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Metro Vancouver Seismic Microzonation Mapping Project

Outreach & Engagement Session
Focus on Eastern Communities

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June 4 2026

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Agenda

9:00 – 9:30am	Welcome
9:30 – 10:00am	Project Overview and Introduction of Map Products
10:00 – 10:15am	Context Setting Presentations

- Regional Seismic Risk and Examples of Use (Jessica Shoubridge)
- Provincial Disaster Risk Reduction Linkages (Robert White)
- Engineers and Geoscientists of British Columbia (Allison Chen)

10:15 – 10:30am	Break
10:30 – 11:55am	Map Review and Feedback Session [interactive]
11:55am	Thank you and Closing

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Metro Vancouver Seismic Microzonation Mapping Project (MVSMMP)

- Phase I: Western Metro Van (2017 - 2024)
  - Suite of 29 maps published, Dec. 2024
- Phase II: Eastern Metro Van (2023 - 2027)

The MVSMMP is a decade-long research project to generate a suite of **region-specific seismic hazard maps**

Seismic microzonation maps display predicted variation in earthquake hazards due to local site conditions

The MVSMMP is led by the University of Western Ontario in collaboration with the Institute of Catastrophic Loss Reduction (ICLR) and with support from the British Columbia Ministry of Emergency Management and Climate Readiness (EMCR).

20 local government communities, 1 electoral area, and 10 First Nation communities of the Katzie, Kwantlen, Kwikwetlem, Matsqui, Musqueam, Squamish, Semiahmoo, Tsawwassen and Tsleil-Waututh

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	Phase I, western Metro Vancouver (2017 – 2024)	Phase II, eastern Metro Vancouver (2023 – 2027)
Principal Investigator	Sheri Molnar	Sheri Molnar
Data Manager / Field Leader	Alex Bilson Darko	Natalia Gómez Jaramillo
Geohazard Mapping Specialist	Mohammad Salabili	Mohammad Salsabili
Research Associates	Hadi Ghofrani, Adebayo Ojo	Hadi Ghofrani, Natalia Gómez Jaramillo
PhD students	Sujan Adhikari, Jamal Assaf, Ali Yeznabad, Alireza Javanbakht	Shuqi Bian, Benjamin Fordjour
MSc students	Chris Boucher, Meredith Fyfe, Natalia Gómez Jaramillo, Magdalena Kapron, Sameer Ladak, Aamna Sirohey	Asha Punia
BSc students	A. Carelli, T. Leishman	C. Motuzas, A. Chote
Additional field support	A. Izman, Y. Shaban, C. Tsang, R. Choboter, T. Foulon, A. Vanderhoeff	T. Leishman, S. Darzipour, S. Bian, M. Barton
Geodata support	R. Ghimire, R. Raoufi, A. Beney, J. Edgett, T. Beattie	H. Sharma M. Barton

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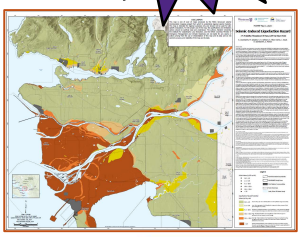
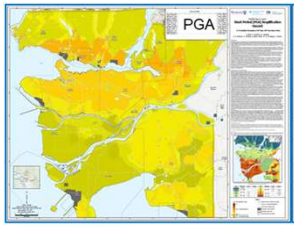
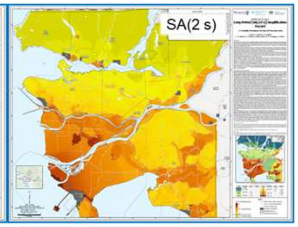
Local / Regional Use

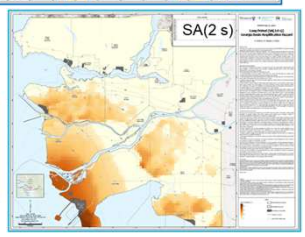
- Improve understanding of seismic hazard
- Community Planning
- Decision Making
- Disaster Resilience
- Emergency Planning
- Engineering
- Hazard & Risk Analyses
- Insurance
- Land-use Planning
- Seismic Mitigation
- Seismic Retrofit
- Structural Design

29 Maps !





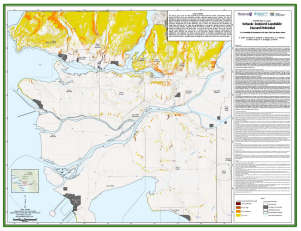




Shaking Amplification Hazard

Georgia Basin Shaking Amplification Hazard

Liquefaction Hazard Potential



Landslide Hazard Potential

Metro Vancouver Seismic Microzonation Mapping Project

Professional Practice Guidelines

metrovanmicromap.ca

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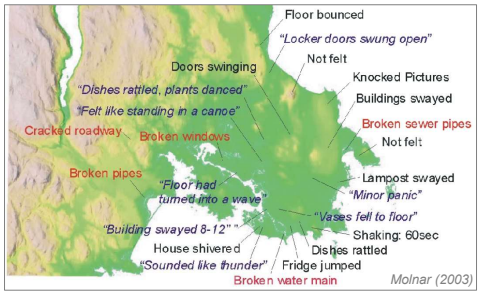
What are seismic microzonation maps?

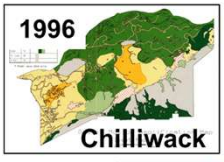
Effects of earthquake shaking are not uniform due to variation in local site conditions

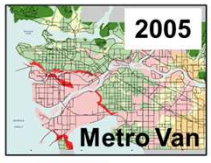
Seismic microzonation is the process of subdividing a seismically prone region into zones of similar {insert type of seismic hazard here}.

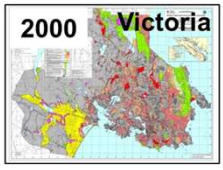
Seismic microzonation maps display predicted variation in earthquake hazards due to local site conditions.
Microzonation maps typically accomplished at urban or region scale

Maps offer a means to **communicate extensive and complex information** in a compact product and **play a critical role** in making this information **accessible to a variety of users**.









Previous SMM led by Vic Levson (BCGS) and Pat Monahan

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Seismic Microzonation Mapping: The Mid-Size Seismic Hazard Vehicle to Drive Change

A wide range of anticipated applications and end-users

- Technical experts:
  - **Earthquake engineering** professionals, stakeholders (**owners of critical or high consequence infrastructure**), and decision makers (**catastrophe modellers or risk analysts**)
  - Technical experts may utilize these map products as inputs to risk analysis to **inform disaster risk reduction, seismic design and retrofitting** or **improved understanding of regional variability** of potential earthquake ground motions for further detailed earthquake investigations and modelling.
- Intermediate users:
  - Decision makers (**emergency managers, land use planners, consultants, architects**) and other stakeholders (**re/insurers, building owners**);
  - May utilize these map products for **emergency response and recovery planning**, **land use planning** or **prioritizing seismic retrofit programs** (adaptation, mitigation, resilience, sustainability), or as inputs for **risk analysis**, **damage estimation**, or **loss calculations for the insurance industry**.
- Others:
  - **Educators to the general public** rely on the accurate communication of seismic hazard and risk information from both primary technical end users and intermediate non-technical end users to inform their personal decision-making (e.g., **developers, real estate agents, insurance agents, homeowners**).

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Levels of seismic microzonation mapping

Level 1	Level 2	Level 3
Susceptibility maps Surficial and remote sensing maps / spatial datasets. Remote sensing (topo) maps. Limited use of subsurface data.	**Susceptibility or Hazard Maps** Subsurface geological data and area-specific data on physical properties.	**Advanced analyses of Hazard** Extensive seismological and subsurface geological, geophysical and geotechnical data and simulations. Detailed subsurface maps and models.

Increase in quality and quantity of geodata

Improved spatial resolution

Increase in seismic hazard analyses

Increase in cost

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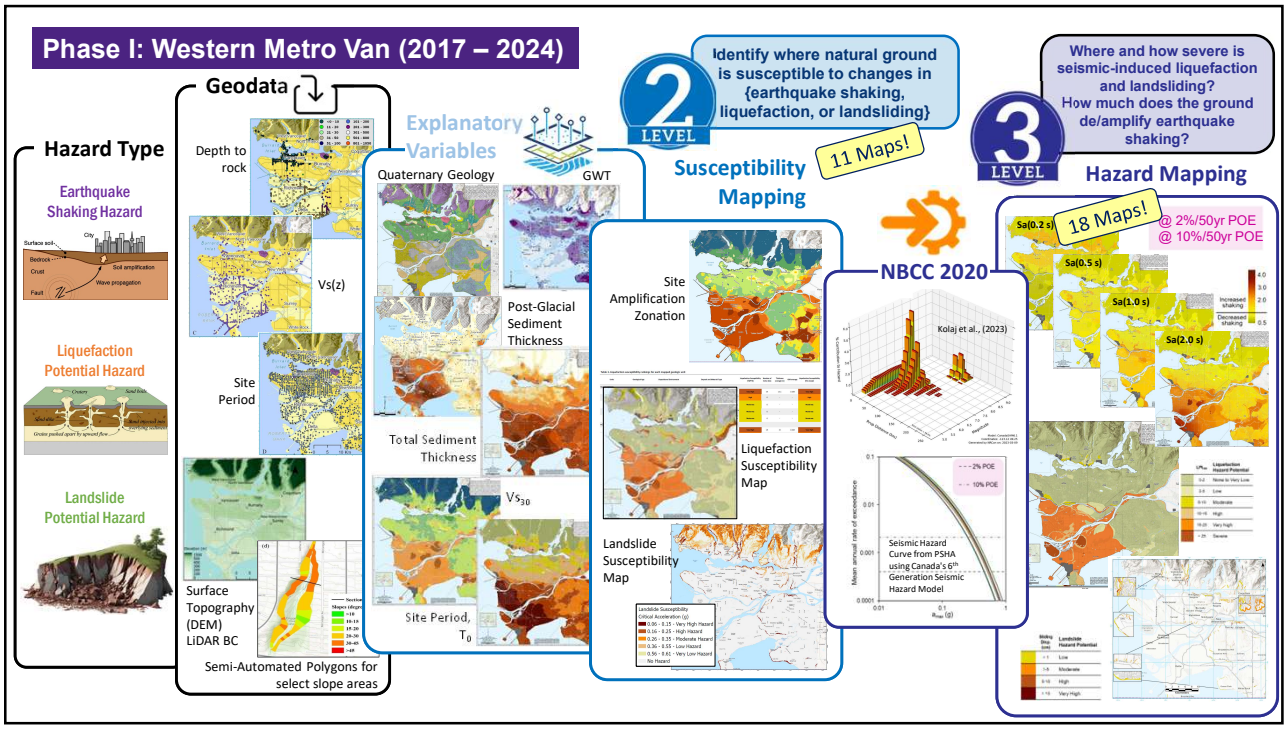

