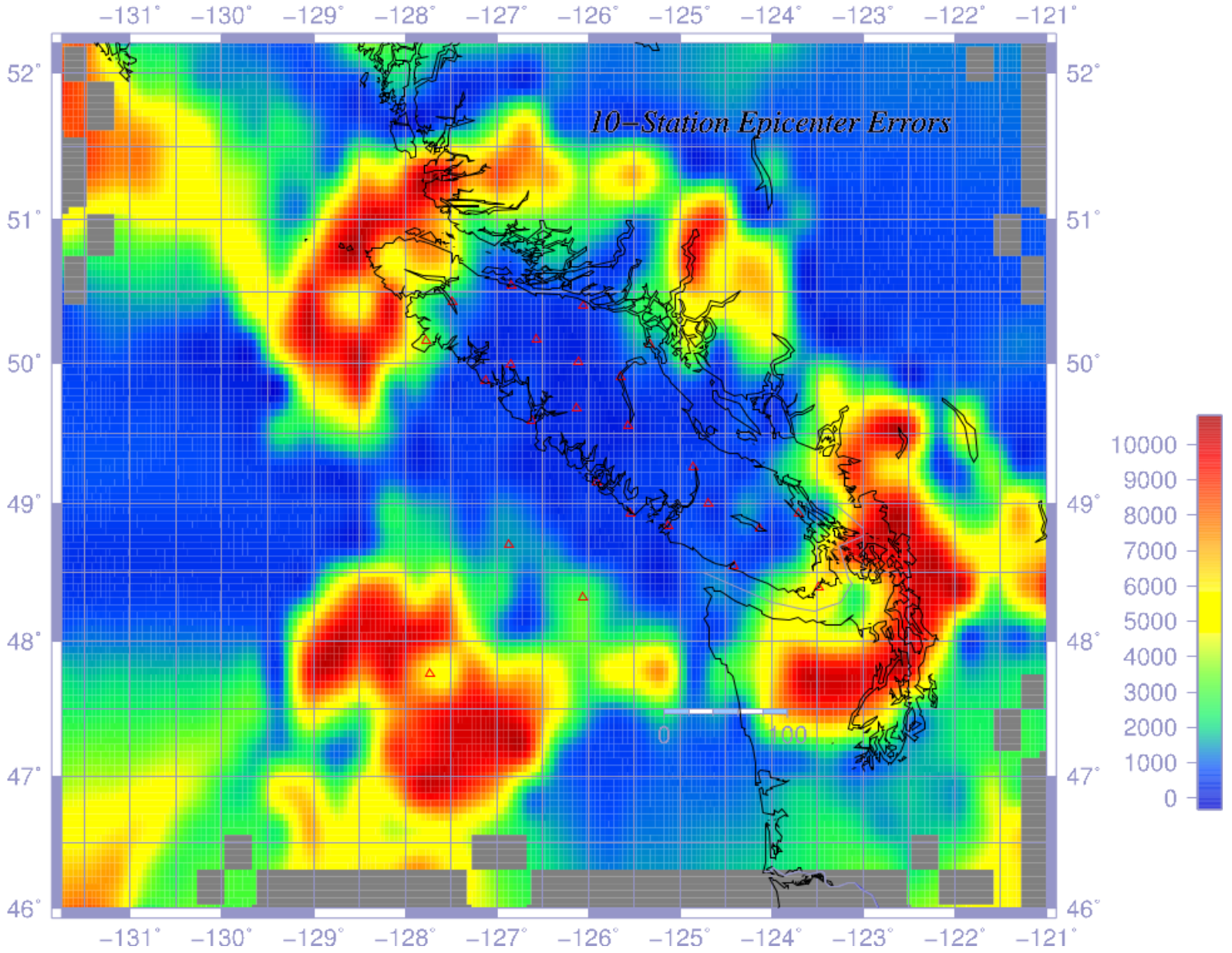
Hospitals, infrastructure, schools, public transportation, firehalls, airports, shake alert/shake ready

