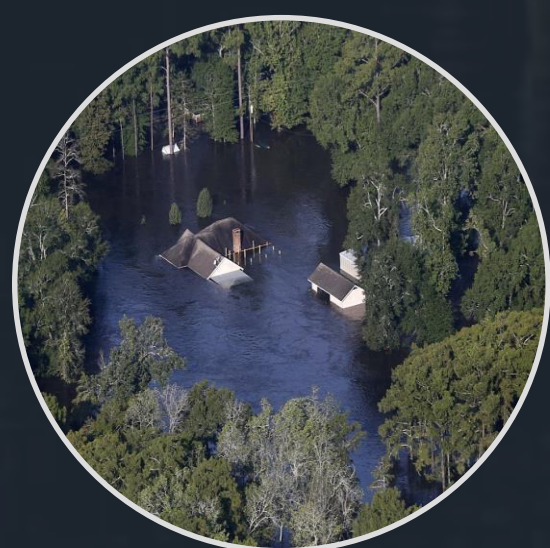




Murray Journey, NRCan
Working together to reduce
earthquake risk in BC



Madeline Maley, BC Wildfire Service
Learning from this year's unprecedented
wildfire season



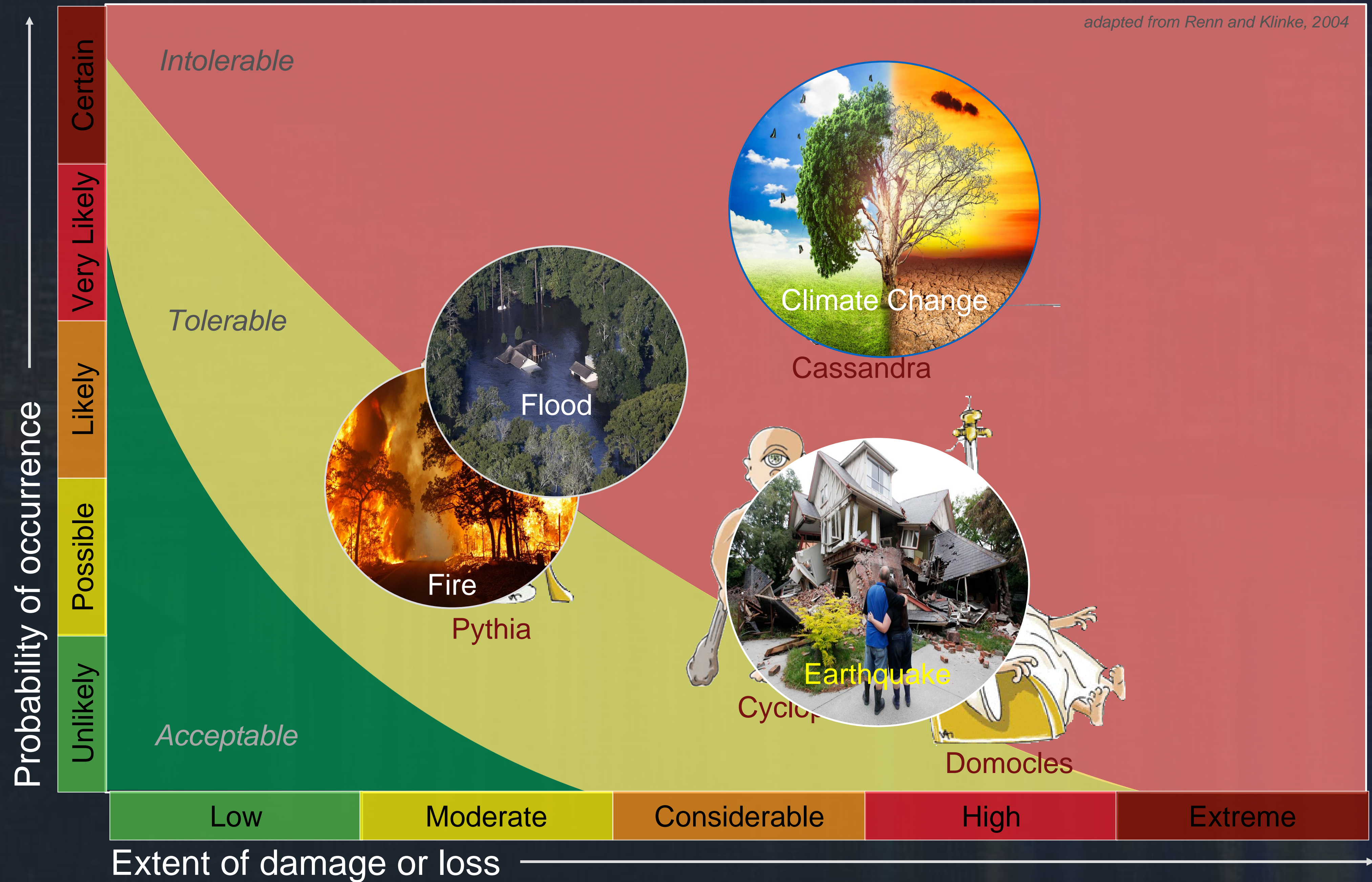
Tamsin Lyle, Ebbwater
State of play in flood mapping,
modeling and mitigation in BC