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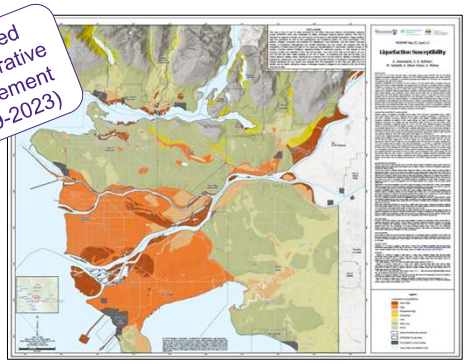
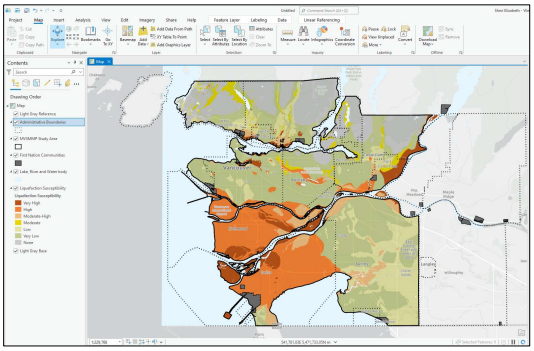
MVSMMP Phase I, 29 Maps Published (Dec. 2024)

Informed from iterative engagement (2019-2023)



Published as static-image Map Sheet
(PDF file format)



Published as Digital Map
(ESRI ArcGIS layer package file)

Maps provided for use "as is"

https://borealisdata.ca/dataverse/MVSMMP

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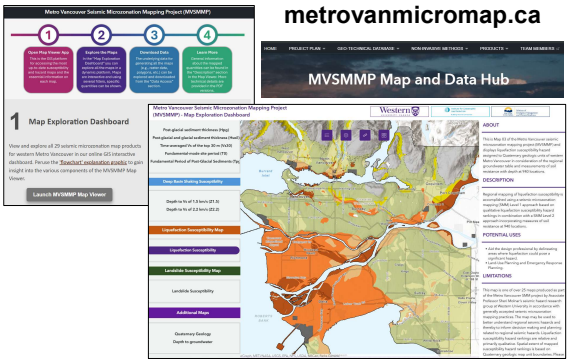
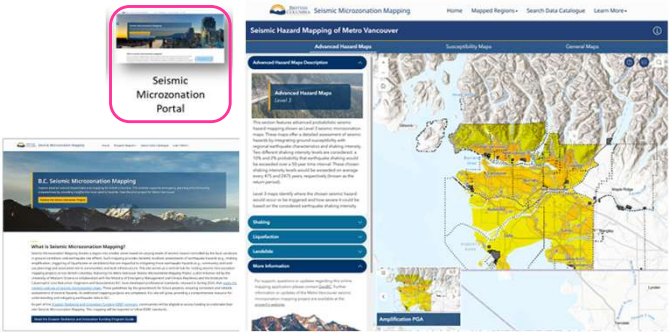
Digital Access and Communication of Published Maps

Developed online map portals using the ESRI ArcGIS Experience Builder app to promote online public knowledge translation and dissemination of the project's mapping.

metrovanmicromap.ca



climatereadyBC



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Achieving Level 3 Seismic Microzonation Mapping of Eastern Metro Vancouver (Phase II)

Geodatabase Development

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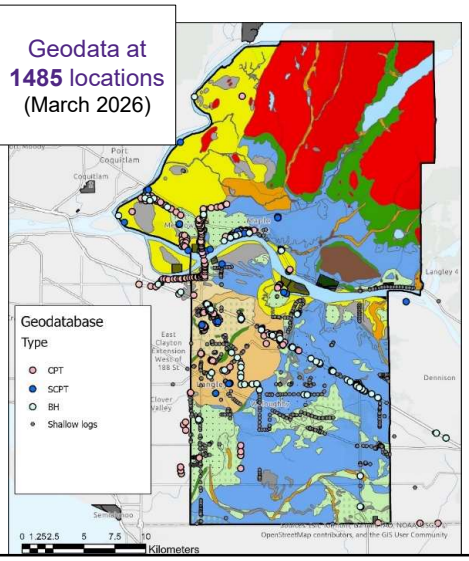
Comprehensive Regional Geodatabase

for Seismic Site Characterization, Development of Regional 3D Velocity Models, and Site-Specific Seismic Hazard Analyses

1. Compile (non-)proprietary geodata from available online (open data) government sources, local municipalities and communities, stakeholder groups, geoconsultants, and engineering firms.
   - Primarily invasive field data types: S/CPT, SPT, downhole Vs, geotechnical laboratory testing.

City of Pitt Meadows THE Natural PLACE · Maple Ridge · Township of Langley · FORTIS BC Energy at work · BRITISH COLUMBIA · GEOPACIFIC CONSULTANTS · BRITISH COLUMBIA Ministry of Transportation and Transit · BRITISH COLUMBIA Ministry of Environment and Climate Change Strategy · Natural Resources Canada / Ressources naturelles Canada · Canada · BRITISH COLUMBIA Ministry of Water, Land and Resource Stewardship · MONAHAN PETROLIUM CONSULTING

Geodata at **1485** locations (March 2026)



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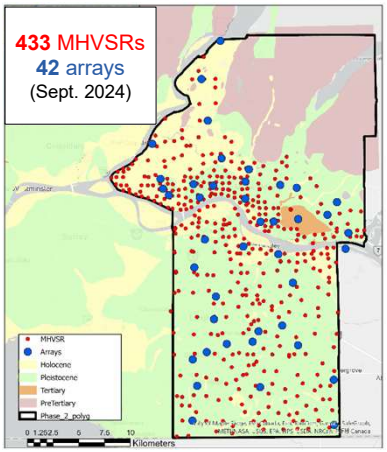
Comprehensive Regional Geodatabase

2. Multi-method non-invasive seismic field testing from two field campaigns (2024, 2025)
   - Single-station microtremor horizontal to vertical spectral ratio (**MHVSR**) testing at **587 locations** at an average ~600 meter spacing
   - Combined active- and passive-source **surface wave array testing** (MASW and AVA) at **59 locations**
   - Joint inversion of site peak frequencies and combined Rayleigh wave dispersion curve to obtain robust Vs depth profile models
- Cost effective for achieving spatial coverage and improved geodata equity across the region

433 MHVSRs
42 arrays
(Sept. 2024)



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Comprehensive Regional Geodatabase

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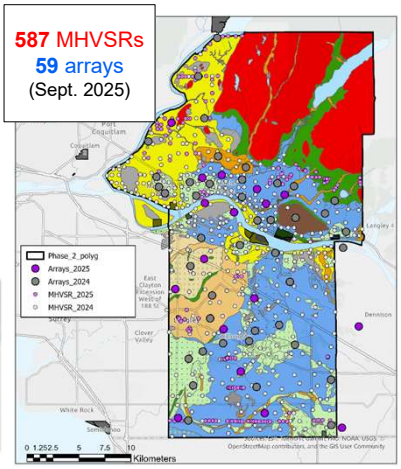
- Cost effective for achieving spatial coverage and improved geodata equity across the region

COMBINATION of invasive and non-invasive geodatasets are necessary to achieve accuracy and coverage (laterally & with depth)