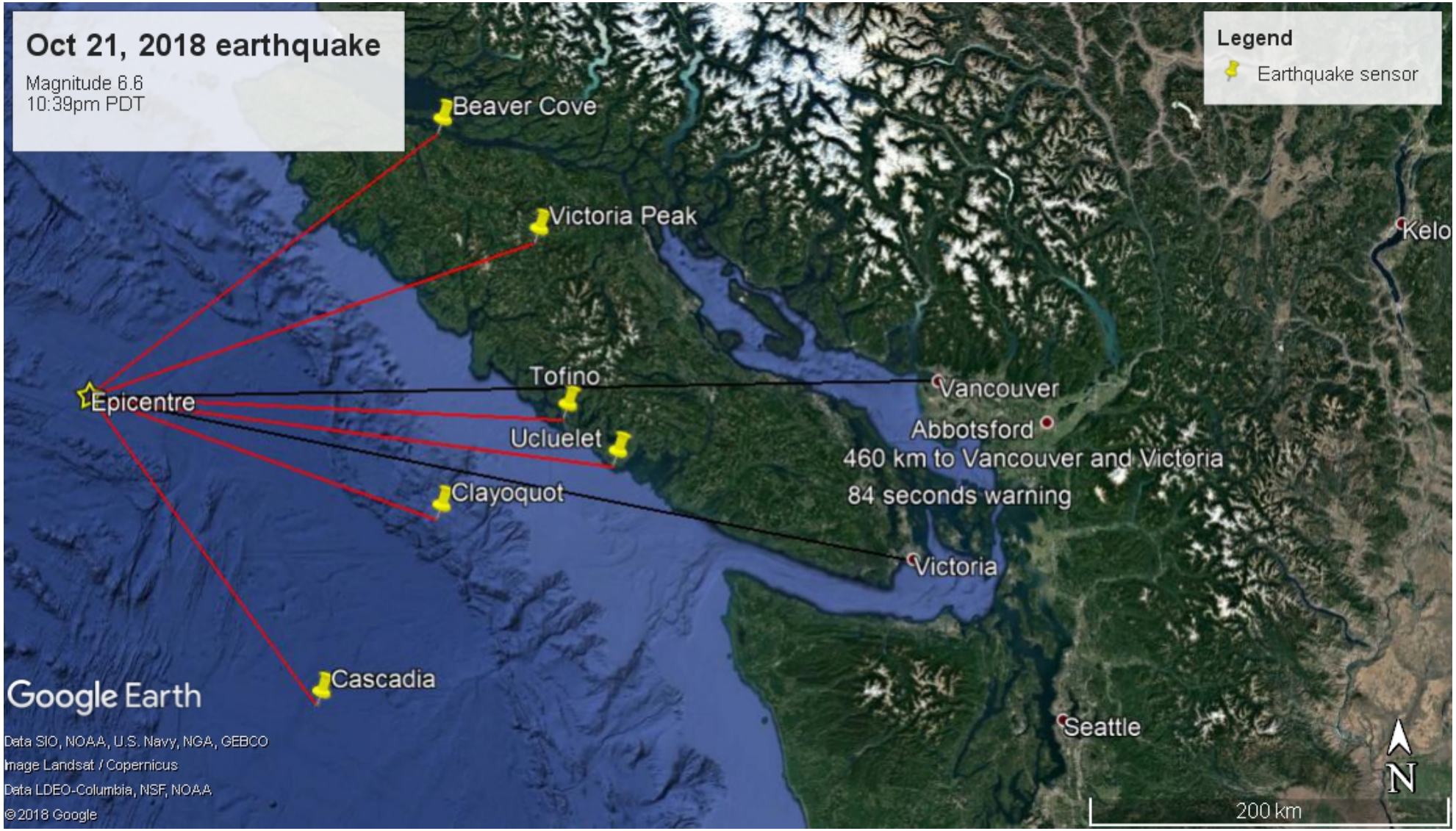
Algorithms:

- Time of arrival
- Shaking intensity


Epicentres of Detected Earthquakes
October 22, 2018 to July 27, 2019
Legend
Actual epicentres
e17
e8
e9
e11
e10
e12
e19
e7
e2
e3
e1
e6
e4
e20
e16
e13
e18
e15
e5
e14
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Data LDEO-Columbia, NSF, NOAA
N
300 km

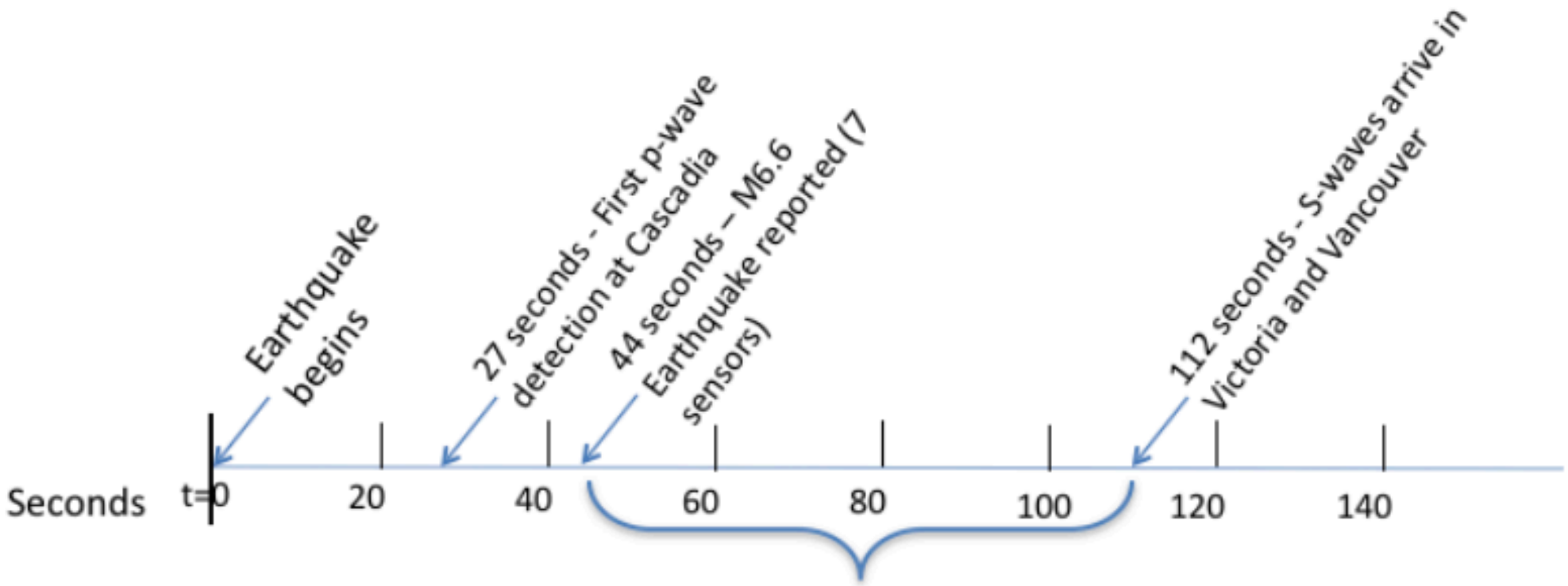
The distribution of errors in epicentre locations from the combined algorithms after the first 4 stations have detected P-wave arrival (scale in meters). The dark red regions mark errors of >10km. Red triangles mark the location of incorporated seismic stations.



