BC Smart Infrastructure Monitoring System

(BCSIMS)

2013 UBC-Tongji-CSRN Symposium

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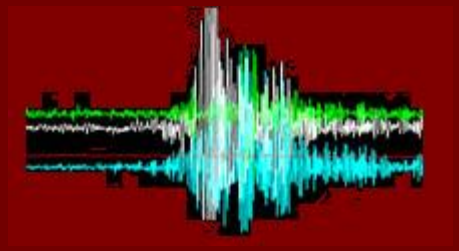
Sr. Seismic & Structural Health Engineer



Bridge Engineering

British Columbia

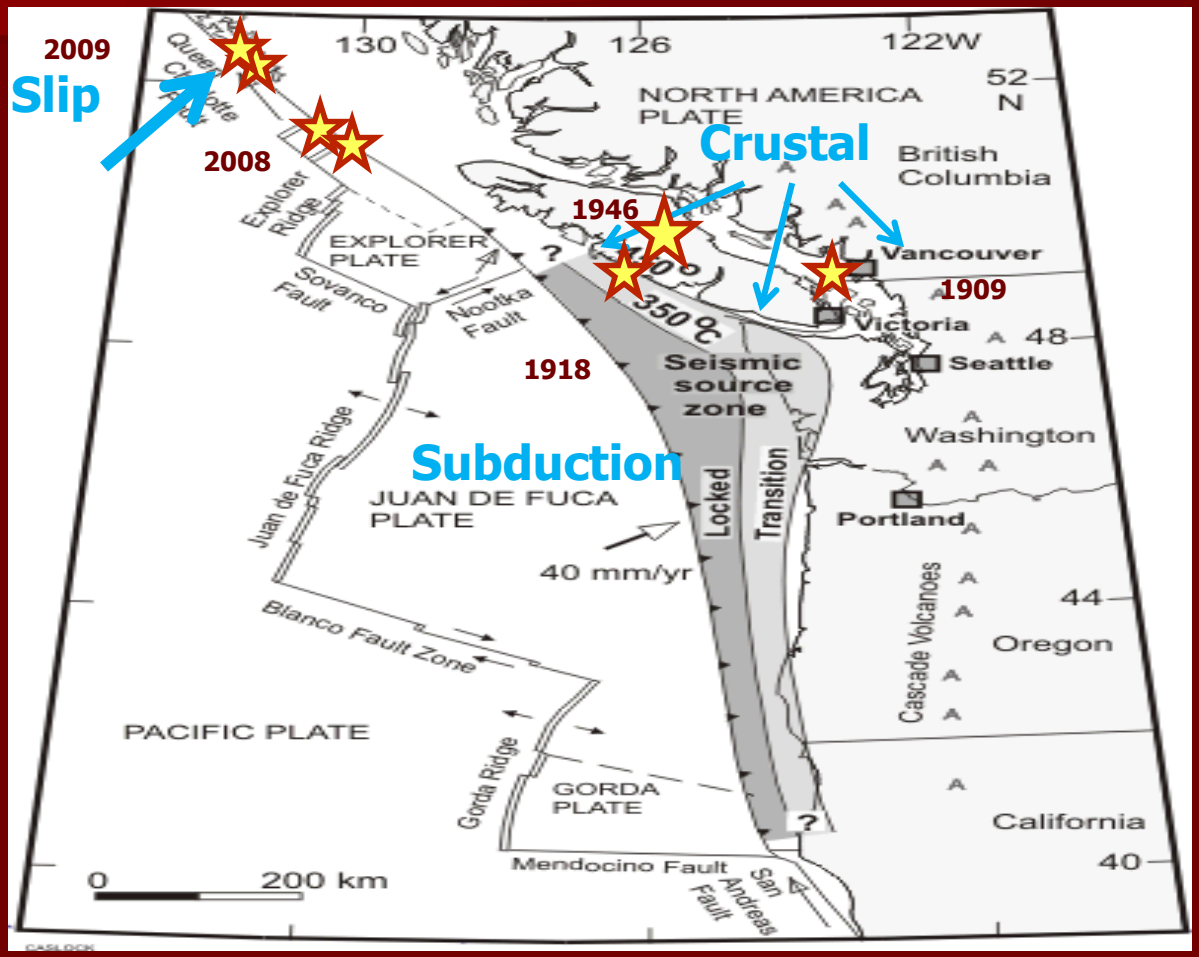
Ministry of Transportation

BCSIMS

- BC Seismicity
- Monitoring networks
- BCSIMS
- Early Warning System

BC Seismicity

Two of the three largest tectonic plates colliding on our doorstep

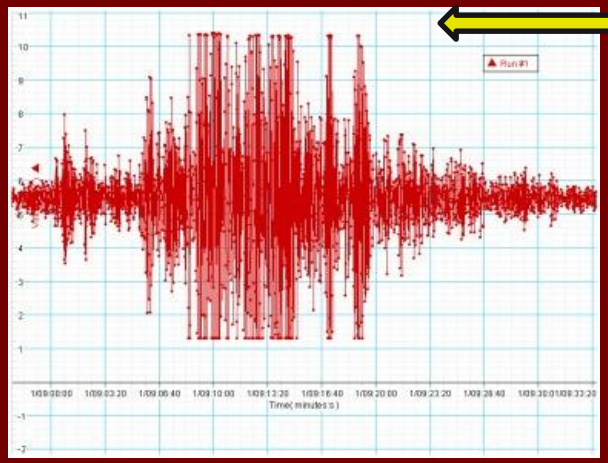


Monitoring Networks

- “Weak” Motion Network
- Strong Motion Network
- Structural Monitoring
- Early Warning Systems

“Weak” Motion Network

- Sensitive – (high gain) but is overwhelmed by near large events
- Used to locate (in 3D) source of earthquake and determine magnitude
- Provide “firm ground” readings
- Need geotechnical estimate of ground effects to estimate surface values on other soils
- Needs staff to review and interpret data



Strong Motion Network

- Not overwhelmed by strong, local events
- Not able to detect far events - higher internal noise
- Can function without the existence of a seismological data center (*very handy attribute*)
- Internal instrument calculation of Intensity, A, V, D
- Ground motion is *measured* (as opposed to being estimated) in situ. The source, propagation and local site effects are already incorporated, no corrections are required
- Instruments inexpensive enough for dense deployment