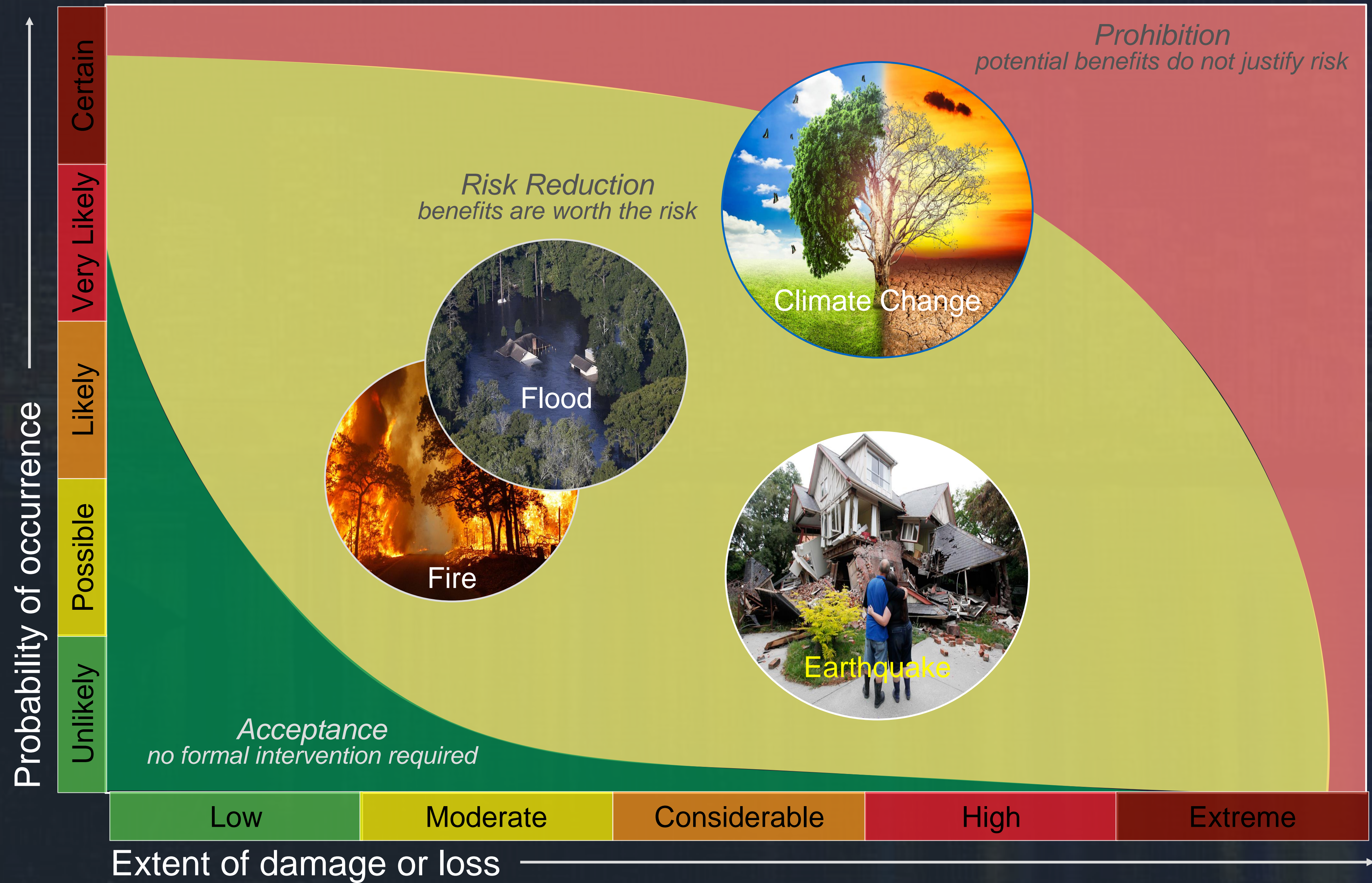
Jessica Shoubridge, EERI
Connecting Challenges with Solutions: Planning
and Building for a More Resilient BC