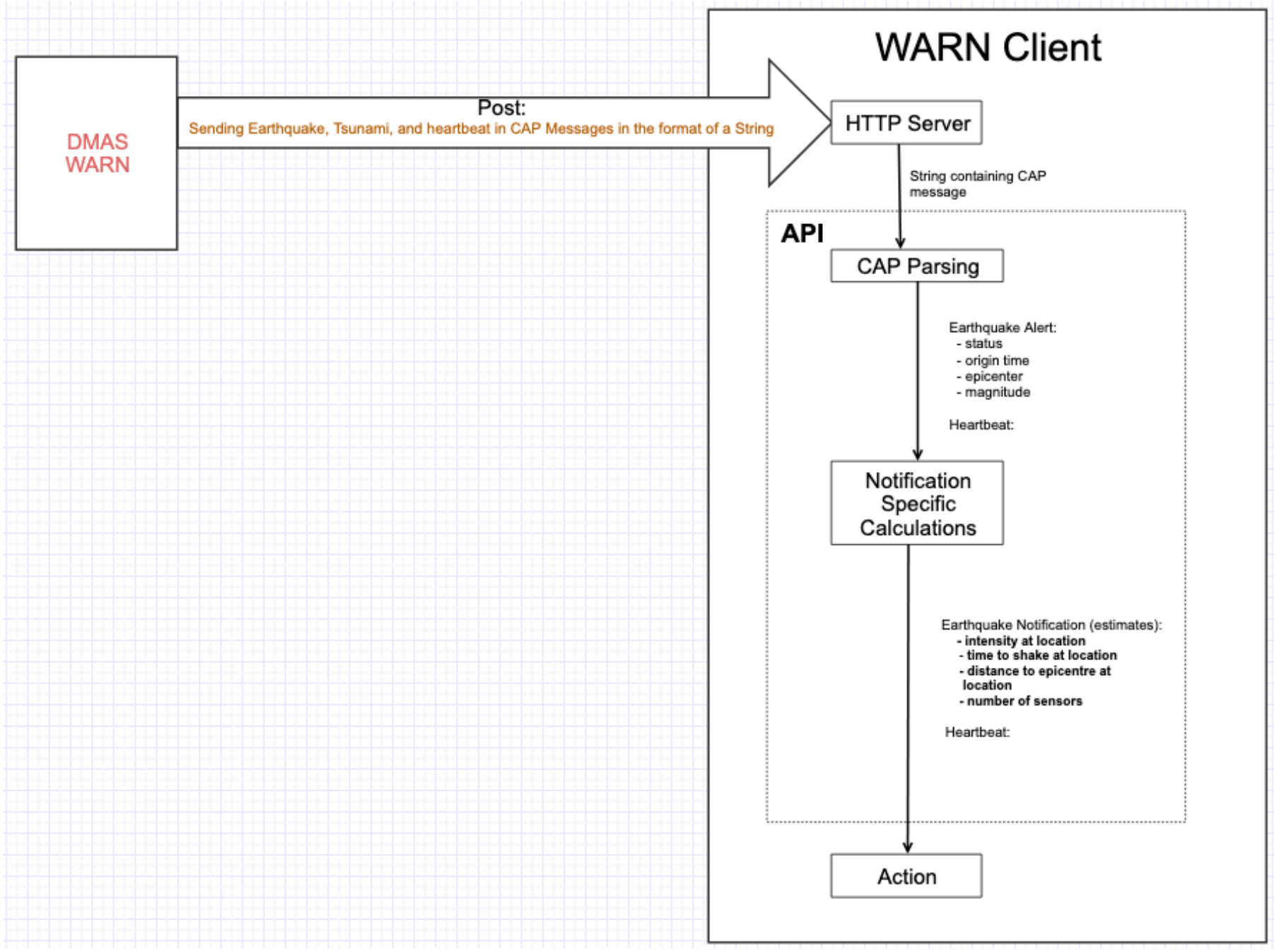

Oct 21, 2018 earthquake
Magnitude 6.6
10:39pm PDT
Legend
Earthquake sensor
Beaver Cove
Victoria Peak
Kelo
Tofino
Vancouver
Epicentre
Abbotsford
460 km to Vancouver and Victoria
84 seconds warning
Ucluelet
Clayoquot
Victoria
Cascadia
Seattle
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Data LDEO-Columbia, NSF, NOAA
©2018 Google
N
200 km

OCTOBER 21, 2018 M6.6 EVENT

Event timeline



Warning time of **68 seconds** to Victoria and Vancouver (460kms from epicentre)


WARN Client
DMAS
WARN
Post:
Sending Earthquake, Tsunami, and heartbeat in CAP Messages in the format of a String
HTTP Server
String containing CAP message
API
CAP Parsing
Earthquake Alert:
- status
- origin time
- epicenter
- magnitude
Heartbeat:
Notification Specific Calculations
Earthquake Notification (estimates):
- intensity at location
- time to shake at location
- distance to epicentre at location
- number of sensors
Heartbeat:
Action

Home | China | World | Asia & Pacific | Europe | Africa | North America

North America | China-NA | Opinion | Window of China | Latest | Photos | Video

www.news.cn 新华网 NEWS www.xinhuanet.com

NORTH AMERICA Friday, October 26, 2018

Editions

"Great Shakeout" earthquake exercise held in Vancouver, Canada

Source: Xinhua | 2018-10-19 11:08:05 | Editor: ZD

Xinhuanet App

People take cover under the table during the "Great Shakeout" earthquake exercise in Vancouver, Canada, on Oct. 18, 2018. About 910,000 people participated in the annual "Great Shakeout" earthquake exercise in British Columbia of Canada. A simulated exercise conducted by Canada Line - Vancouver's driverless, computer-controlled train system, to practice how the transit operators and residents react after the earthquake early warning system issue alert. (Xinhua/Liang Sen)

Education

- EEW 101
- Exercise scenarios

Training

- Response Protocols
- ShakeOut Drill

Outreach

- ~48M impressions

Thank you!

Questions?