Haida Gwaii 2012-10-28

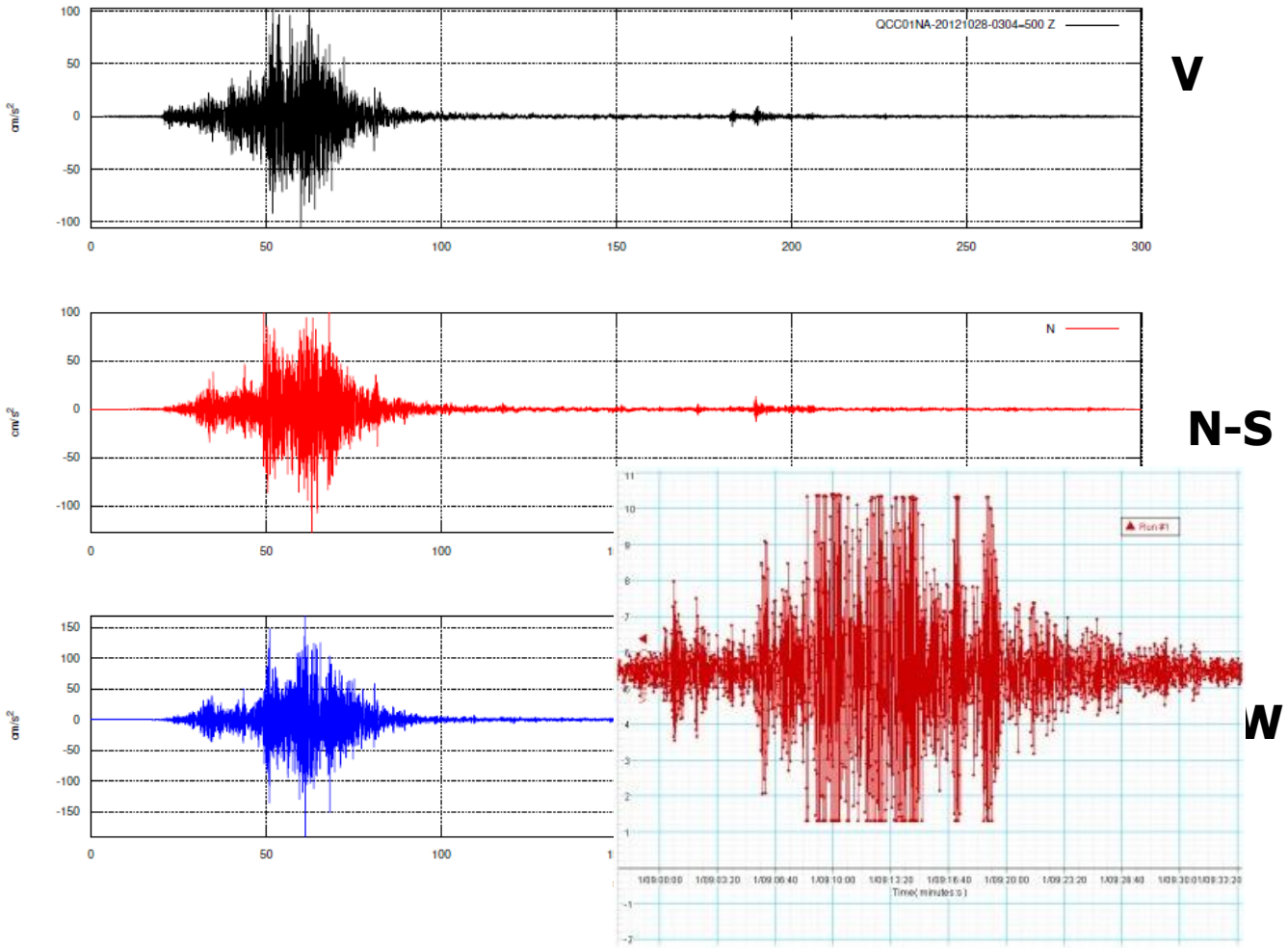
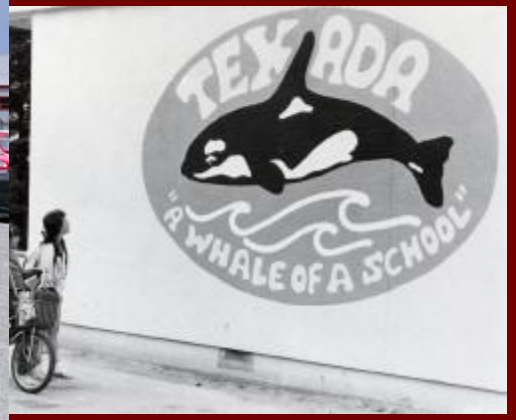


Figure 2: QCC01, main event, acceleration record. Time axis starts at 3:04:30 UTC

Powell River Strong Motion Sites



Structural Monitoring

- Provides response of structure to the ground shaking
- Damage detection
- Damage location – this is complex
- Bonus – ongoing structural health monitoring
  - Response of structure to ambient vibration
  - Confirmation of design hypotheses
  - Rehabilitation planning
  - Detection of impact, dislocation and deterioration

Early Warning Systems

- Japan is the leader in these systems - has an advanced system – worked very well during last earthquake
- Turkey also has a small but excellent system
- Mexico, California have limited systems
- BC has a very limited system – GMT
- The next step for many of us – to expand and improve our systems

- BC EWS – in development

Concept of BCSIMS

- Autonomous and remotely operated
- Parameters relevant to engineers and responders
- Structural sensors respond to EQ, wind, traffic, impacts .....
- Results displayed online at the website **www.bcsims.ca** either through the public or authorized access, and emails reports (alerts) to subscribers
- Shake maps enable emergency managers, responders and inspectors to estimate damage, location and need
- Engineers use shake maps/values to compare with what structures designed for – decide potential for damage
- For instrumented structure, estimate potential damage and location
- Facilitate attention to structural & utility problems to avoid escalation

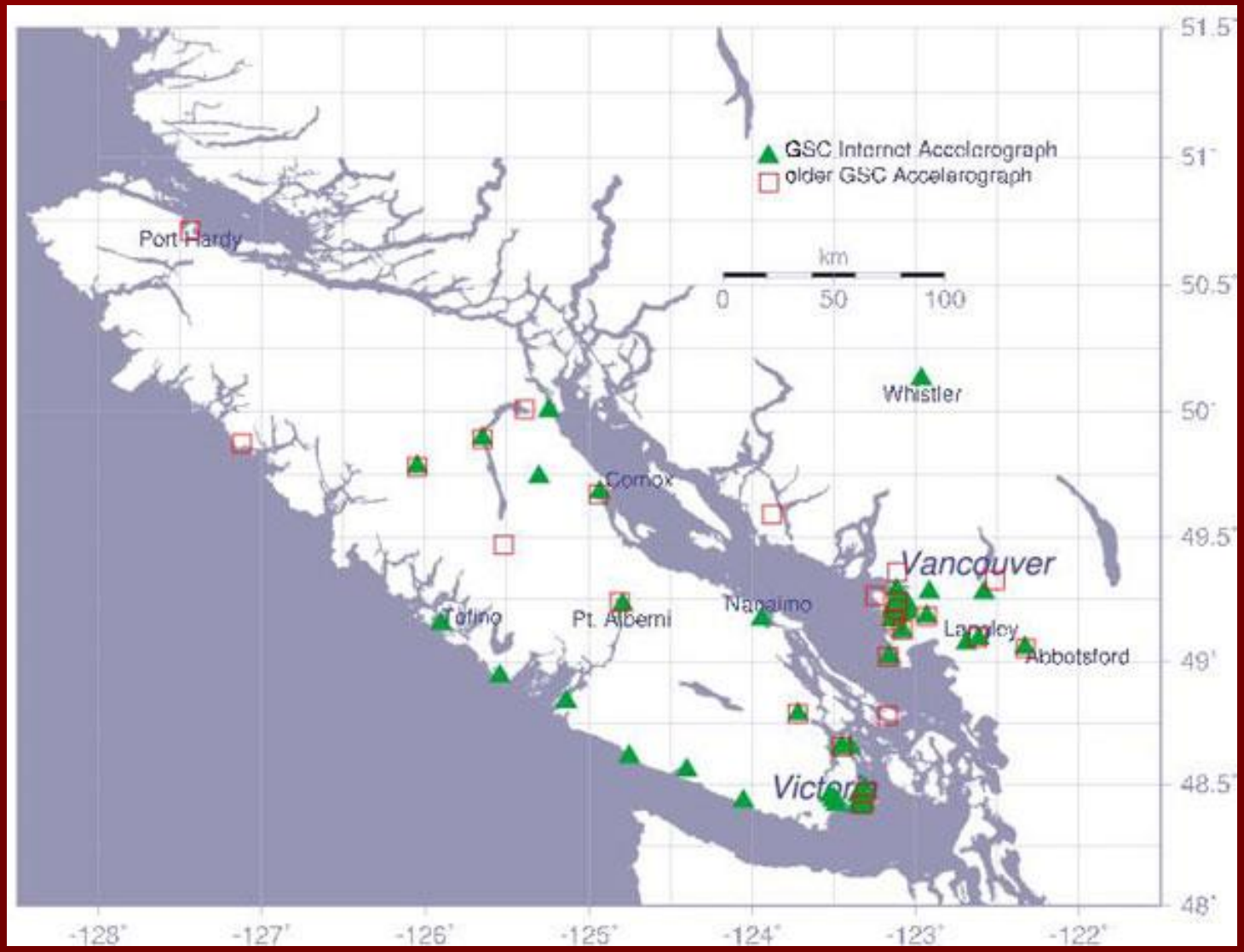
The Team

1. BC Ministry of Transportation and Infrastructure
2. UBC Earthquake Engineering Research Facility (EERF), Department of Civil Engineering
3. Pacific Geoscience Centre of Geological Survey of Canada
4. Institut National de Recherche en Informatique et en Automatique (INRIA) – of France
5. Structural Vibration Solutions A/S (SVS) of Denmark