587 MHVSRs
59 arrays
(Sept. 2025)



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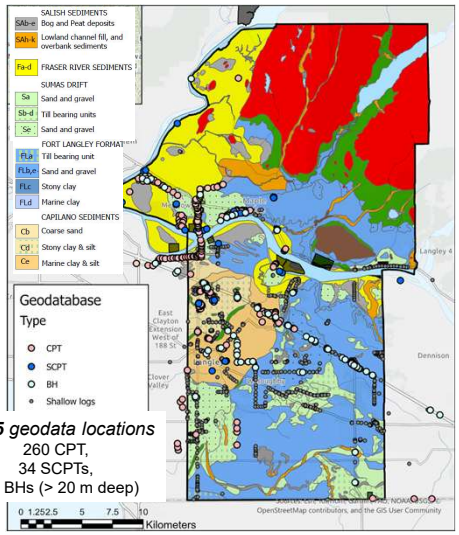
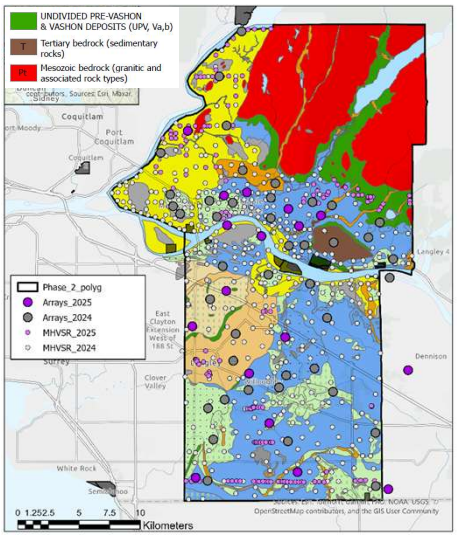
Phase II Geodatabase Summary
Seismic site conditions of eastern Metro Van



***1,485** geodata locations*
260 CPT,
34 SCPTs,
108 BHs (> 20 m deep)



Priority of ***regional coverage*** of the **2024** field campaign (grey).
- 42 array sites for Vs(z)
- 433 MHVSR sites for Amp(f)

*Priority of **targeted*** seismic testing locations of the **2025** field campaign (purple).
- 17 array sites for Vs(z)
- 154 MHVSR sites for Amp(f)

The combined 2024 and 2025 field campaigns achieved multi-method seismic **array** testing at **59 sites** and single-seismometer **MHVSR** testing at **587 locations**, respectively. Adequate regional coverage and spatial density was successfully achieved by the two field campaigns.

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Achieving Level 3 Seismic Microzonation Mapping of eastern Metro Vancouver (Phase II)

2 LEVEL

Identify where natural ground is susceptible to changes in earthquake shaking

Seismic Shaking Susceptibility Mapping

		Phase I	Phase II
1.	Thickness of post-glacial sediments (Hpg)	MVSMMP Map 05 doi: 10.5683/SP3/T4UQM6	MVSMMP Map 05E (**draft**)
2.	Thickness of post-glacial and glacial sediments (Hsoil)	MVSMMP Map 06 doi: 10.5683/SP3/8Y8N8D	MVSMMP Map 06E (in prep)
3.	Time-averaged Vs of the top 30 meters (Vs30)	MVSMMP Map 07 doi: 10.5683/SP3/VBR7UT	MVSMMP Map 07E (**draft**)
4.	Fundamental period of post-glacial sediments (Tpg)	MVSMMP Map 08 doi: 10.5683/SP3/QXNGTQ	MVSMMP Map 08E (in prep)
5.	Fundamental site period (T0)	MVSMMP Map 09 doi: 10.5683/SP3/RNVWIN	MVSMMP Map 09E (in prep)

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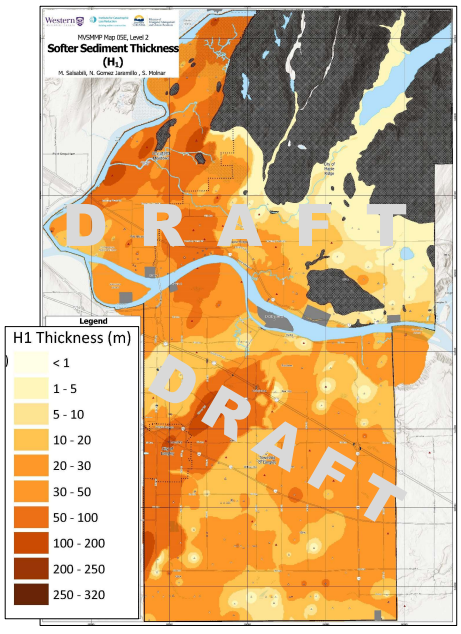
Map 05E, H1 ~~Hpg~~
Thickness of softer sediments

- H1 is one of several measures that summarize subsurface site conditions, including Quaternary geology, total sediment or drift thickness, Vs30, and site resonance periods.

POTENTIAL USES:

- Help in understanding the spatial distribution of earthquake amplification hazards, which is crucial in seismic hazard microzonation. Earthquake ground motions are amplified around the natural modes of vibration of a site by shear wave resonance which is strongly linked with this H1 mapping of eastern Metro Vancouver.
- Help in pinpointing areas where the soil is more prone to liquefaction, settlement, and other seismic-related issues.
- **Urban Planning**: In populated areas, these maps support site-specific planning by providing context for local geological conditions, which is vital for construction and infrastructure development.



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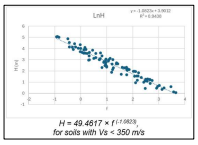
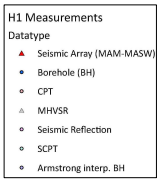
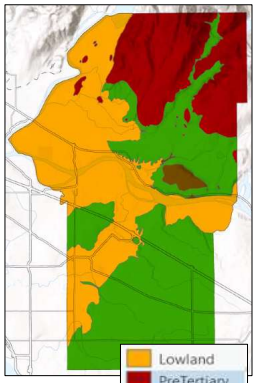
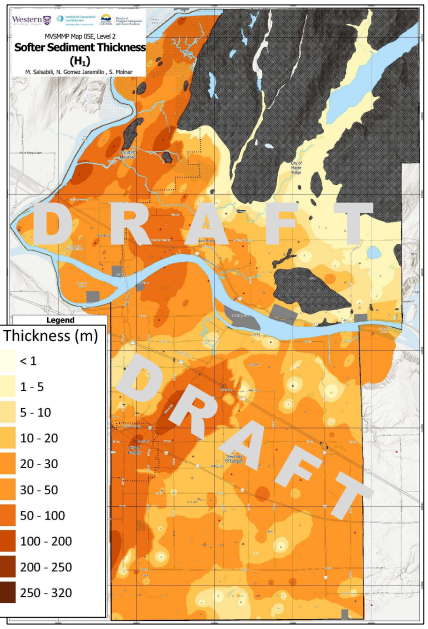
Map 05E, H1 (formerly Hpg)
Map 06E, Hsoil (in progress)





- Compiled ~348 H1 measurements from geologic boreholes and S/CPT refusal depths, and H1 estimates from our seismic array & MHVSR testing and GSC seismic reflection profiles.
  - Reconciling H1 values amongst data sources is ongoing.
  - Areas of outcropping rock included (H1 = 0 m).
- Region divided into lowland (*n = 144*) and upland (*n = 204*) zones. Inverse Distance Weighting (IDW) spatial interpolation performed within each zone.
  - 8 data neighbours used in prediction.
  - Lowland IDW included some anisotropy / spatial ellipticity oriented at 35⁰ (NE-SW).
  - No trend in upland zone (circular interpolation).





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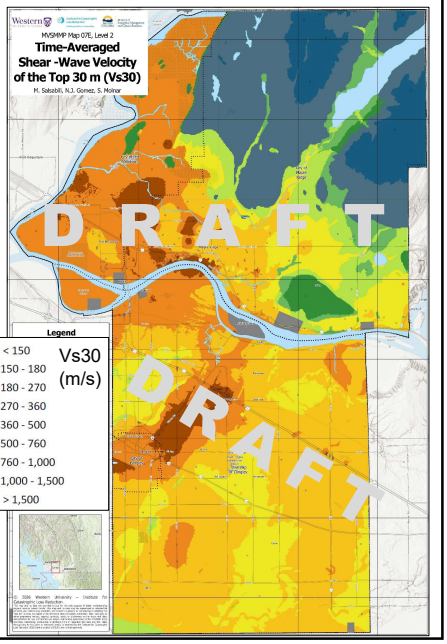
Map 07E, Vs30
Time-averaged shear-wave velocity of the top 30 meters

- Vs30 is one of several measures that summarize subsurface site conditions, including Quaternary geology, thickness of sediments, and site resonance periods.

POTENTIAL USES:

- **Terrain Classification and Site Characterization**: Vs30 maps can be combined with terrain classification and surface geology data to provide a more comprehensive understanding of site conditions and their influence on seismic response.
- **Ground Motion Models (GMMs)**: Vs30 is a widely used explanatory variable in GMMs, which are a fundamental component of seismic hazard assessments, national seismic hazard maps, and rapid response systems like ShakeMap.
- **Building Codes**: Vs30 is used in international building codes to determine site response and site classification for seismic design purposes.
- **Seismic Loss Estimation**: Vs30 maps can be used to estimate the impact of site conditions on seismic losses for residential buildings.
- **Earthquake Hazard Mapping**: Vs30 data can be integrated with other information, such as microtremor data, to map earthquake hazard zones.