Teron Moore, MA DEM, PMP
Public Safety Program Manager
250.721.8610
tmoore@uvic.ca

SAGE ON EARTH CONSULTING

Using Earthquake Risk Modeling Results in Municipal Seismic Risk Mitigation Policy

UBCM Convention 2019

September 24, 2019

Sahar Safaie, Principal Consultant at Sage On Earth Consulting

Project Team: City of Vancouver, Natural Resources Canada, Sage On Earth Consulting, UBC, Compass Resource Management
Funded through: NRCan DRR Pathways Project

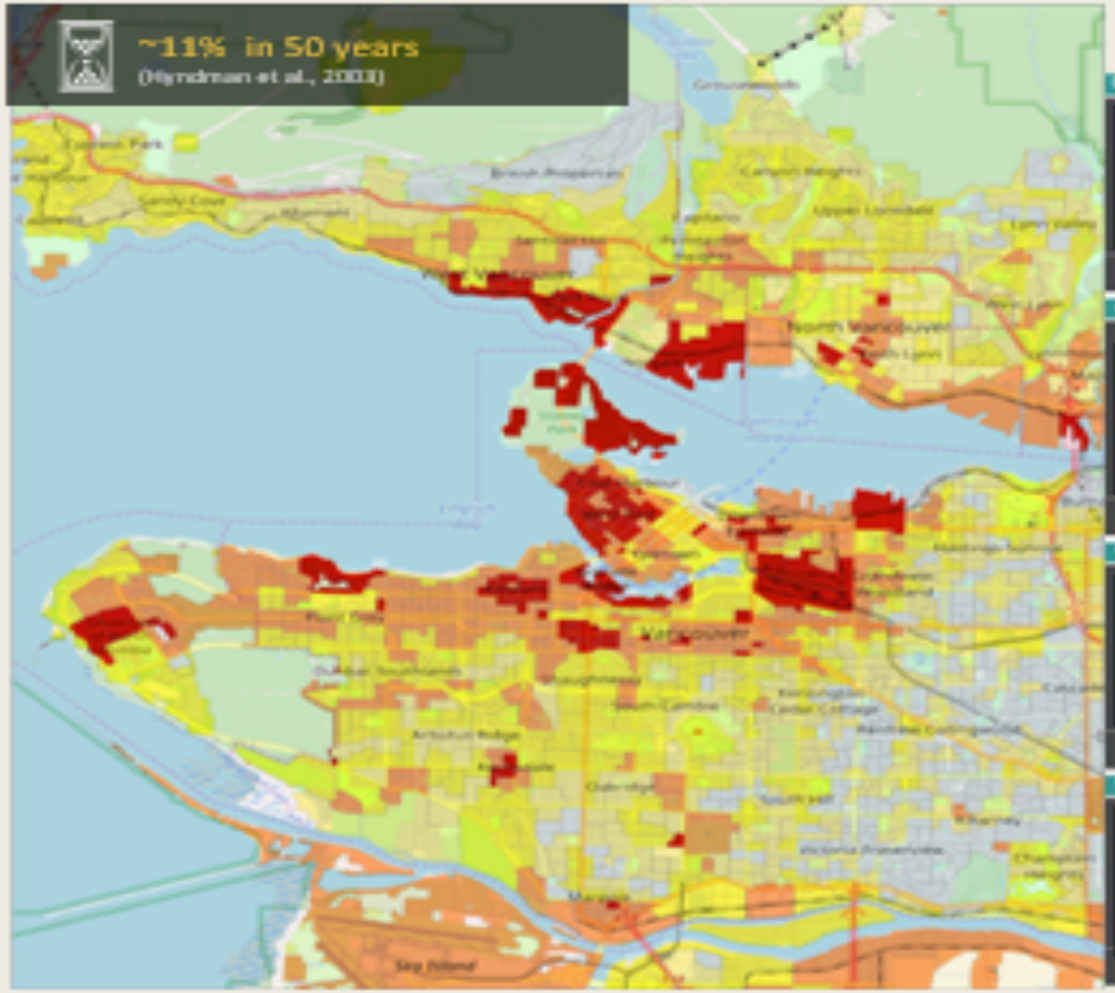
The Context and Background


Risk and Resilience Information
Structured Decision Making
A Set of Policy Options
Objectives
Set of Options
Evaluation Criteria
Decision Making