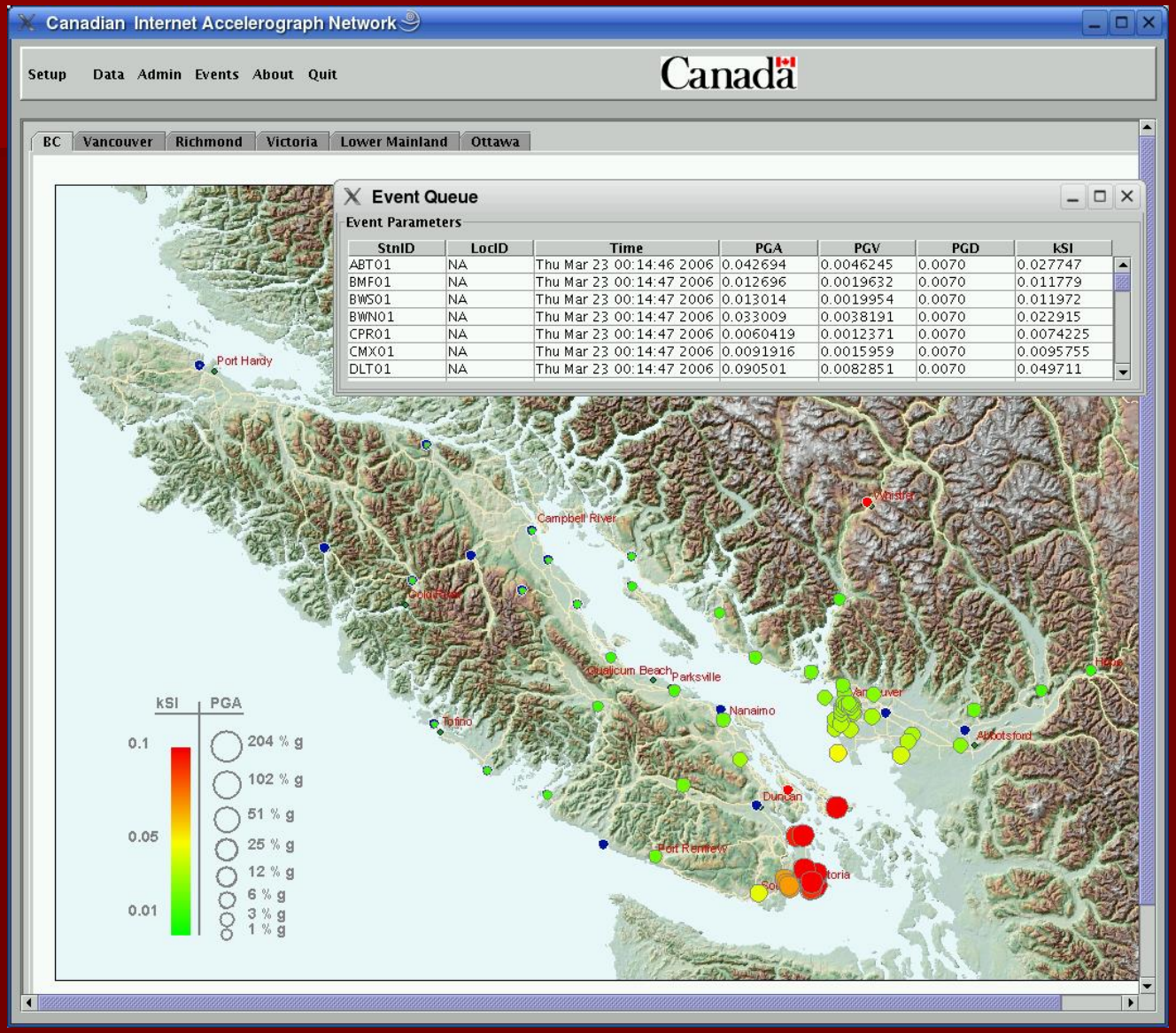
BCSIMS - Why MoTI?

- **MoTI Responsibility**
  - Aged bridges and rehabilitation challenges
  - Post earthquake inspections
  - Keeping the routes open
- **Being prepared (planned retrofits, awareness)**
- **Field intelligence – damage, severity?**
- **Prioritization**
- **Changing plans**
- **Risks/decisions**
- **Post Disaster Response & Recovery**

2005 and Prior – SM notice



2006 - SM notice



StnID	LocID	Time	PGA	PGV	PGD	kSI
ABT01	NA	Thu Mar 23 00:14:46 2006	0.042694	0.0046245	0.0070	0.027747
BMF01	NA	Thu Mar 23 00:14:47 2006	0.012696	0.0019632	0.0070	0.011779
BWS01	NA	Thu Mar 23 00:14:47 2006	0.013014	0.0019954	0.0070	0.011972
BWN01	NA	Thu Mar 23 00:14:47 2006	0.033009	0.0038191	0.0070	0.022915
CPR01	NA	Thu Mar 23 00:14:47 2006	0.0060419	0.0012371	0.0070	0.0074225
CMX01	NA	Thu Mar 23 00:14:47 2006	0.0091916	0.0015959	0.0070	0.0095755
DLT01	NA	Thu Mar 23 00:14:47 2006	0.090501	0.0082851	0.0070	0.049711

BCSIMS Home Page

British Columbia Smart Infrastructure Monitoring System (BCSIMS) - Windows Internet Explorer

http://www.bcsims.ca/

Ministry of Transportation and Infrastructure | UBC Civil Engineering | Natural Resources Canada / Ressources naturelles Canada

Earthquakes Canada | Séismes Canada
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Authorized User...

Activity & Event History

Station Activity

Show last 24 hours

From date: 2013-08-17 To date: 2013-08-18

Show Earthquake Activity List

Earthquake Events

Select Shapemap Data:

Show Earthquake Event List

Options

Hide Legend

Color Map: Default

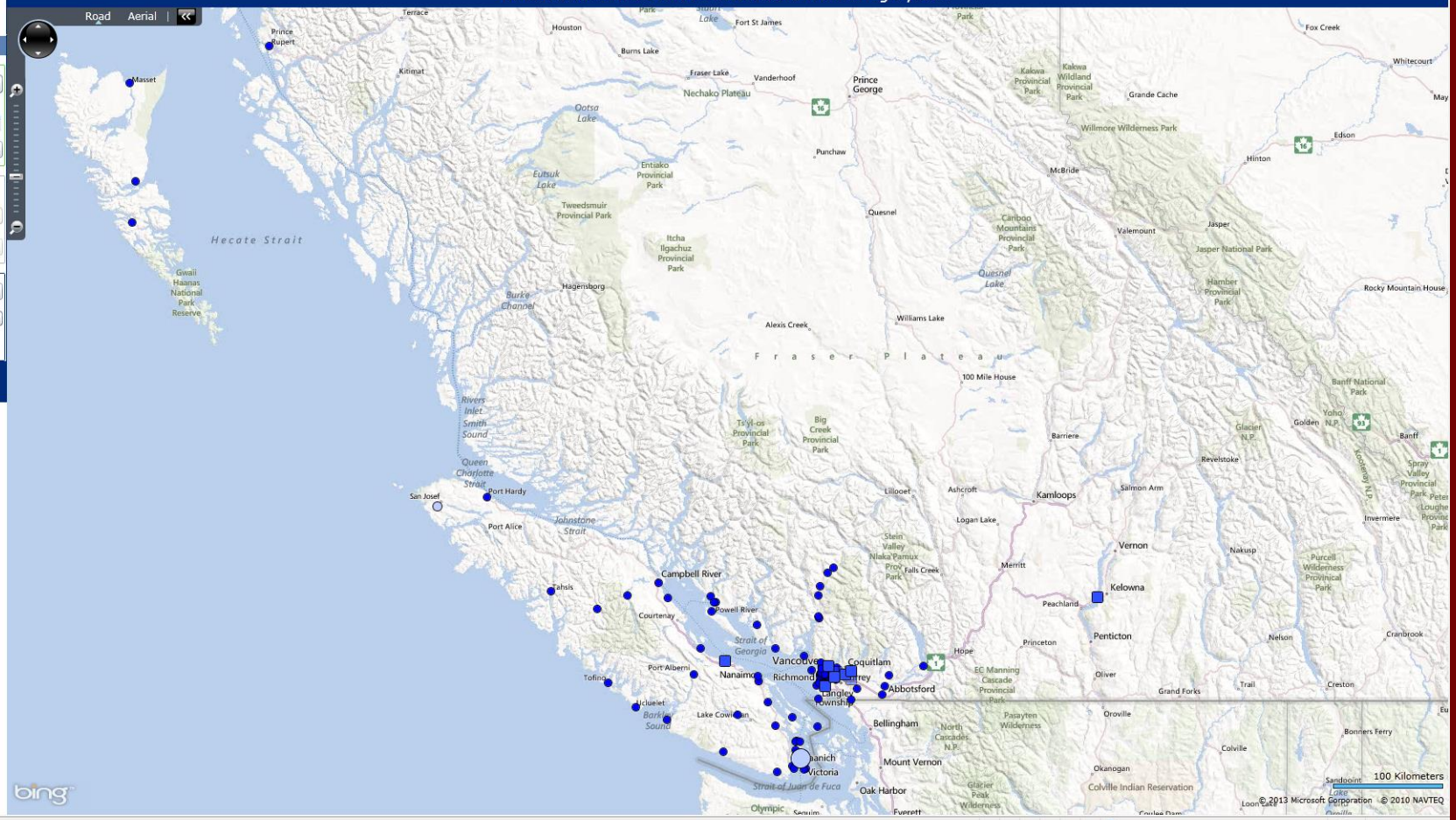
Opacity:

Station Information

Network Layers

British Columbia Smart Infrastructure Monitoring System

Road | Aerial



kSI[cm/s] | PGA[g]

100.0 75.0 50.0 25.0 0.0

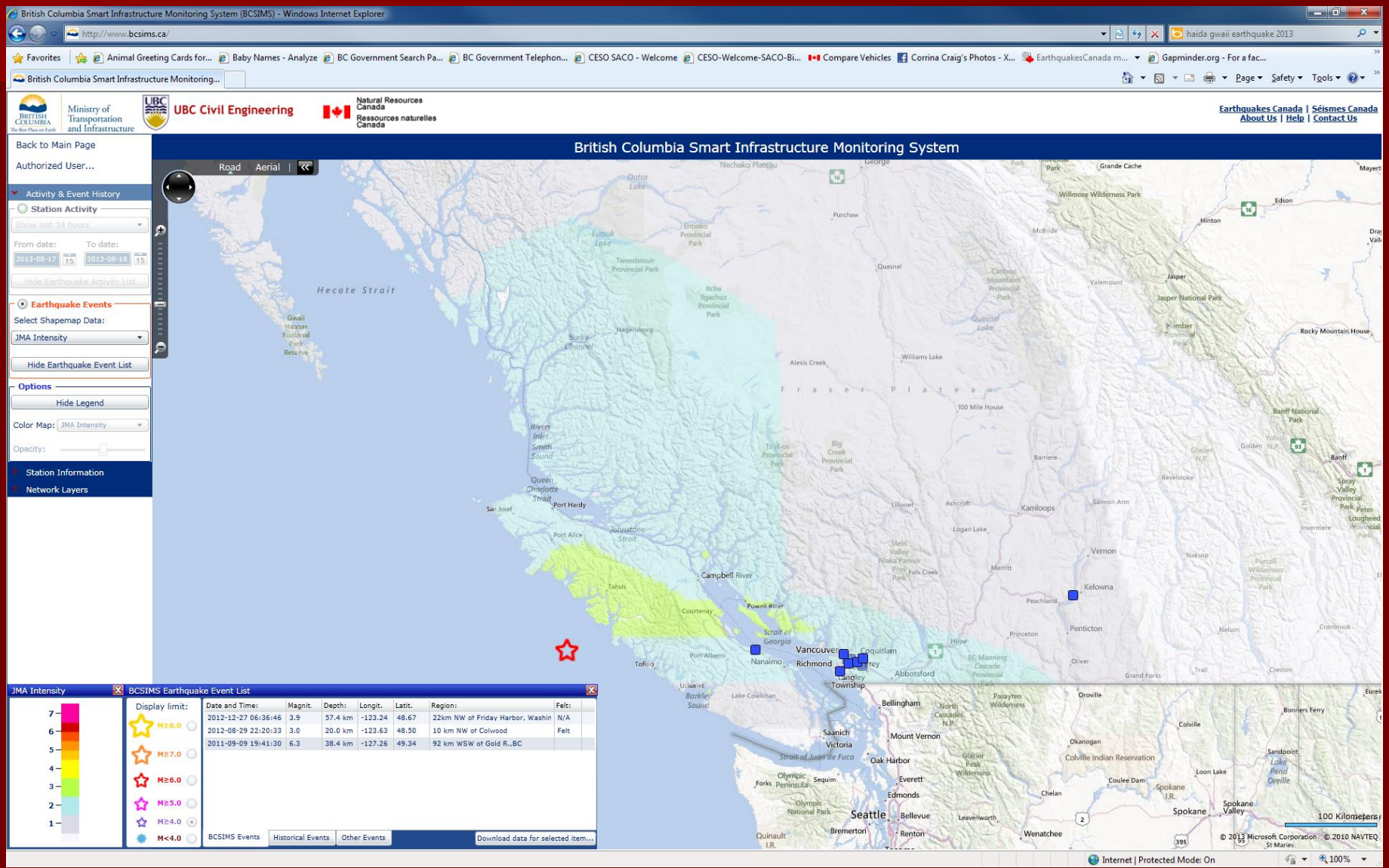
2.00g 1.00g 0.50g 0.25g 0.01g

Internet | Protected Mode: On 100%

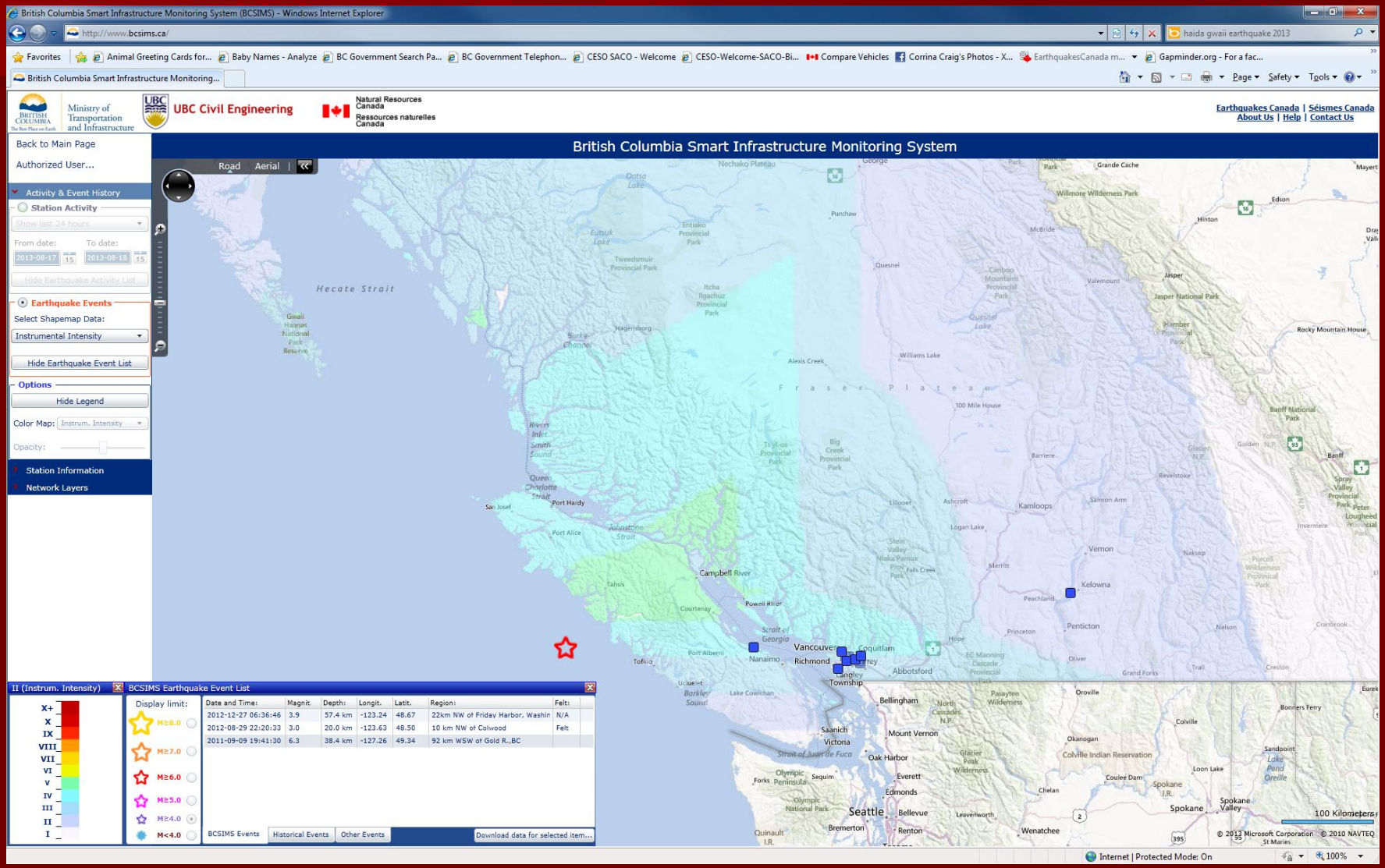
Using BCSIMS - Earthquake Response

- Zoomable Shake Maps with
  - Intensity
  - Acceleration
  - Velocity
  - Displacement
- Structural status
- Historical event data