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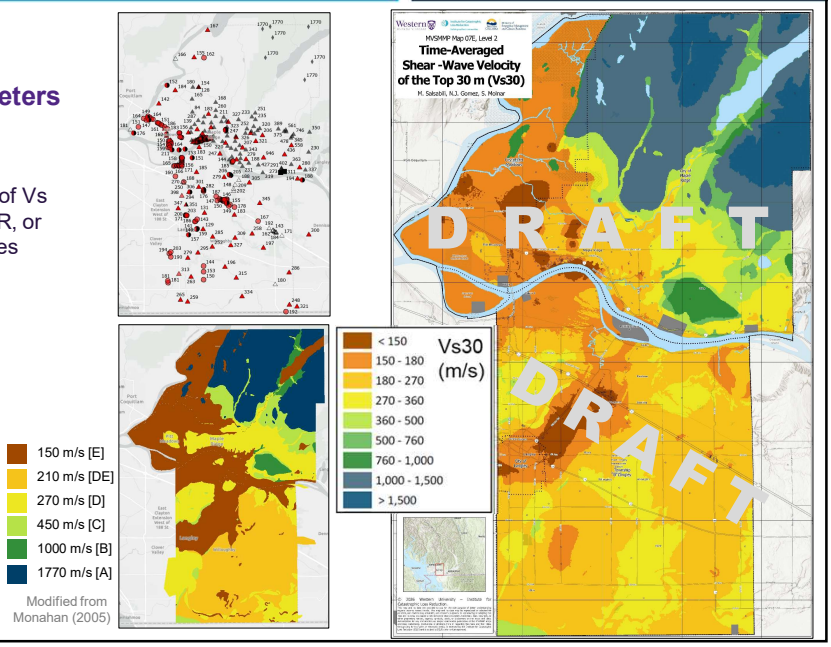
Map 07E, Vs30

Time-averaged Vs of the top 30 meters

- Calculated 328 Vs30 values
  - Calculated from *in situ* measurements of Vs profiling (DH, SCPT, AVA-MASW-MVSR, or MHVSR), and estimated from Vs profiles converted from CPT and SPT data
- We have used empirical Bayesian kriging (EBK) to spatially predict Vs30 based on variable regression coefficients (~5 across region) developed from the *in situ* Vs30 data & topographic DEM & average Vs30 of previous seismic site class mapping (Monahan 2005)



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Achieving Level 3 Seismic Microzonation Mapping of eastern Metro Vancouver (Phase II)

Liquefaction Hazard Mapping

3 Maps

		Phase I	Phase II
1.	Liquefaction Susceptibility	MVSMMP Map 03 doi: 10.5683/SP3/68QQXS	MVSMMP Map 03E (**draft**)
2.	Seismic-Induced Liquefaction Hazard Potential: 10% Probability of Exceedance in 50 Years or 475 Year Return Period	MVSMMP Map 12 doi: 10.5683/SP3/2OSVI0	MVSMMP Map 12E (**draft**)
3.	Seismic-Induced Liquefaction Hazard Potential: 2% Probability of Exceedance in 50 Years or 2475 Year Return Period	MVSMMP Map 13 doi: 10.5683/SP3/X23A5D	MVSMMP Map 13E (**draft**)

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Liquefaction Hazard Mapping

Level 1	Level 2	Level 3

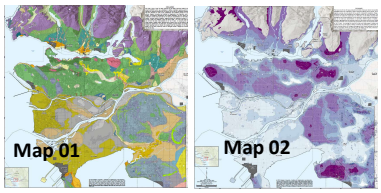
Identify if/where natural ground is susceptible to liquefaction

Considers the local soil resistance (how sandy, how saturated)

But will the natural ground liquefy given the regional seismic hazard?

Consider both the local soil resistance WITH the earthquake shaking that would occur over a mean return period of 475 or 2475 years

1 LEVEL **Qualitative Approach**



Quaternary Geology — Groundwater Table Depth

Liquefaction Susceptibility Rating

FEMA-Hazus-MH5.1
Technical Manual (2022)

- Geologic Age
- Depositional Env.
- Material type
- Depth to GWT

(Youd & Perkins 1978)

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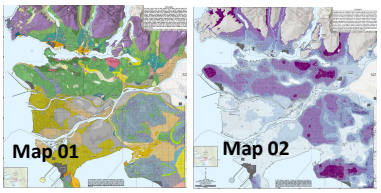
Liquefaction Susceptibility Mapping

1 LEVEL **Qualitative Approach**



Quaternary Geology — Groundwater Table Depth

Liquefaction Susceptibility Rating

FEMA-Hazus-MH5.1
Technical Manual (2022)

- Geologic Age
- Depositional Env.
- Material type
- Depth to GWT

(Youd & Perkins 1978)

2 LEVEL **Quantitative Data & Analyses**

Measures of Soil Resistance from Regional Geodatabase

- SPT(z) and CPT(z) measurements with depth
- Thickness of liquefiable layers (H_{cr})
- Average cyclic resistance ratio (CRR)

Initial — Final

Table 1. Liquefaction susceptibility rankings for each mapped geologic unit

Units	Geological Age	Depositional Environment	Deposit and Material Type	Liquefaction Susceptibility (Y&P78)	Number of insitu data	Thickness average (m)	CRR average	Liquefaction Susceptibility (this study)
Recent Sediments								
NG,An,f	< 500 yrs	Anthropogenic (An)	Undifferentiated fill (f) containing sand, gravel, till, crushed stone 1 to 10m thick	Very High	54	13.1	0.198	Very High
NG,BS,o	Holocene	Bog and Swamp (BS)	Undifferentiated organic (o) deposits, consists of fine sand slit and clay deposit in lakes	High	0	-	-	High
NG,C,Tl	Post last Glaciation	Colluvial (C)	Colluvial landslide (l) and mass-wasting deposits. Unconsolidated sediments. Rock fragments in a matrix of boulder, gravel, sand silt and minor clay	Moderate	0	-	-	Moderate
NG,C,T	Post last Glaciation	Colluvial (C)	Apron or talus (T) scree deposits, Rubble and block accumulation at the bottom of steep slopes 1 to 10 m thick	Moderate	0	-	-	Moderate
NG,C,v	Post last Glaciation	Colluvial (C)	Colluvium veneer (v) < 3m thick, Thin and discontinuous cover of slope wash material, containing matrix of boulders, gravel, sand, silt usually up to 2m thick	Moderate	0	-	-	Moderate

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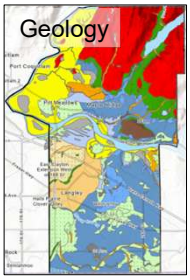
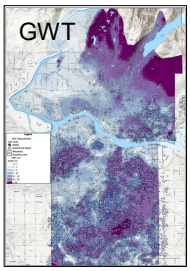
Liquefaction Susceptibility

Identify where natural ground is susceptible to liquefaction

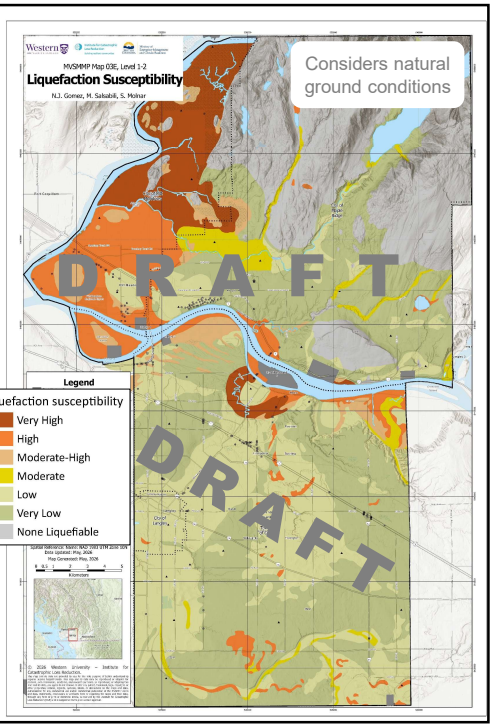




Soil Stratigraphy	Geounit	Description		Liquefaction susceptibility Eastern Metro Vancouver			
		Deposit environment	Material	Number of in situ data	Average Hcr (m)	Average CRR	Liquefaction susceptibility
Fraser River Sediments	Fb	Overbank	Sand and Silt	8	8.3	0.149	Very High
Fraser River Sediments	Fc	Overbank	Silt and silty clay	40	4.0	0.136	High
Fraser River Sediments	Fc,d	Deltaic	Mostly Sand				High
Fraser River Sediments	Fh	Estuarine	Sand				High
Salish Sediments	SAb	Bog	Peat	10	2.9	0.145	Moderate-High
Salish Sediments	SAc	Bog	Peat				High
Salish Sediments	SAd	Organic sandy loam to clay loam	Organic Loam				Low
Salish Sediments	SAe	Bog	< 4m Peat	1	12.5	0.143	High
Salish Sediments	SAh	Channel fill	Sand-Clay				Moderate-High
Salish Sediments	SAi	Mountain Stream	Gravel				Moderate
Salish Sediments	SAj	Mountain Stream	Sand and Gravel				Moderate
Salish Sediments	SAj,l	Mountain Stream	Sand and Gravel				Moderate
Salish Sediments	SAk	Channel Fill	Sand and Gravel				Moderate
Salish Sediments	SAm	Slope wash sand, on Fc, d, Saj	Gravel sand				Moderate
Sumas Drift	Sa	Outwash	Sand & Gravel	1	0.0	---	Low
Sumas Drift	Sb	Ice contact	Gravel sand, till	1	1.5	0.140	Low
Sumas Drift	Sc	Ice contact	Gravel sand, till				Low
Sumas Drift	Sd	Ice contact	Gravel sand, till	1	3.2	0.156	Low
Sumas Drift	Se	Raised proglacial deltaic	Gravel sand	51	4.2	0.141	Low
Sumas Drift	Sg	Ice contact	Sandy Till				Very Low
Capilano Sediments	Cb	Raised Beach	Coarse Sand	1	7.3	0.130	Low
Capilano Sediments	Cd	Marine	Silty clay	6	0.0	---	Very Low
Capilano Sediments	Ce	Marine	Clay, silty clay and loam	39	0.85	0.133	Low
Fort Langley Formation	Fl,a	Fluvial	till sand & clay				Very Low
Fort Langley Formation	Fl,a,b,d,e		Mixed till sand & clay				Low
Fort Langley Formation	Fl,b	Outwash	Gravel & Sand				Low
Fort Langley Formation	Fl,c	Glaciomarine	Stony Clayey silt to sand	21	0.2	0.175	Very Low
Fort Langley Formation	Fl,d	Marine	Clay, silty sand - sensitive	3	0.6	0.136	Very Low
Fort Langley Formation	Fl,e	Deltaic	Gravel & Sand	1	0.9	0.144	Low
Vashon Drift	Va	Glacial	Glacial Till				Very Low
Vashon Drift	Va,b	Glacial	Glacial Till				Very Low
Vashon Drift	Vb	Glaciofluvial	Sand and Gravel				Very Low
Pre-Vashon Deposits	PVf	Glacial, Semiahmoo till	Till				Very Low
Undivided Pre-Vashon	UPV	Undivided	Till				Very Low
Tertiary	T	Tertiary - sedimentary rock					None
Pre-Tertiary	Pt	Granitic Rock					None