Earthquake Planning Scenarios
Georgia Strait (M7.3) Fault Rupture

	PGA	MMI
	2.8%	IV
	6.2%	V
	12.0%	VI
	22.0%	VII
	40.0%	VIII

Scenario Risk
- Low
- Moderate
- Considerable
- High
- Extreme



CITY OF VANCOUVER

Natural Resources Canada / Ressources naturelles Canada
Canada

Earthquake Planning Scenarios

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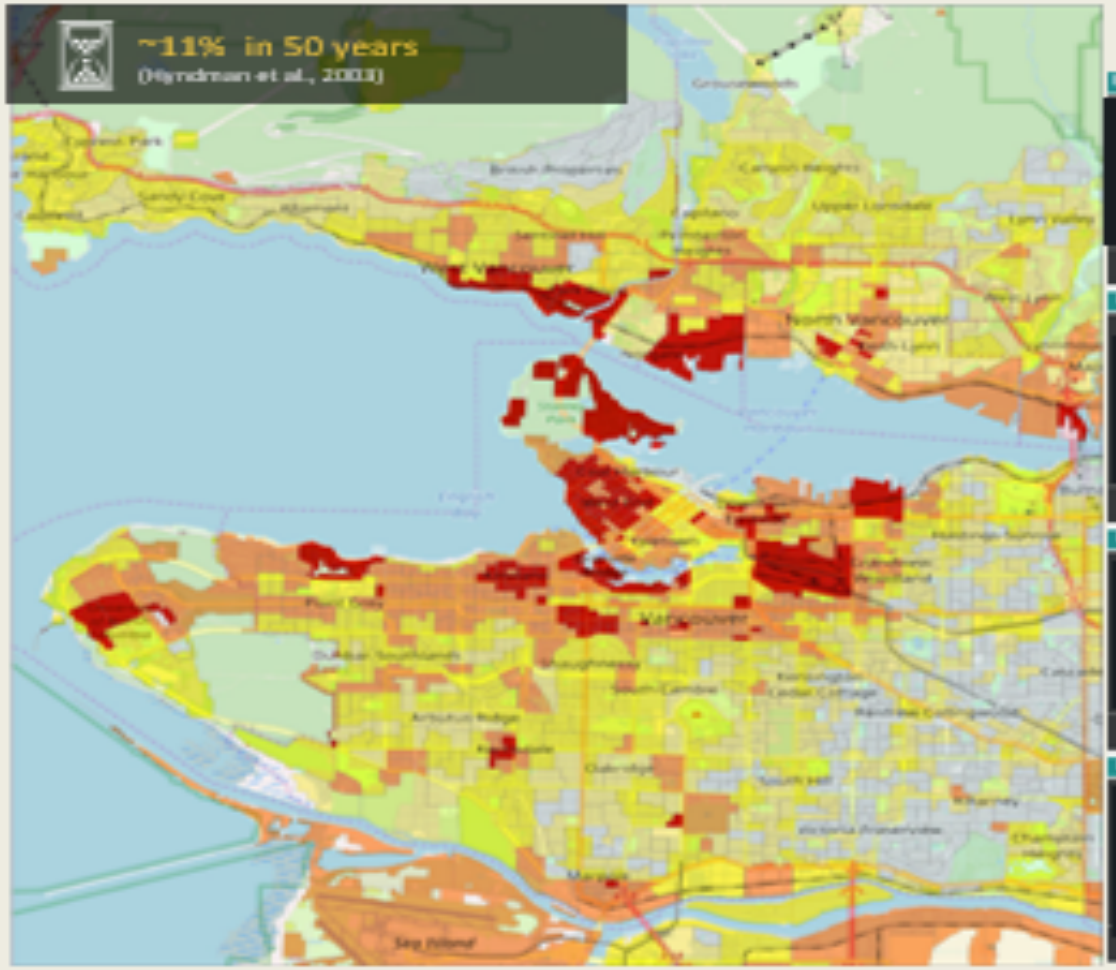
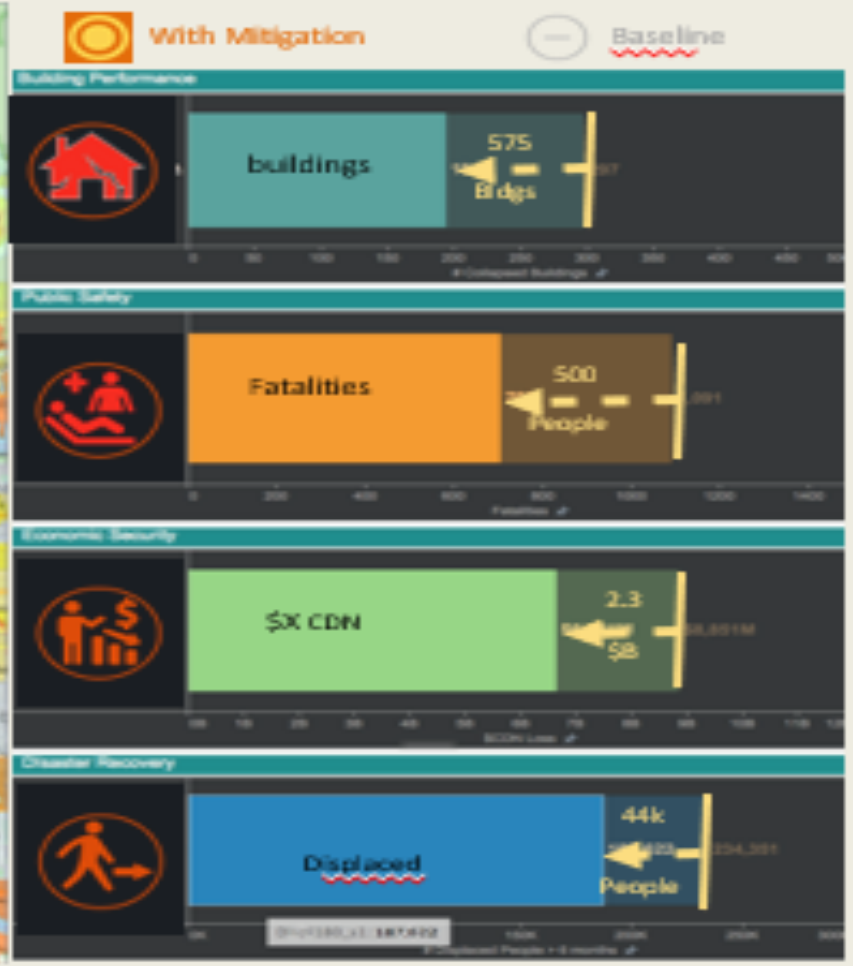




CITY OF VANCOUVER

Natural Resources Canada / Ressources naturelles Canada

Canada

Social Vulnerability Theme Maps for City of Vancouver

Residents with Lower Financial Response Capacity

Contributing indicators:

- Low-income adults
- High shelter costs
- Government transfer recipients
- Unemployed workers
- Tenants in subsidized housing
- Work from home