JMA Intensity map for 6.3 on Nootka Fault



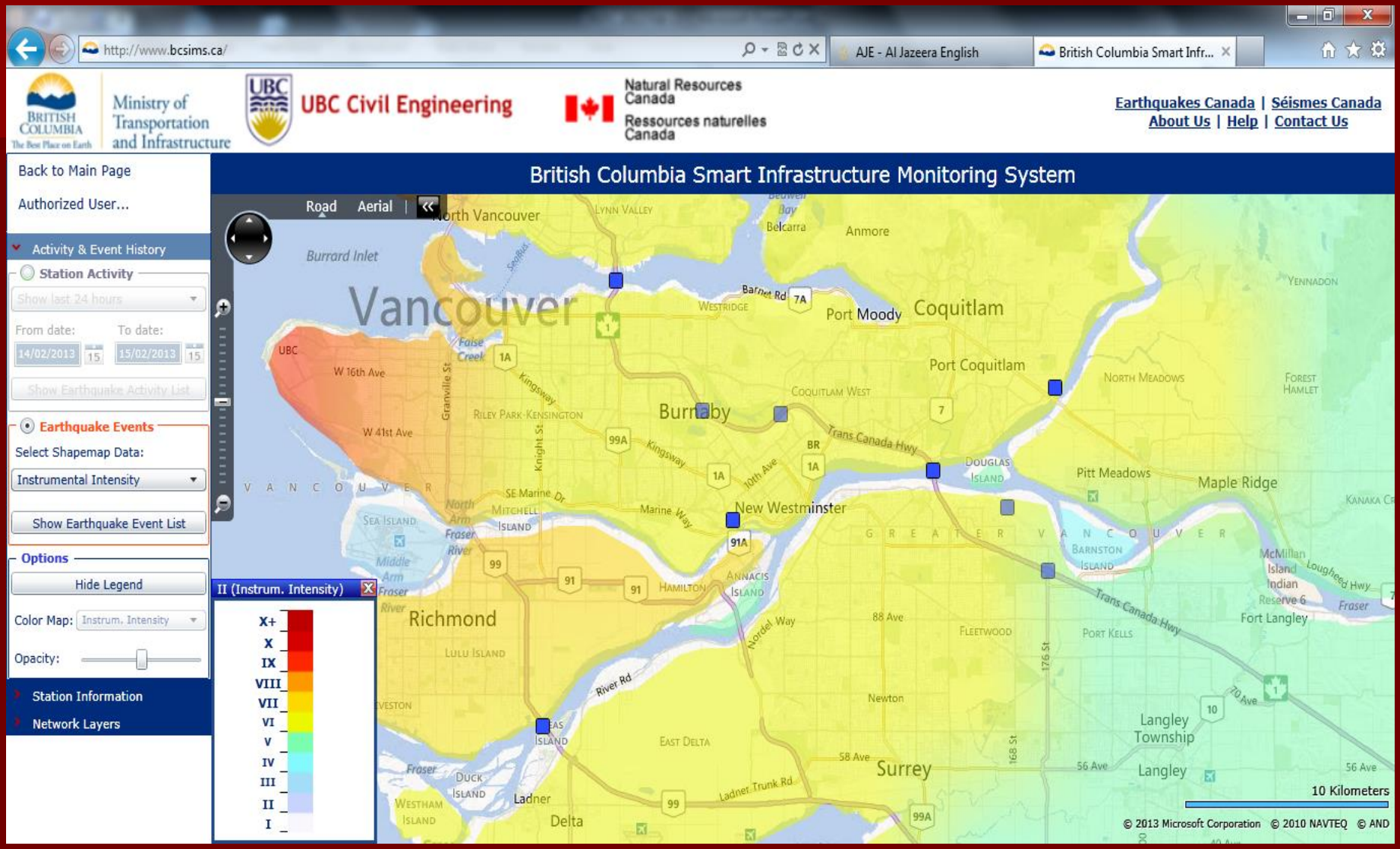
Instrument Intensity map for 6.3 on Nootka Fault



Using BCSIMS - Earthquake Response

- **Real-time field intelligence**
  - **Compare measured seismic Demand with predetermined Capacity**
  - **Rapid plan adjustment**
  - **Effective deployment of response resources**
  - **Damage estimations – global & local**
  - **Earlier start to recovery efforts**
  - **Ongoing monitoring – aftershocks**

Simulation – zoomed shake map

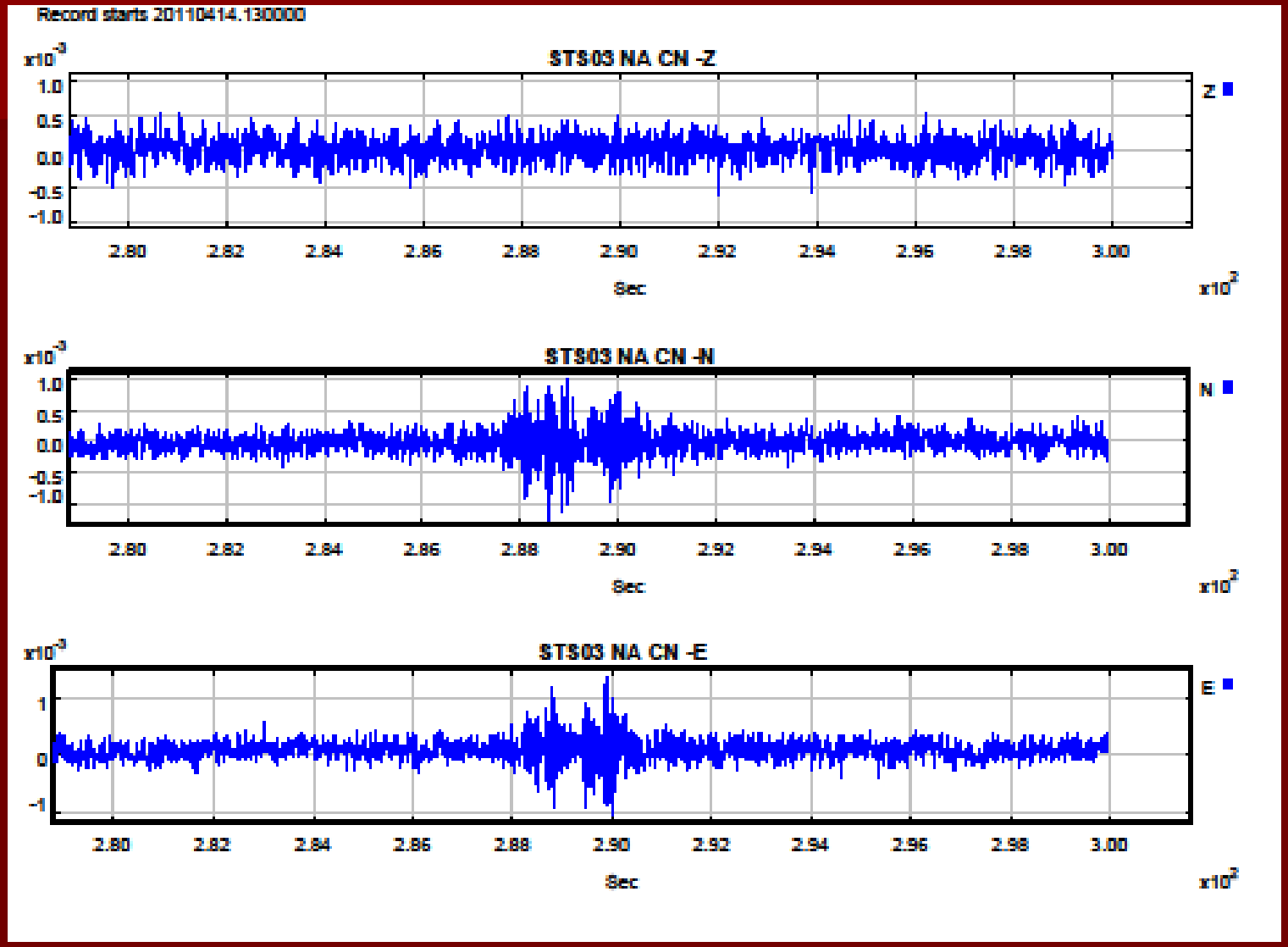


System Alerts

- Notice that the shake maps do not show station dots (just the instrumented bridges)
- We can overlay the shake maps with relevant layers
  - bridge inventory layer – for us
  - Disaster routes, other major routes - for iNet
  - Hospitals, first aid stations - ?
  - Water/sewer lines - ?