184 data locations

Profile Type
- CPT
- SPT
- Vs



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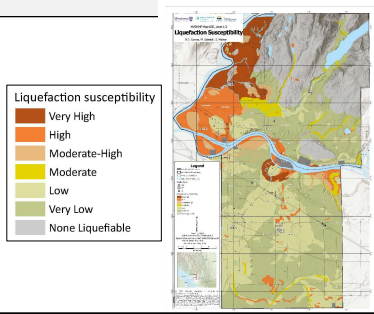
Liquefaction Hazard Mapping

Level 1	Level 2	Level 3

Identify if/where natural ground is susceptible to liquefaction

Considers the local soil resistance (how sandy, how saturated)



But will the natural ground liquefy given the regional seismic hazard?

Consider both the local soil resistance WITH the earthquake shaking that would occur over a mean return period of 475 or 2475 years

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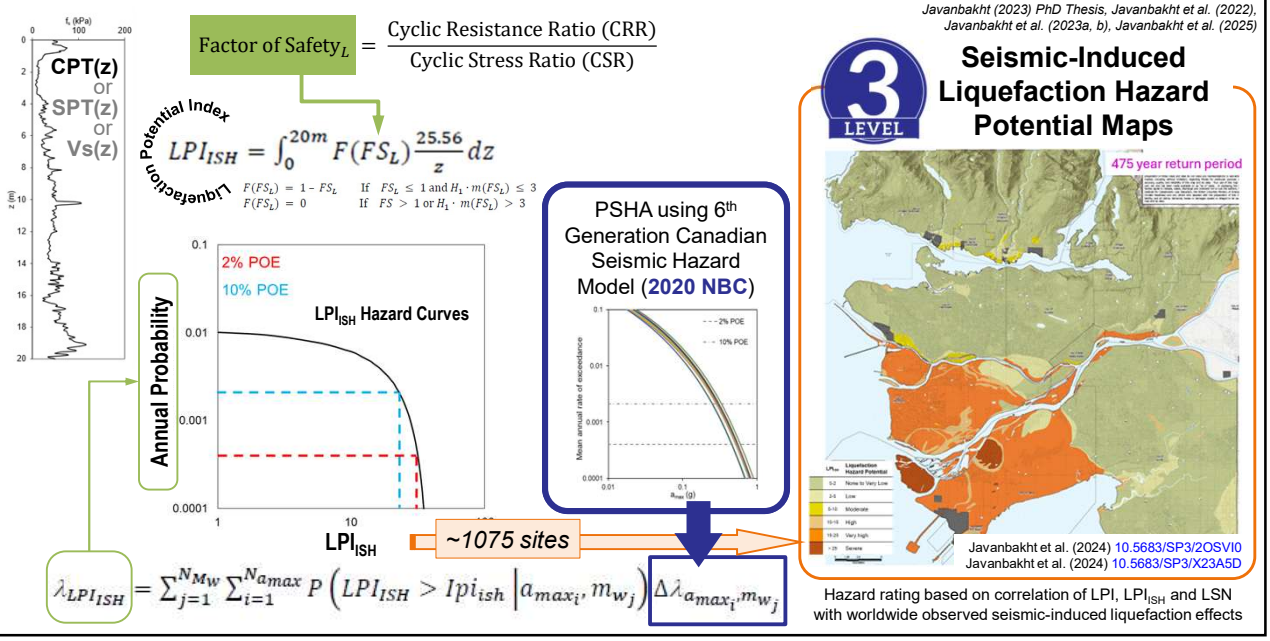
Javanbakht (2023) PhD Thesis, Javanbakht et al. (2022), Javanbakht et al. (2023a, b), Javanbakht et al. (2025)



Hazard rating based on correlation of LPI, LPI_{ISH} and LSN with worldwide observed seismic-induced liquefaction effects

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Developed a descriptive legend for liquefaction hazard mapping

Liquefaction Hazard Potential

LPI_{ISH}

0.0 - 2.0	NONE to VERY LOW - No to little expression of soil liquefaction at ground surface.
2.1 - 5.0	LOW - Minor expression of soil liquefaction at ground surface, some sand boils (sand emerged onto surface).
5.1 - 10.0	MODERATE - Moderate expression of soil liquefaction, more instances and greater volume of sand boils at ground surface that can lead to some structural damage.
10.1 - 15.0	HIGH - Moderate expression of soil liquefaction as sand boils and ground settlements that can cause structural damage.
15.1 - 25.0	VERY HIGH - Major evidence of soil liquefaction at the ground surface including damage and disruption to the ground surface that can lead to differential settlements of structures.
> 25	SEVERE - Extensive evidence of soil liquefaction at the ground surface including disruption and damage to the ground surface that can lead to severe settlements of structures and damage to underground services.

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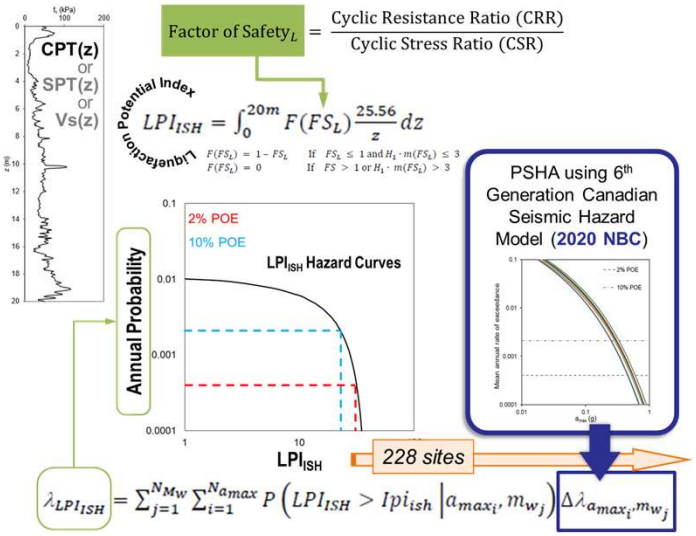
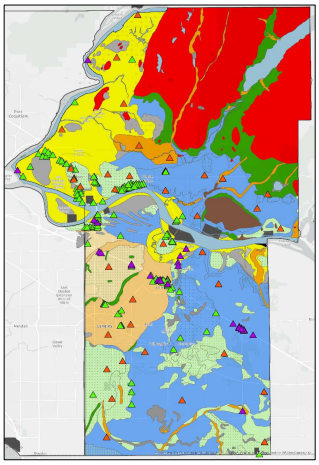
Liquefaction Hazard Mapping (Phase II)





LPI_{ISH} calculated at 228 sites

- 153 CPT sites (100%)
- 34 SPT sites (100%)
- 41 Vs(z) sites (more possible)

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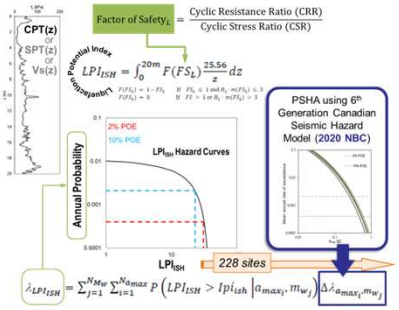
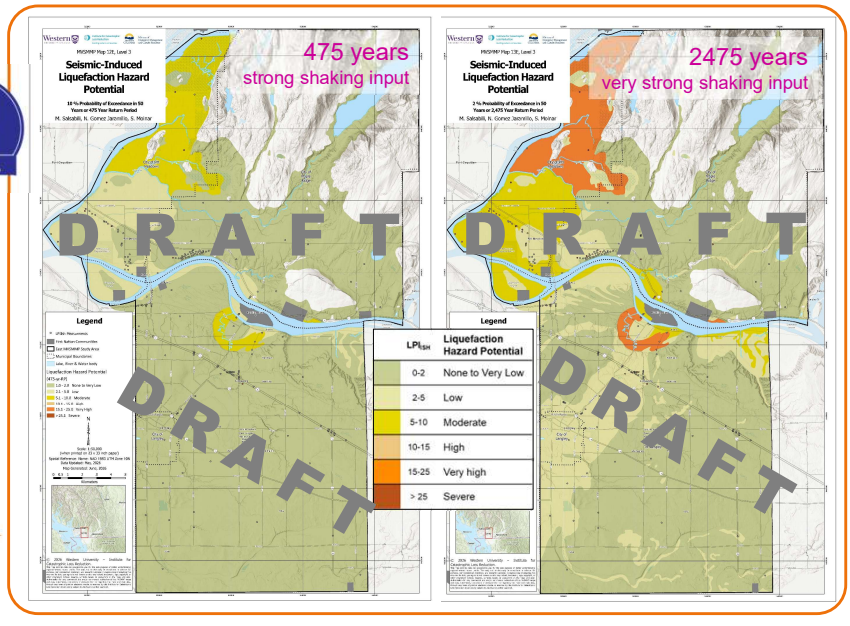
Liquefaction Hazard Mapping