How we make sense of risk

adapted from Renn and Klinke, 2004



Evaluating risk reduction opportunities





Dynamics of Risk

Hazard



Vulnerability

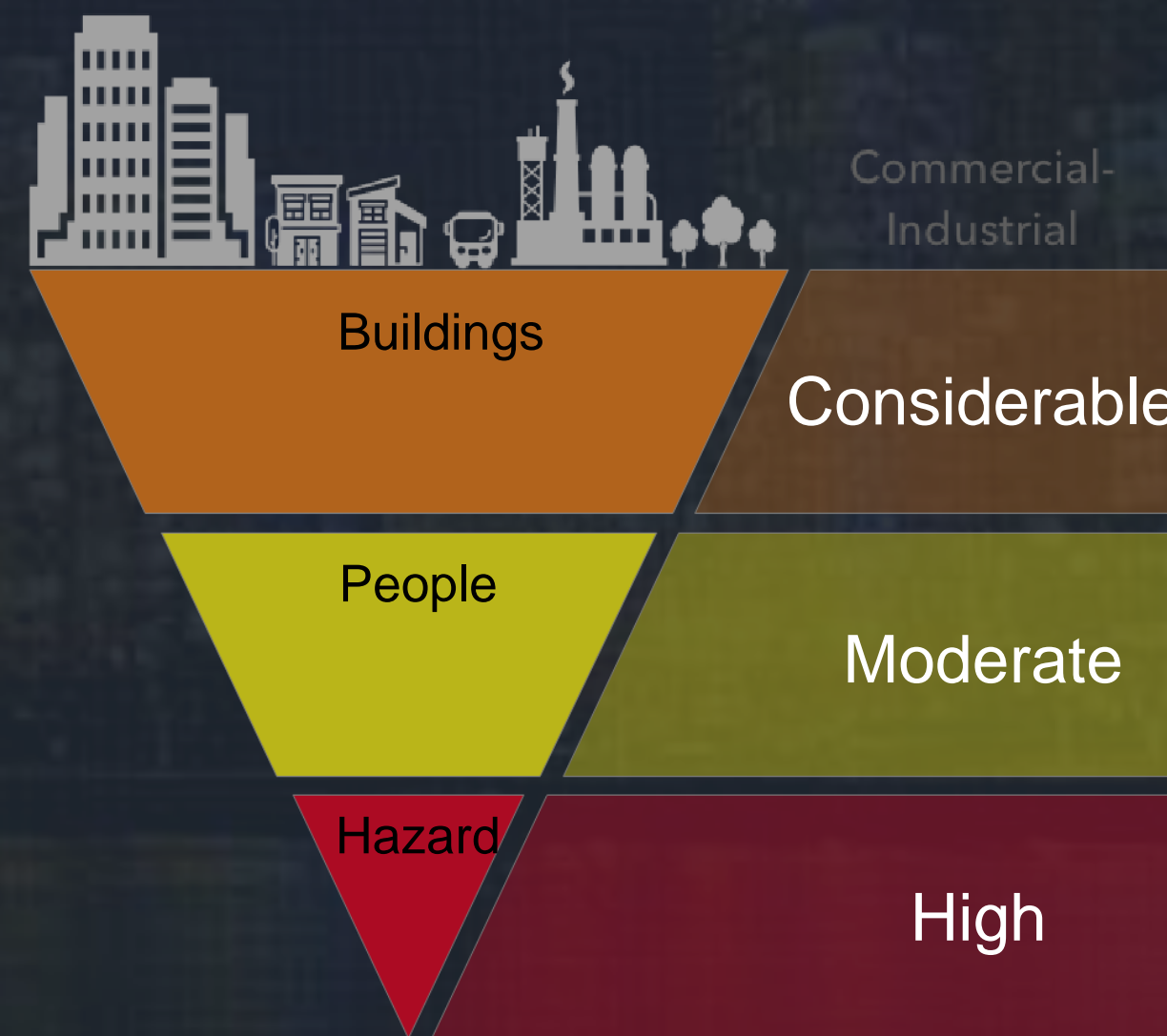