Using BCSIMS – To Come – layers

2011 April 14 Rockslide Sea-to-Sky



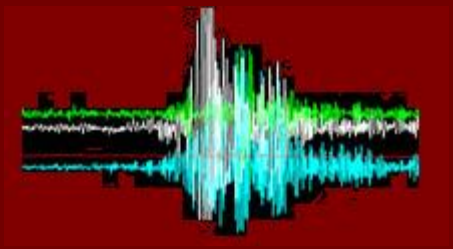
Using BCSIMS: Structure Information

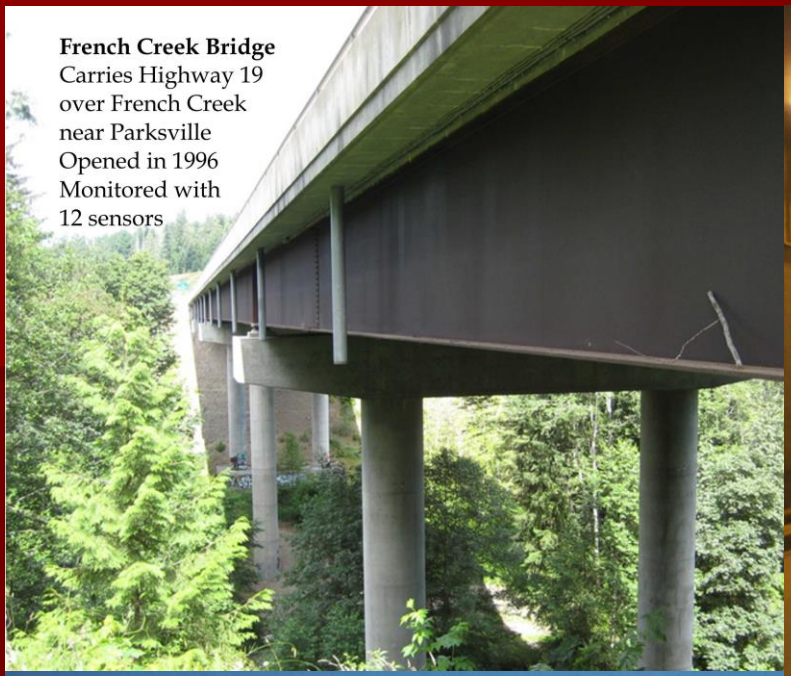
- Reports: Summary and comprehensive set of information in HTML format (can be received by email or accessed through website)
- Information on monitoring system, photos, drawings, bridge information
- Public data and authorized data access
- Results: statistics for each measured channel, drift, modal analysis, damage detection
- 3D model with results

Instrumented Provincial Bridges

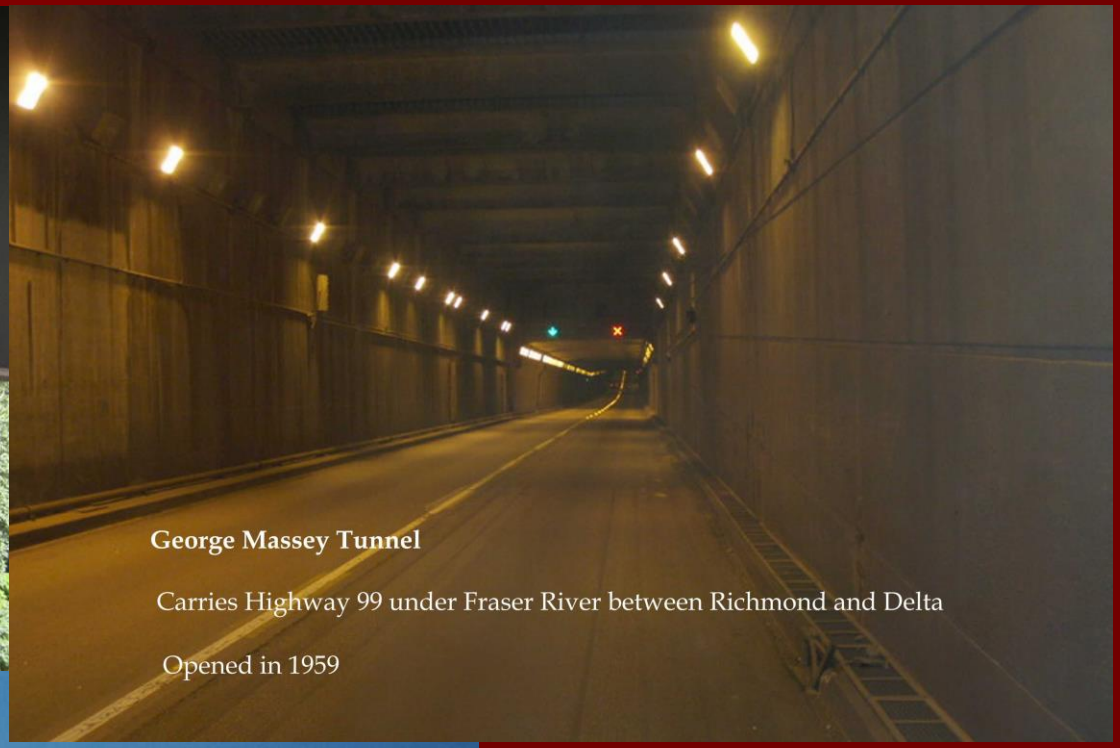
- Currently instrumented
  - Queensborough
  - French Creek
  - Portage Creek
  - George Massey Tunnel
  - William R Bennett Bridge
  - Pitt River Bridge

  - Port Mann
  - Fraser Heights
  - Kensington
  - Gaglardi
  - 176th St
  - Second Narrows





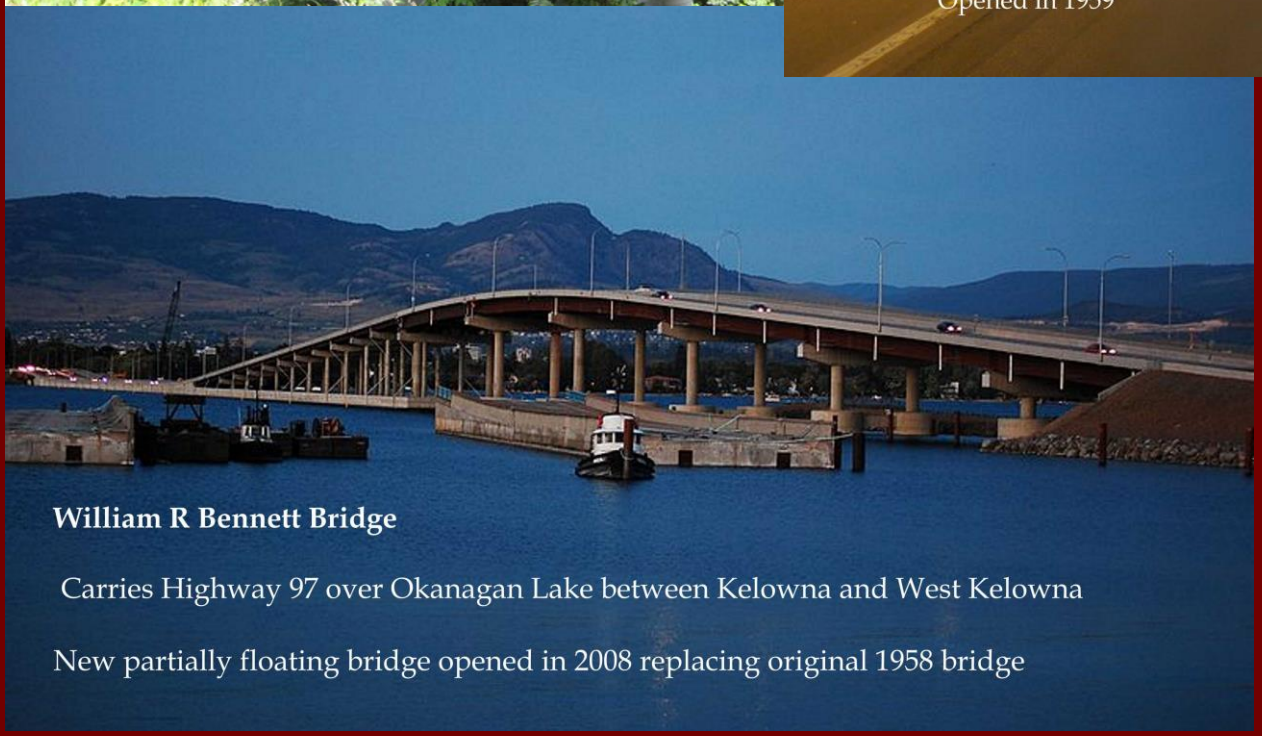
French Creek Bridge
Carries Highway 19
over French Creek
near Parksville
Opened in 1996
Monitored with
12 sensors