3 LEVEL





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Achieving Level 3 Seismic Microzonation Mapping of eastern Metro Vancouver (Phase II)

Landslide Hazard Mapping
3 Maps

		Phase I	Phase II
1.	Landslide Susceptibility	MVSMMP Map 04 doi: 10.5683/SP3/7PWN0W	MVSMMP Map 04E (**draft**)
2.	Seismic-Induced Landslide Hazard Potential: 10% Probability of Exceedance in 50 Years or 475 Year Return Period	MVSMMP Map 14 doi: 10.5683/SP3/KMT2VK	MVSMMP Map 14E (**draft**)
3.	Seismic-Induced Landslide Hazard Potential: 2% Probability of Exceedance in 50 Years or 2475 Year Return Period	MVSMMP Map 15 doi: 10.5683/SP3/WA6MER	MVSMMP Map 15E (**draft**)

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Landslide Hazard Mapping

Level 1	Level 2	Level 3

Identify if/where natural slopes are susceptible to landsliding

Considers slope angle, slope material (cohesion, friction angle) ≈ yield acceleration

But will the natural slope slide given the regional seismic hazard?

Consider both the slope's soil resistance WITH the earthquake shaking that would occur over a mean return period of 475 or 2475 years

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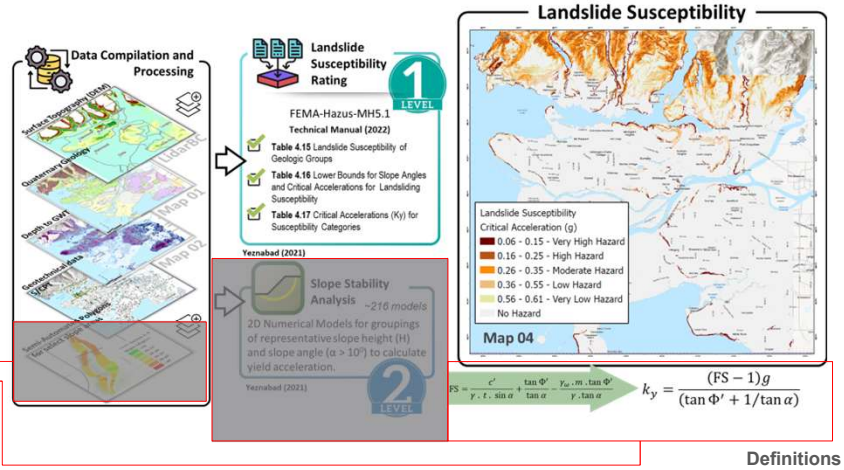
Phase II updates to Landslide Susceptibility (k_y) mapping

- Our Phase I methodology to generating slope polygons improved slope geometry accuracy but was inefficient and user-dependent. We needed a faster and 'better' approach (see next slides).
- Our Phase I methodology to calculate ky using 2D slope models is replaced with solving the infinite slope model approximation for FS and ky.
- Slope geotechnical parameters are optimized (c', φ) so that ≥ 90% of slopes have FS ≈ 1.



Definitions
FS: Factor of Safety in Static condition
Ky: Yield Acceleration

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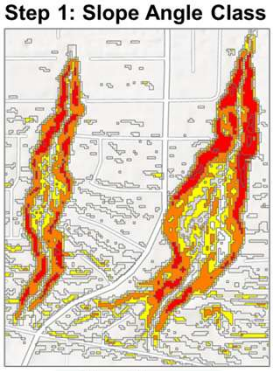
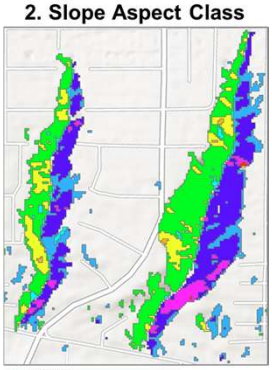
Phase II update: Improving GIS-automated creation of slopes as polygon areas

Step 1: Slope Angle Class



Slope_Class
0.001 - 9.9
9.901 - 15
15.001 - 20
20-30
30-40
40-60 degrees

2. Slope Aspect Class



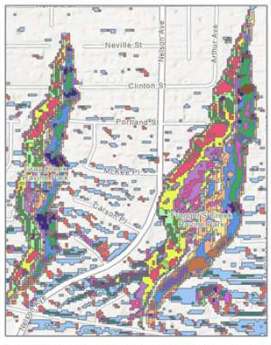
Flat (-1)
North (0 - 22.5)
Northeast (22.5 - 67.5)
East (67.5 - 112.5)
Southeast (112.5 - 157.5)
South (157.5 - 202.5)
Southwest (202.5 - 247.5)
West (247.5 - 292.5)
Northwest (292.5 - 337.5)
North (337.5 - 360)

Slope aspect = direction slope is facing (9 quadrants of 360 degree rotation)

3. Geology

Uniformly Vashon/Capilano (VC) unit shown here
Soil cohesion, c'
friction angle, ϕ'
GWT: dry condition

Results in unique slope unit mapping



Each polygon represents a unique combination of slope **Angle + Aspect + Geology**

Outcome: Creation of *Unique Condition slope Units* with uniform single-value but unique input parameters (α, c', ϕ') to solve FS.

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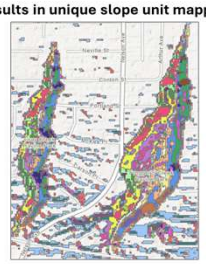
MVSMMP Map 04E, Landslide Susceptibility Map

Results in unique slope unit mapping



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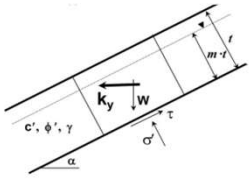
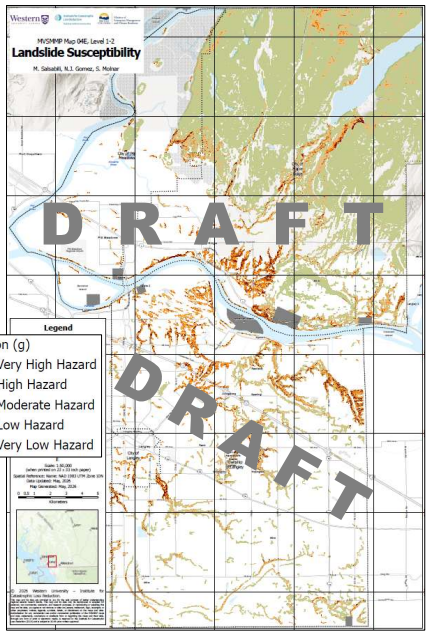
Outcome: Creation of *Unique Condition slope Units* with uniform single-value but unique input parameters (α, c', ϕ') to solve FS.



$$k_y = \frac{(FS - 1)g}{(\tan\phi' + 1/\tan\alpha)}$$

$$FS = \frac{c'}{\gamma \cdot t \cdot \sin\alpha} + \frac{\tan\phi'}{\tan\alpha} - \frac{\gamma_w \cdot m \cdot \tan\phi'}{\gamma \cdot \tan\alpha}$$

Solve FS and ky for each unique slope unit.



- Slope angle is determined at a 50-m resolution from a 5-m resolution topographic DEM.

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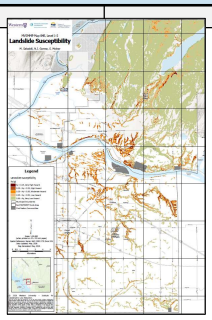
Landslide Hazard Mapping

Level 1	Level 2	Level 3

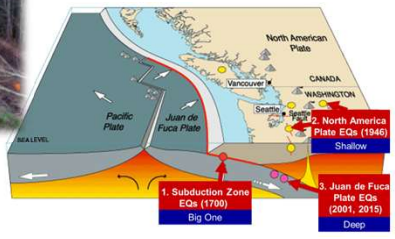
Identify if/where natural slopes are susceptible to landsliding

Considers slope angle, slope material (cohesion, friction angle) ≈ yield acceleration



But will the natural slope slide given the regional seismic hazard?