Residents with Lower Financial Response Capacity

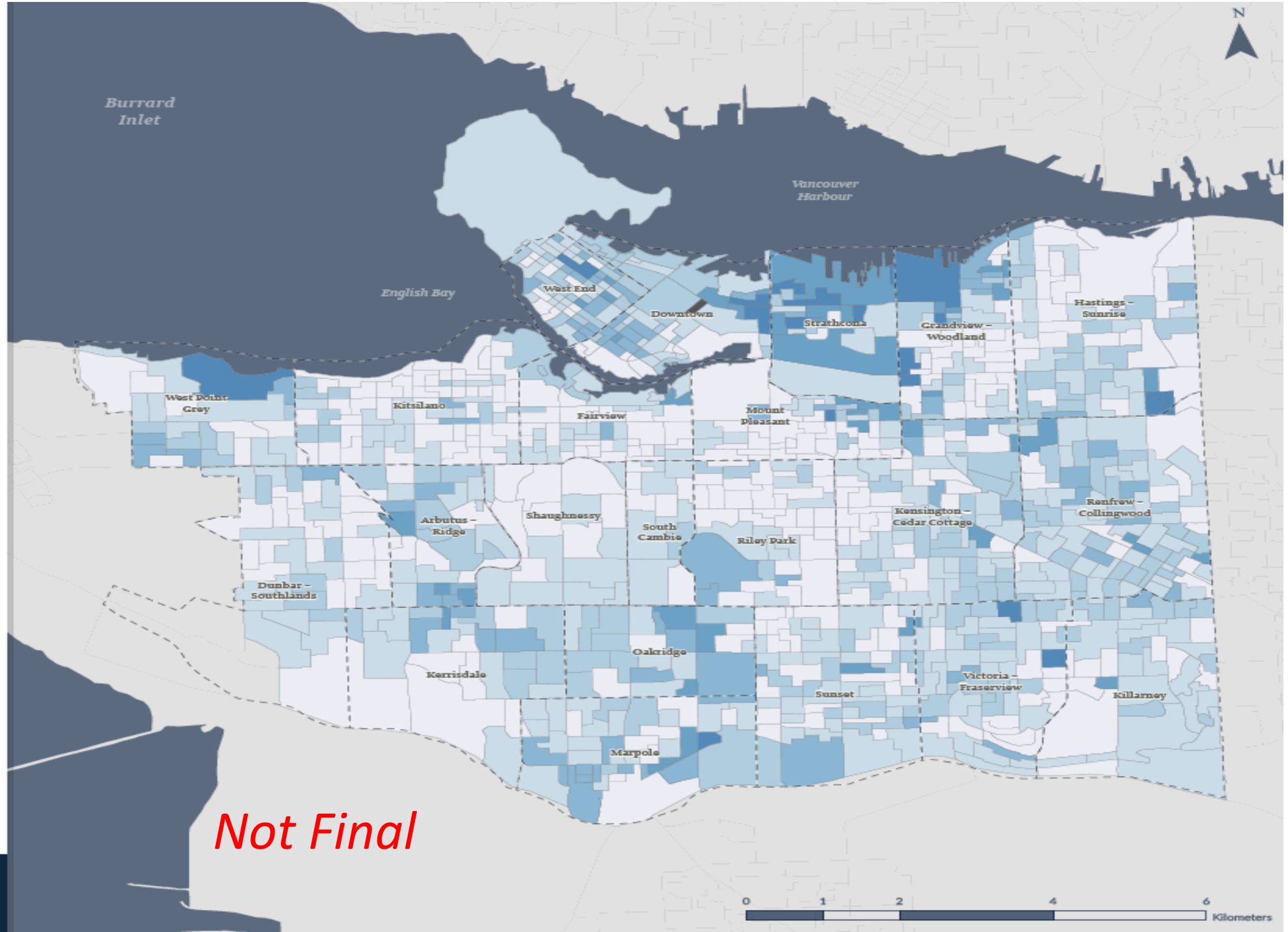
Number of indicators above threhold

- 0 indicators (329)
- 1 indicator (326)
- 2 indicators (190)
- 3 indicators (83)
- 4 indicators (43)
- 5 indicators (21)
- 6 indicators (0)
- No data (1)
- Community Boundaries
- Neighbouring Municipalities

Source Data: Statistics Canada, 2016 census.