George Massey Tunnel

Carries Highway 99 under Fraser River between Richmond and Delta

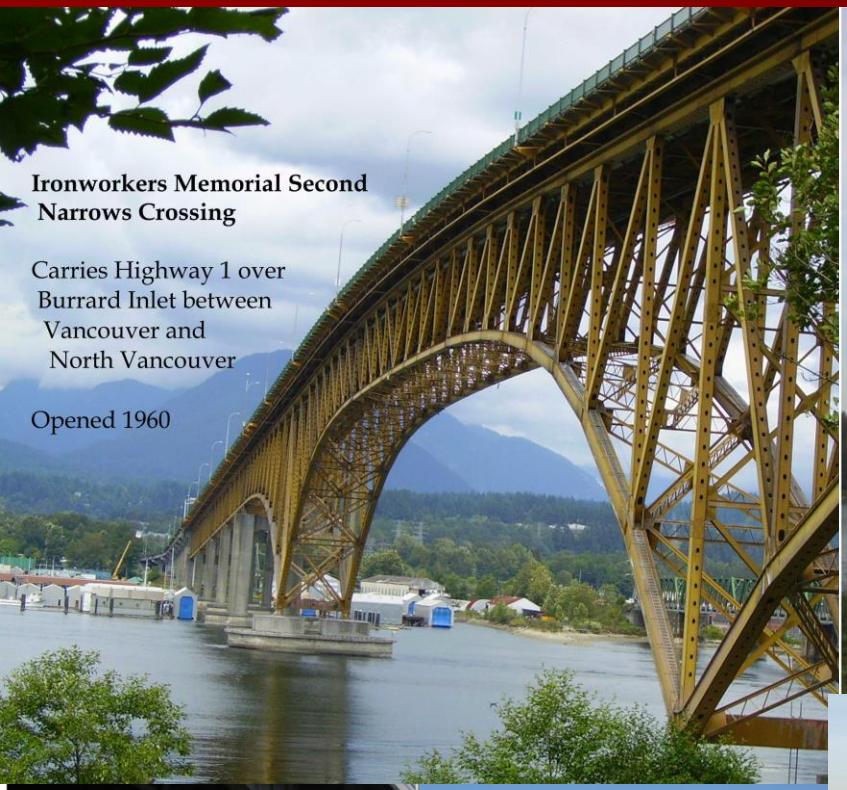
Opened in 1959

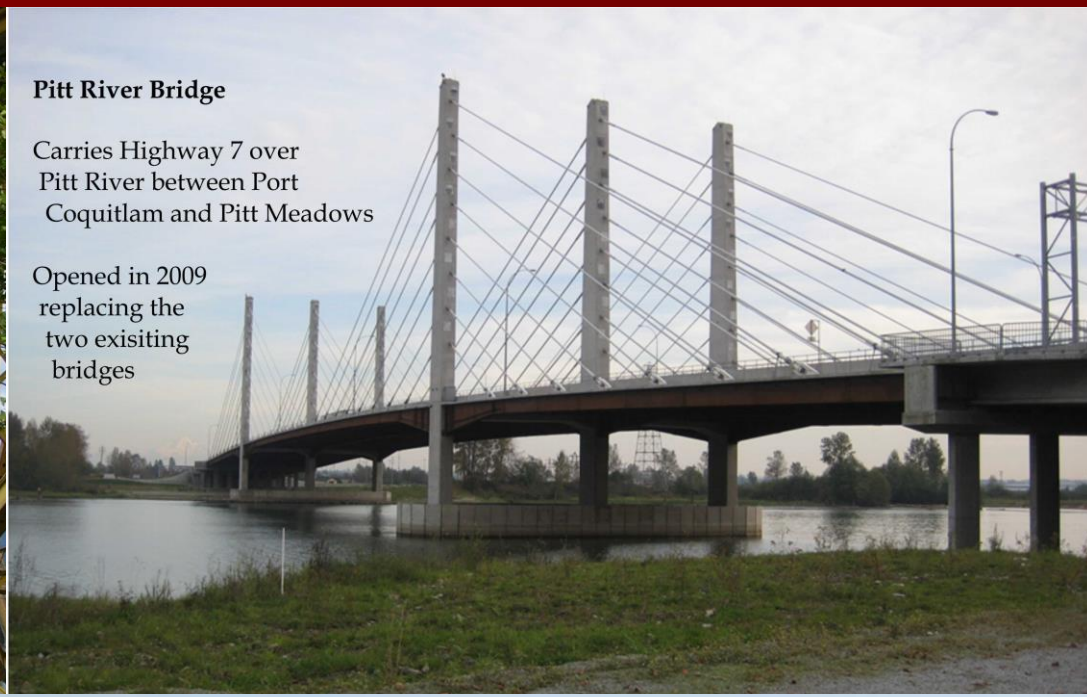


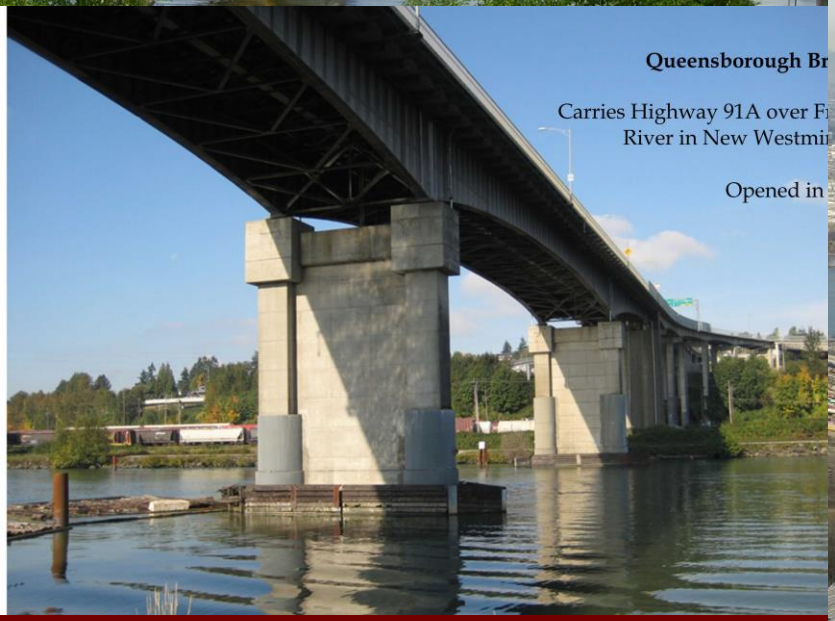
William R Bennett Bridge

Carries Highway 97 over Okanagan Lake between Kelowna and West Kelowna

New partially floating bridge opened in 2008 replacing original 1958 bridge

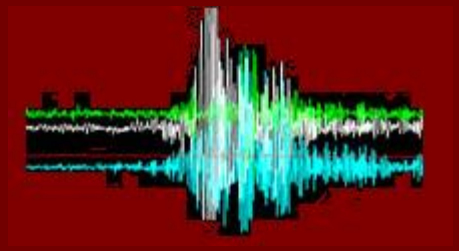

Ironworkers Memorial Second
Narrows Crossing
Carries Highway 1 over
Burrard Inlet between
Vancouver and
North Vancouver
Opened 1960


Pitt River Bridge
Carries Highway 7 over
Pitt River between Port
Coquitlam and Pitt Meadows
Opened in 2009
replacing the
two exisiting
bridges


Queensborough Br
Carries Highway 91A over Fi
River in New Westmi
Opened in

Instrumented Provincial Bridges

- To Come – New
  - Hwy 17 overpass/SFPR
  - Sunbury
  - BNSF
  - Tannery
- To Come – Existing
  - Powell R bridge
  - 5 more being identified



Additional SHM – to come

- City of V

Additional SHM – to come

- Ministry of Education
  - Undecided number of retrofitted schools
- Catholic Archdiocese of Vancouver
  - 20 schools identified – potential 60 total

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http://www.bcsims.ca/

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Pitt River Bridge
Station ID: 3233 DBID: 2 Longitude: W122.73 Latitude: N49.25 Web Camera...