Consider both the slope's soil resistance WITH the earthquake shaking that would occur over a mean return period of 475 or 2475 years



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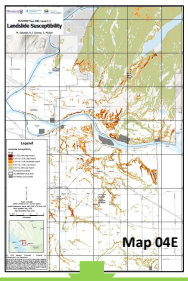
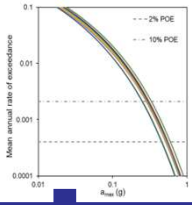
Landslide Susceptibility (*Ky*)



PSHA using 6th Generation Canadian Seismic Hazard Model (**2020 NBC**)



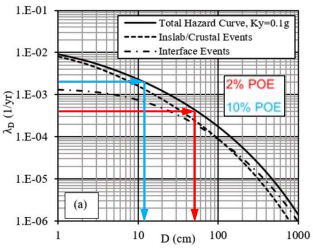
$$\lambda_D = \iint P(D > x | GM_z, M_j, Ky)\, P(GM_z).P(M_j|GM_z)\, dz.dj$$

Seismic Displacement Prediction Models (SDPMs)

$$\ln D = f(\mathrm{Ky}, \mathrm{IM(T)}, \mathrm{M}) \pm \varepsilon$$

Sliding Displacement Hazard Curves

$$\lambda_{D,Total} = \lambda_{Crustal} + \lambda_{Inslab} + \lambda_{Interface}$$



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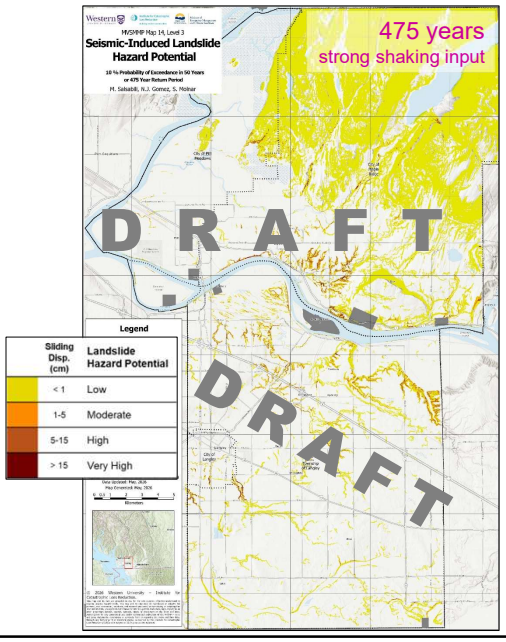

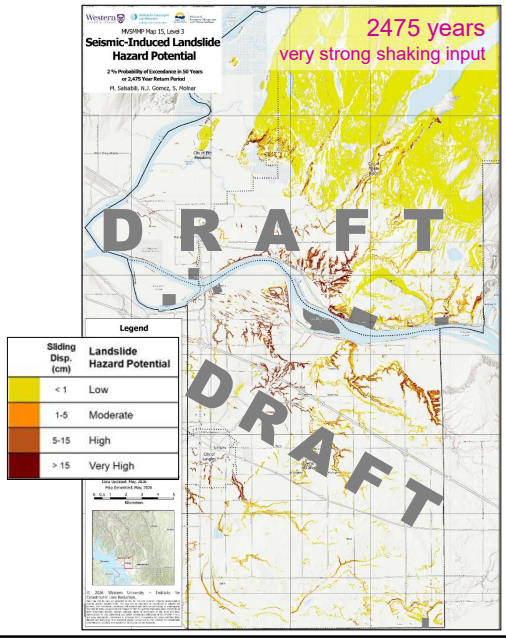

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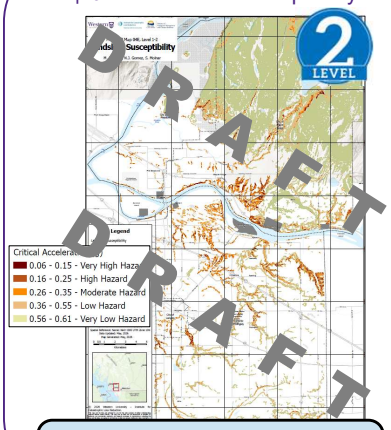
Landslide Susceptibility and Hazard Mapping

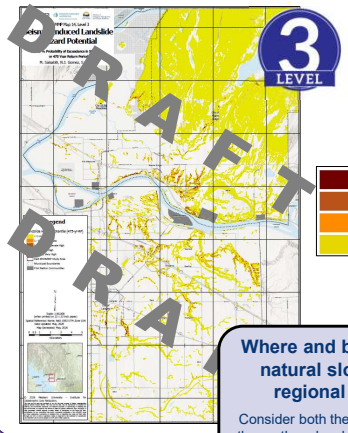
Map 04E: Landslide Susceptibility



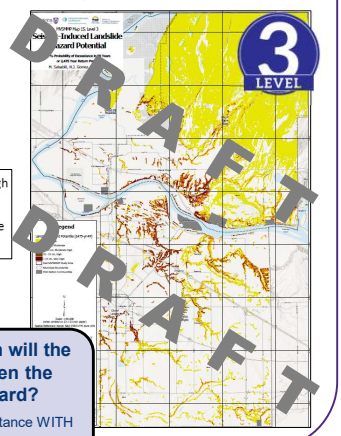
Identify if/where natural ground is susceptible to landsliding

Based on the local slope geometry and its geology

Map 14E: Landslide Hazard Potential (from strong shaking)



Map 15E: Landslide Hazard Potential (from very strong shaking)



Where and by how much will the natural slope slide given the regional seismic hazard?

Consider both the slope's soil resistance WITH the earthquake shaking that would occur over a mean return period of 475 or 2475 years

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Which maps are preferred?

- Static (PDF) maps are downloaded 50-65% more than digital maps
- 2475-year return period preferred over 475-year return period
- Liquefaction maps are most downloaded; High downloads of Quaternary geology maps too
- Vs30 most downloaded shaking-related map (as expected)
- PGA and SA(1 s) preferred shaking amplification map products

Download MVSMMP_Map03_LQSusceptibility.pdf	121	
Download MVSMMP_Map13_LiqHazPotential_2475RP.pdf	115	
Download MVSMMP_Map01_QtyGeology.pdf	113	
Download MVSMMP_Map12_LiqHazPotential_475RP.pdf	89	
Download MVSMMP_Map07_Vs30.pdf	86	
Download MVSMMP_Map03_SupplementaryTable_LiqSuscepRanki	76	
Download MVSMMP_Map15_LandHazPotential_2475RP.pdf	72	
Download MVSMMP_Map04_LDSSusceptibility.pdf	72	
Download MVSMMP_Map14_LandHazPotential_475RP.pdf	62	
Download MVSMMP Map 03 - Liquefaction Susceptibility.lpkx	62	
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Who are using these maps? For what purposes?

Who?

- Civil / Infrastructure Engineers, College and University students, Engineering Geologists, Geologists, GIS Technicians, Specialist Engineers, Transportation Engineers

What Purposes?

- Education, General Understanding (*Understanding ground conditions where my child lives*)
- Research, Course term project
- Initial site characterization, High-level screening
- Cross-referencing susceptibility and / or hazard values
- [Municipal] Risk analyses, Researching seismic design standards, Developing performance-based seismic design

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Agenda

9:00 – 9:30am	Welcome
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- Provincial Disaster Risk Reduction Linkages (Robert White)
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10:30 – 11:55am	Map Review and Feedback Session [interactive]
11:55am	Thank you and Closing

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Metro Vancouver

Seismic Microzonation Mapping

Regional Risk Context & DRR Use Cases

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The High Level "Why"

- Seismic hazard in the region represents catastrophic risk; loss estimates such as $20 billion for initial shaking (no aftershocks), $10 billion for fire-following
- Seismic hazard is unique in terms of frequency & consequence metrics, requires tailored approach
- Seismic hazard still represents significant threat for loss of life/casualties (typically unlike wildfire & flood hazards)
- Better hazard input data allows for better overall DRM: improving regional risk reduction, recoverability & sustainability
- The region continues to grow at a fairly consistent/high rate, increasing exposure, with an economy heavily tied to real estate industry and related values

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8 Yrs Outreach & Engagement

- Workshops & webinars to gain feedback on draft maps, provide project updates, build awareness (~2019-2026).
- URBC panel discussion, regional engineers/planners/EMs, Metro Vancouver Conference Day, PIBC-SC Session for Planners, ICLR Friday Forum webinar, etc.
- Objective: support the uptake & use of the map set/related data for a variety of end-users ensuring ppl understand the process & outputs

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How are/can/will these maps be used?

- To inform new or more detailed risk assessment/analysis work (e.g. new EDMA requirements, regional risk assessments), assess multi-hazard risk/cascading impacts (e.g. how subsidence/uplift & sea level rise will impact liquefaction susceptibility)
- To improve building performance (new builds & retrofits)
- To support local/regional land use & development planning
- To improve asset management practices & planning
- To support emergency preparedness, response, recovery
- Etc. (cat modelling, insurance…)

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Risk Management Uses at LA Scale

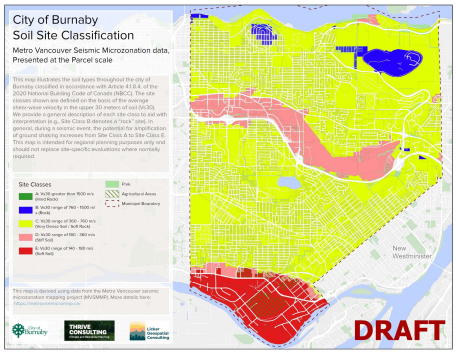
- B-SAFER is part of the City's **Community Safety Plan** and is supported by the Province of BC's Disaster Resilience and Innovation Funding (DRIF) program.

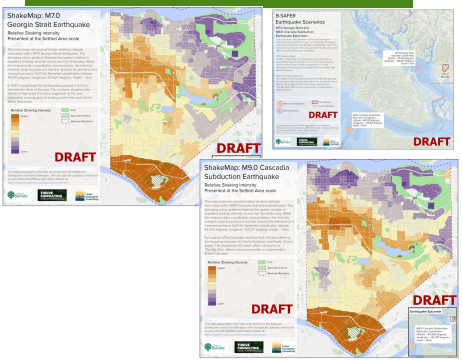
Burnaby Strategies and Actions for Earthquake Resilience (B-SAFER)

Working together to prepare for future earthquakes.