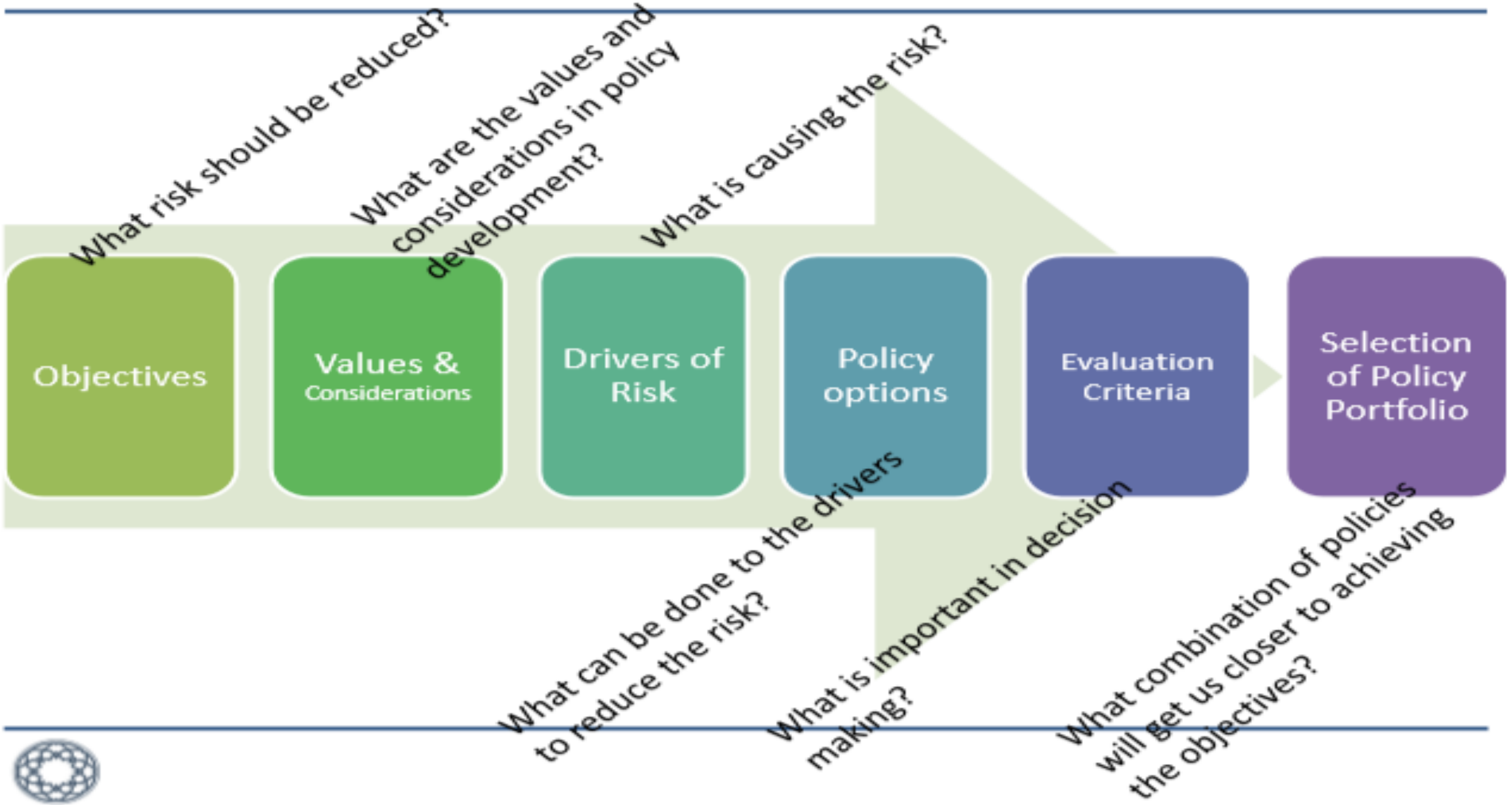
Map by: Ryan P. Reynolds (ryan.reynolds@ubc.ca)

Map created: September 4, 2019



THE UNIVERSITY OF BRITISH COLUMBIA

Policy Development and Decision Making Framework



Cov Seismic Mitigation Policy: Context and Values

Values informing the objectives and judgements made throughout the process:

- Loss of life is not acceptable
- No building will collapse catastrophically
- Timely recovery is essential for maintaining socio-economic prosperity and preserving the City's sense of place
- Considering efficiencies of multi-hazard approach, co-benefiting and leveraging other policies and programs
- Social equity and affordability principles are applied in policy design and implementation plan

Seismic Mitigation Policy Objectives

Increasing Buildings Resilience

- Decrease # of buildings that are damaged beyond repair
- Reducing # of people with damaged and destroyed dwelling

Increasing Life Safety

- Reduce Fatalities
- Reduce Critical Injuries
- Increase connectivity of disaster response routes