Station Events | Station History

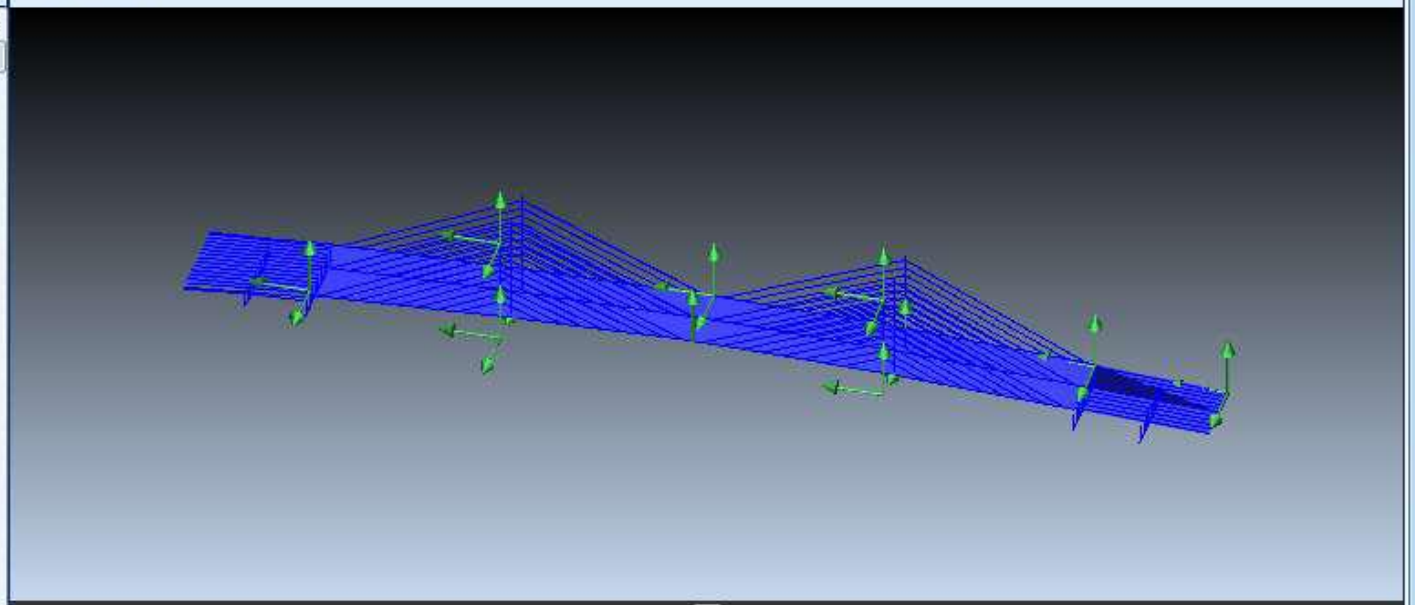
Select Date Range
From 2011-06-27 To 2013-02-04

Select a time series recording in the list below

2013-01-29 13:50:00	Scheduled
2013-01-28 13:50:00	Scheduled
2013-01-27 13:50:00	Scheduled
2013-01-26 13:50:00	Scheduled
2013-01-25 13:50:00	Scheduled
2013-01-24 13:50:00	Scheduled
2013-01-23 13:50:00	Scheduled
2013-01-22 13:50:00	Scheduled
2013-01-21 13:50:00	Scheduled
2013-01-20 13:50:00	Scheduled
2013-01-19 13:50:00	Scheduled
2013-01-18 13:50:00	Scheduled
2013-01-17 13:50:00	Scheduled
2013-01-16 13:50:00	Scheduled
2013-01-15 13:50:00	Scheduled
2013-01-14 13:50:00	Scheduled

Reports | Station Information | Results

Sensor Layout | Sensor Statistics | Data Analysis Results | Drift Analysis | Hysteresis



Name	Channel No.	Position	Dir. X	Dir. Y	Dir. Z	Sensor Type	Signal Type	Unit	Post Process	Projectior

http://gsc.nrcan.gc.ca/index_e.php

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Pitt River Bridge

Station ID: **3233** DBID: **2** Longitude: **W122.73** Latitude: **N49.25** Web Camera...

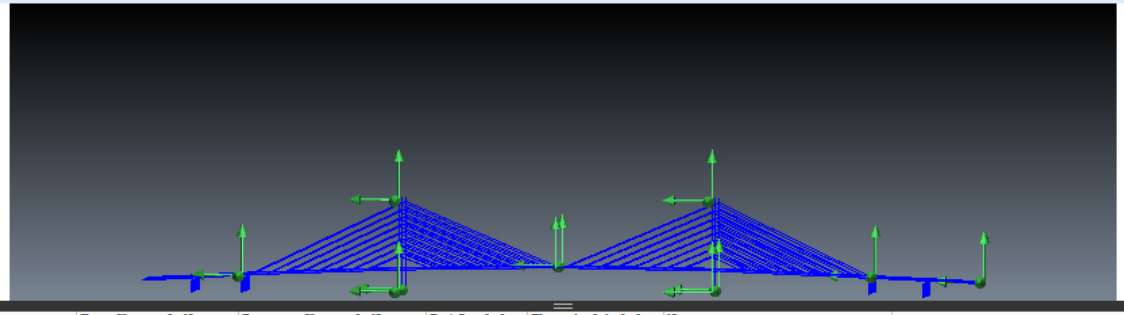
Station Events | Station History

Select Date Range
From 2013-01-01 To 2013-02-13

Select a time series recording in the list below

Reports | Station Information | Results

Sensor Layout | Sensor Statistics | Data Analysis Results | Drift Analysis | Hysteresis



Date	Top Channel Name	Bottom Channel Name	Drift [m]	Threshold [m]	Notes
08/08/2012 12:10:00 PM	TA-03	TA-03	0	0.011	Drift between two columns
13/03/2012 1:30:00 PM	TA-03	TA-03	1.1E-07	0.011	Drift between two columns
05/03/2012 3:40:00 PM	TA-03	TA-03	6E-08	0.011	Drift between two columns
05/03/2012 12:10:00 PM	TA-03	TA-03	1.1E-07	0.011	Drift between two columns
05/03/2012 10:00:00 AM	TA-03	TA-03	1.968E-05	0.011	Drift between two columns

Internet | Protected Mode: On 100%

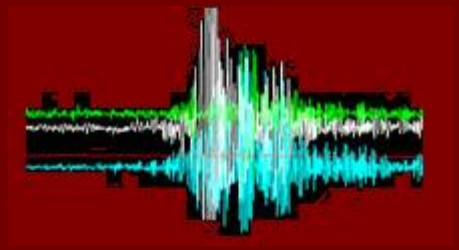
In-process & Coming System Updates

- Major graphical interface overhaul
- Improved shake map algorithms
- Mapping for mobile devices
- Capability for messaging on the homepage
- Multiple user-selected data layers
- Simplified structure information pages

BC Early Warning System

- Network system
- MoTI/UBC developing/testing new instruments
  - Small
  - Low power usage
  - Combined with SMN – for economy
  - Must detect and measure P-wave & PGA
  - Inexpensive
- Ocean Networks developing system software

THANK YOU



Bridge Engineering

BRITISH COLUMBIA

Ministry of Transportation