Timeline — City of Burnaby

- Background review — spring 2025
- Community conversations — fall 2025
- Draft strategy — winter 2026
- Final strategy and action plan — spring 2026





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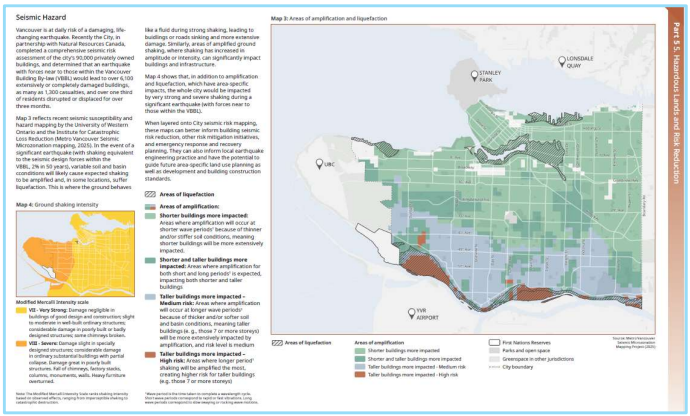
Risk Management Uses at LA Scale



Official Development Plan, City of Vancouver

The City of Vancouver chose to overlay liquefaction hazard potential mapping with selected short-period (PGA) and long-period (2 seconds) amplification hazard mapping for communication of earthquake hazards in their ODP.

This chosen tri-map presentation is one approach to communicating the project's mapping for municipal planning and policy development.

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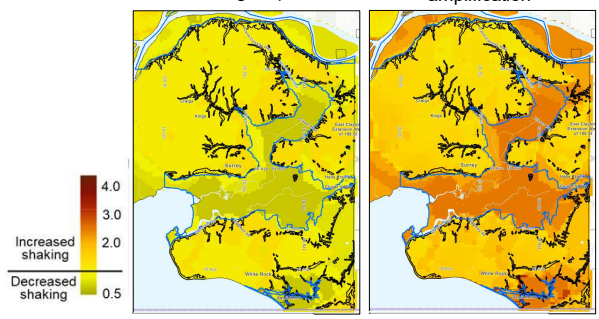
Risk Management Uses at LA Scale

Development Permit Areas, City of Surrey

MVSMMP Map 22, PGA shaking amplification

MVSMMP Map 26, SA(2 sec) shaking amplification



Assaf et al. (2024) 10.5683/SP3/ULMSX9

Assaf et al. (2024. 10.5683/SP3/ZIPEZX

- DPAs ensure development occurs 'appropriately' within distinct classifications of hazards (e.g., steep slopes, flood prone areas).
- 'Appropriately' is based on hazard-specific thresholds, either provincially mandated (e.g., 200-year floodplain) or 'generally accepted practice'
- Maps on left show comparison of City of Surrey's existing flood prone hazard DPA compared to the MVSMMP shaking amplification hazard mapping. Ongoing discussions with City of Surrey about adjusting / new hazard DPA boundaries.

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Thank you!
Questions?
How do you foresee using this new seismic hazard info?

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Provincial Disaster Risk Reduction Linkages

Metro Vancouver Seismic Microzonation Mapping Project

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ClimateReadyBC & Other Digital Products

ClimateReadyBC

- Helps communities and practitioners understand and reduce climate and disaster risk

EmergencyInfoBC

- Amplifies current and up to date information during emergencies

PreparedBC

- Provides personal preparedness information and resources

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ClimateReadyBC

- Developed as a one-stop online platform for communities and practitioners to understand and reduce disaster and climate risk
- Information and resources on hazards, data, tools, and funding
- Searchable and downloadable resource catalogue
- URL: https://climatereadybc.gov.bc.ca/
- Email: ClimateReadyBC.gov.bc.ca

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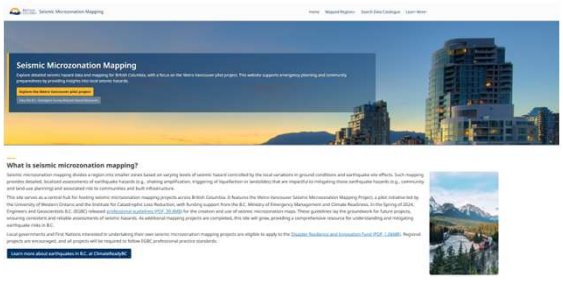
Accessing Seismic Microzonation Maps

Metro Vancouver Seismic Microzonation Mapping Project Website

- URL: metrovanmicromap.ca



BC Seismic Microzonation Mapping Portal

- Accessed via ClimateReadyBC - Earthquake
- URL: climatereadybc.gov.bc.ca/pages/earthquakes

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Emergency and Disaster Management Act – Risk assessment and planning

What is changing for municipalities and regional districts

- The Province has approved an Order in Council to bring EDMA risk assessment and planning requirements into effect for municipalities and regional districts starting January 1, 2027.
- Existing plans may provide a useful foundation that can be updated to meet the new requirements.
- EMCR guidance will indicate an expectation that this work should be completed within four years.
- EMCR will support implementation through guidance (available soon).

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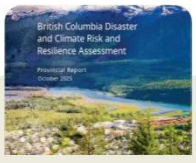
Disaster and Climate Risk and Resilience Assessment Resources

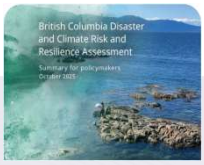
https://climatereadybc.gov.bc.ca/pages/dcrra



Full technical report

Hazard Insights Tool

Executive summary



Summary for policymakers

Story map

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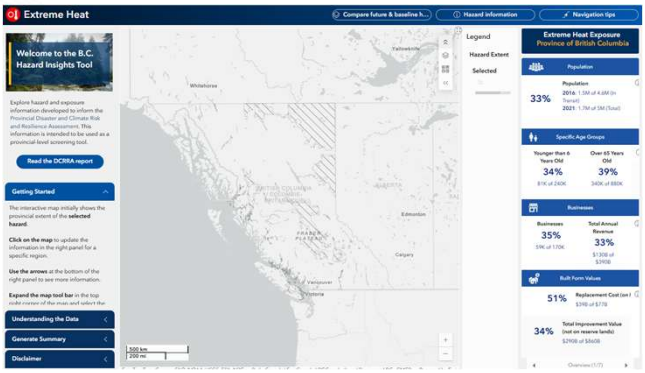
B.C. Hazard Insights Tool – HIT



- **Provincial-scale layer for six hazards**
  - New analysis, including future climate projections, for extreme heat, drought, coastal flood
  - Existing datasets used in new ways for wildfire, earthquake, riverine flood
- **Provincial-scale hazard-exposure analysis**
  - Population data, population vulnerability index, built environment assets, critical facilities, business data, environmental assets, etc.
- **Data and reports available for use**

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https://communityclimatefunding.gov.bc.ca/

Community Climate Funding Guide

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Thank you!

Robert White, Seismic Specialist
Seismic@gov.bc.ca

For EDMA questions, please contact:
EMCR Policy and Legislation
EMCR.PolicyandLegislation@gov.bc.ca

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Professional Practice

- Promote comprehension and use through professional practice standards

1. EGBC Technical Peer Review of project methodologies, analyses, and map outcomes
2. EGBC Professional Practice Guidelines *Development and Use of Seismic Microzonation Maps in British Columbia*

How is this unique?
There is no Canadian standard or guidelines for SMM

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Guidelines (published May 2024)
Use and Development of Seismic Microzonation Maps in BC

Webinar available online
Professional Practice Guidelines: Use and Development of Seismic Microzonation Maps in BC

Note that EGBC has a new practice advisory about
Site Response Analysis and Site-Specific Response Spectra

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EGBC Professional Practice Guidelines
Development and Use of Seismic Microzonation Maps in British Columbia

The intent of these guidelines is to:

- Provide a **common approach for development** of seismic microzonation maps in British Columbia
- Provide a **common approach for use** of seismic microzonation maps in BC
- Inspire the effective use of new and existing microzonation maps

The intended audiences for these guidelines are:

● Local governments & First Nations & Treaty Nations ● Structural engineers ● Geotechnical engineers ● Liquefaction mapping professionals ● Landslide mapping professionals ● Ground shaking mapping professionals ● Others (e.g., infrastructure owners, re/insurers)

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Map Review and Feedback Interactive Session

- Four "map stations" to visit and review the drafted MVSMMP Phase II eastern Metro Vancouver select mapping
  - Seismic shaking susceptibility maps
    - **H1**, Thickness of softer sediments
    - **Vs30**, Time-averaged shear-wave velocity of the top 30 meters
  - **Liquefaction Susceptibility and Hazard Mapping**
  - **Landslide Susceptibility and Hazard Mapping**

- Invest your time in understanding the different types of maps. Get a 'feel' for the upcoming final map products.
- Refer to the questions at each station. Help to provide oral, written, or digital feedback. Let us know how we are doing!

"The map is wrong because…"
"These maps are great and I plan to use them for…"

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Thank you and Closing

Thank you for your time reviewing the draft MVSMMP maps of eastern Metro Vancouver. Your feedback helps us to improve these digital products.

Coming in 2027!

Today's session was organized by Western University with the BC Ministry of Emergency Management and Climate Readiness (Maggie Mazurkewich, Robert White) in support by Thrive Consulting (Jessica Shoubridge) and IPREM (Anna Kelemen).

We are grateful to Katzie First Nation elders Ed and Yvonne Pierre for today's opening and Pipaːmʼ Catering for today's treats.

https://pipamcatering.com/

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