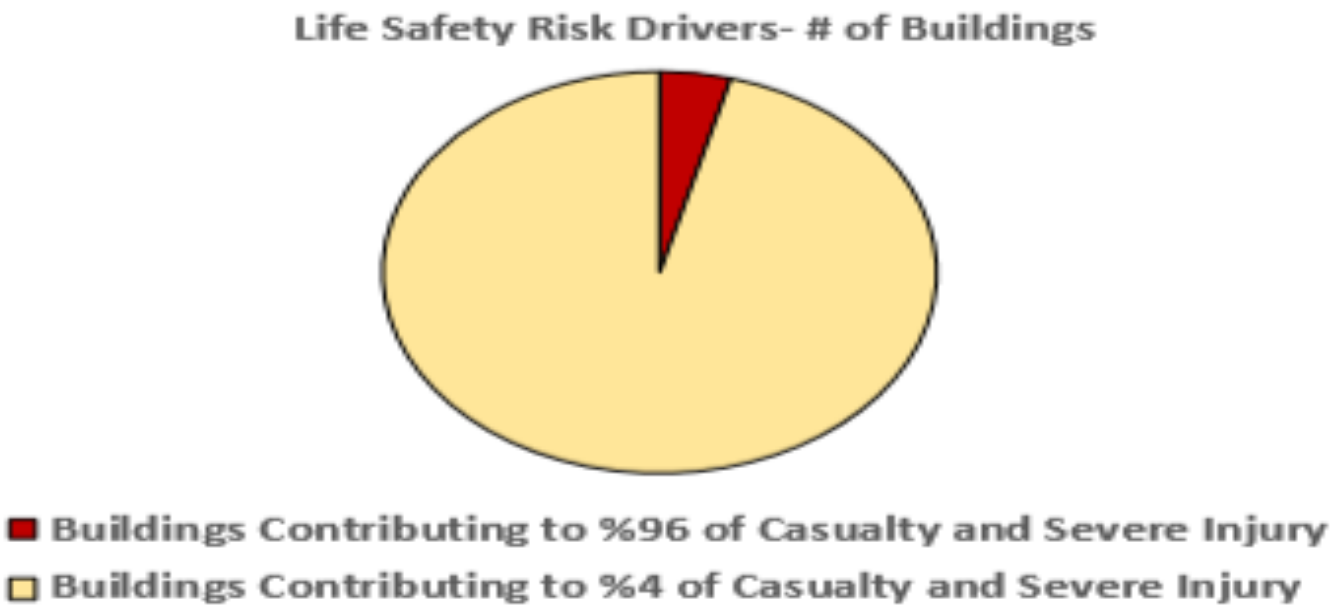
Reducing Direct Economic Loss

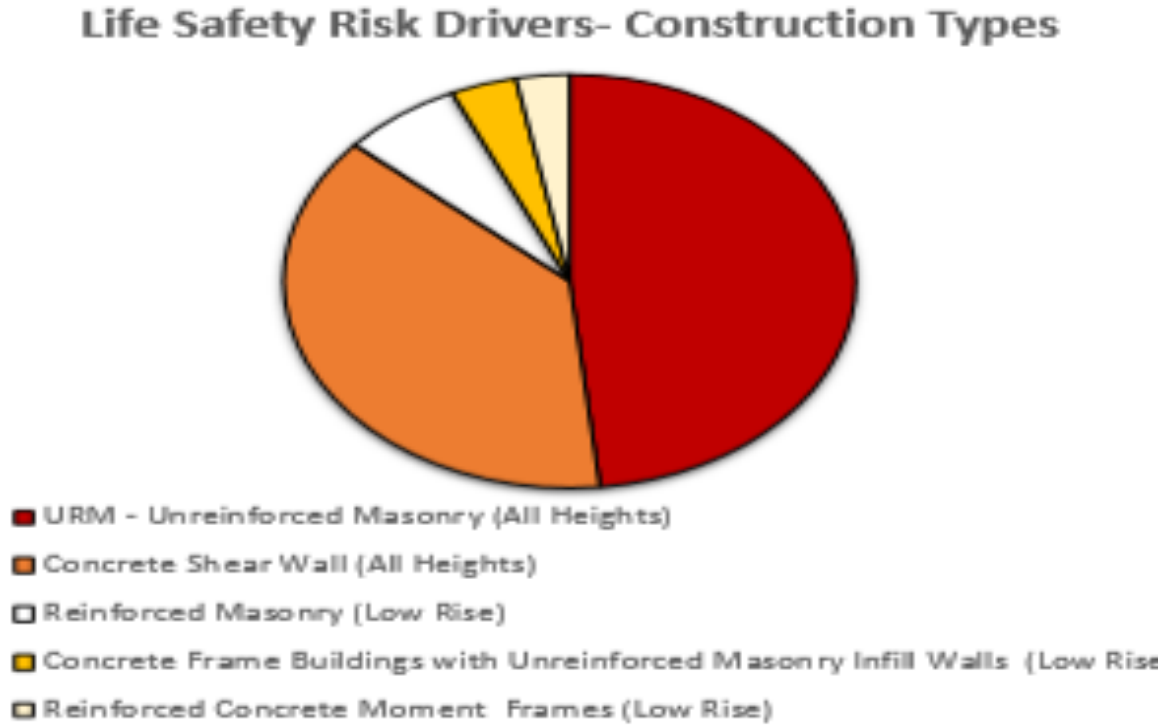
- Reduce capital asset loss to private home owners
- Reduce capital asset loss to businesses
- Increase capacity of home owners to manage residual risk
- Increase capacity of businesses to manage residual risk, specially small and medium enterprises (SME)

Reducing Recovery Time Post Disaster

- Reducing # of People Displaced
- Reducing cordoning and high concentration of damage to a neighborhood
- Reducing the debris generation in commercial cores/centres, transit routes, arterials, disaster response routes

Risk Drivers: Example- Buildings Driving Life Safety Risk





Physical Interventions: Policy Examples

Inventory Only	• Seattle, Washington, USA: URM Inventory conducted by City in 2014 and validated in 2016
Notification Only	• California, USA: 2004 law requiring unmitigated URM to post placards with EQ warning; After 1989 inventory law
Voluntary Retrofit	• Berkeley, CA USA: Berkeley Single-Family and Duplex Program for wood-frame, 2+ unit residential in 1991
Disclosure Measures	• Wellington, NZ: Public Disclosure of earthquake-prone buildings (EPB) on public registrar since 2006
Mandatory Evaluation	• Palo Alto, CA, USA: 1986 program for mandatory evaluation; voluntary upgrade of structurally deficient buildings
Mandatory Retrofit	• New Zealand: 2016 Mandatory Retrofit Policy of Earthquake Prone Buildings
Demolish (& Reconstruct)	• Los Angeles, CA, USA: 2015 mandatory program of non-ductile concrete buildings offers owners the option to demolish

Evaluation Criteria

A	Risk Reduction	Reducing casualty and injuries in a major earthquake
		Reducing displacement
		Reducing EQ disaster economic impact
		Reducing recovery time post disaster
B	Cost	Cost to homeowners
		Cost to Gov (whatever the source maybe)
C	Socio-economic equity	implementation of the mitigation policy considers their financial capacity without discriminating the low income and poor
		implementation of the mitigation policy would consider the special needs of new immigrants, indigenous, and vulnerable groups
D	Housing affordability	A range of affordable housing choices is available for affected people during seismic mitigation policy implementation
		Implementation of the seismic mitigation policy is aligned with the City of vancouver affordability strategy (the retrofit policy will not have negative impact on the housing affordability)
E	Implementation Intensity/Impact to City	Tied to resources, capacities and timeline of intervention.

Requirement for an Implementable Policy

LEGISLATION

FINANCING

CAPACITY

Grants	Grants for full or partial costs of retrofitting
Financing	Loans with attractive interest rates
	Property Assessed Financing Loan
	Improved Mortgage Terms
Tax Benefits	TaxCredits/Breaks
	Real State Transfer Tax Rebate
	Special District or Historic Designation Tax Reductions
Rebates and Fee Wavers	Rebates for full or partial cost of assessment and various aspects of retrofitting
	Waivers or Reductions of Building Permit Fees
Insurance	Insurance Benefit
Pass through to Renters	Pass Through of Retrofit Costs to Tenants

A Best Practice Guide for Local Governments

As part of Disaster Risk Reduction Pathways project, NRCan and key provincial partners will lead the process for developing a Best Practice Guideline for use by Municipalities for developing Earthquake Risk Mitigation Policy.

understanding risk → *disaster resilience*

Thanks!

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