Exposure

Developing a multi-hazard risk profile for BC

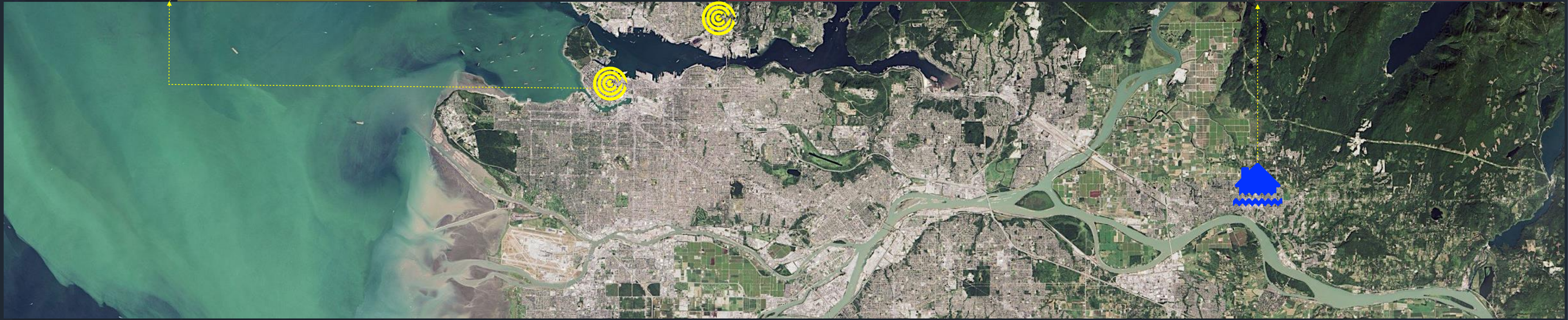
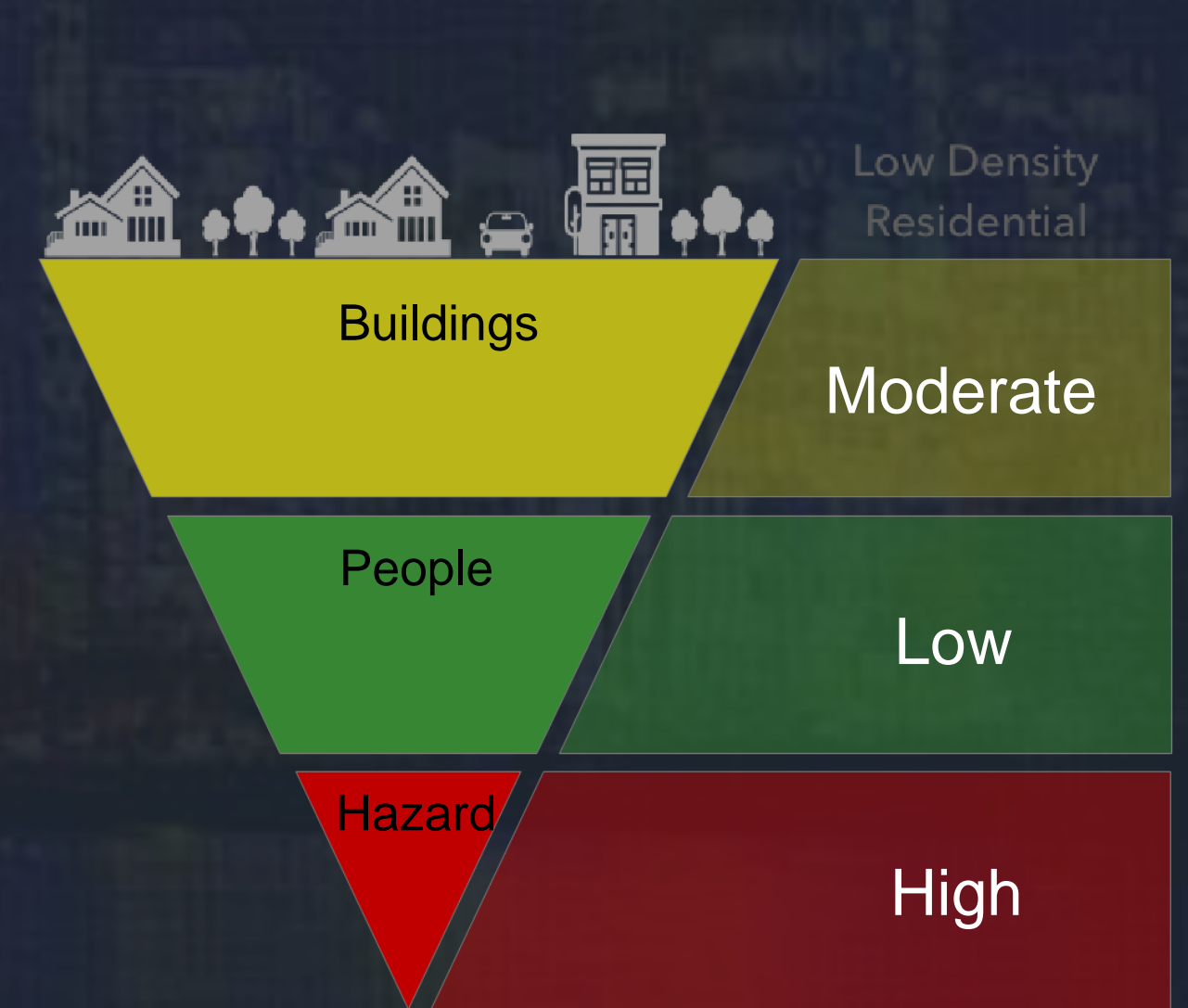
High-Density Residential



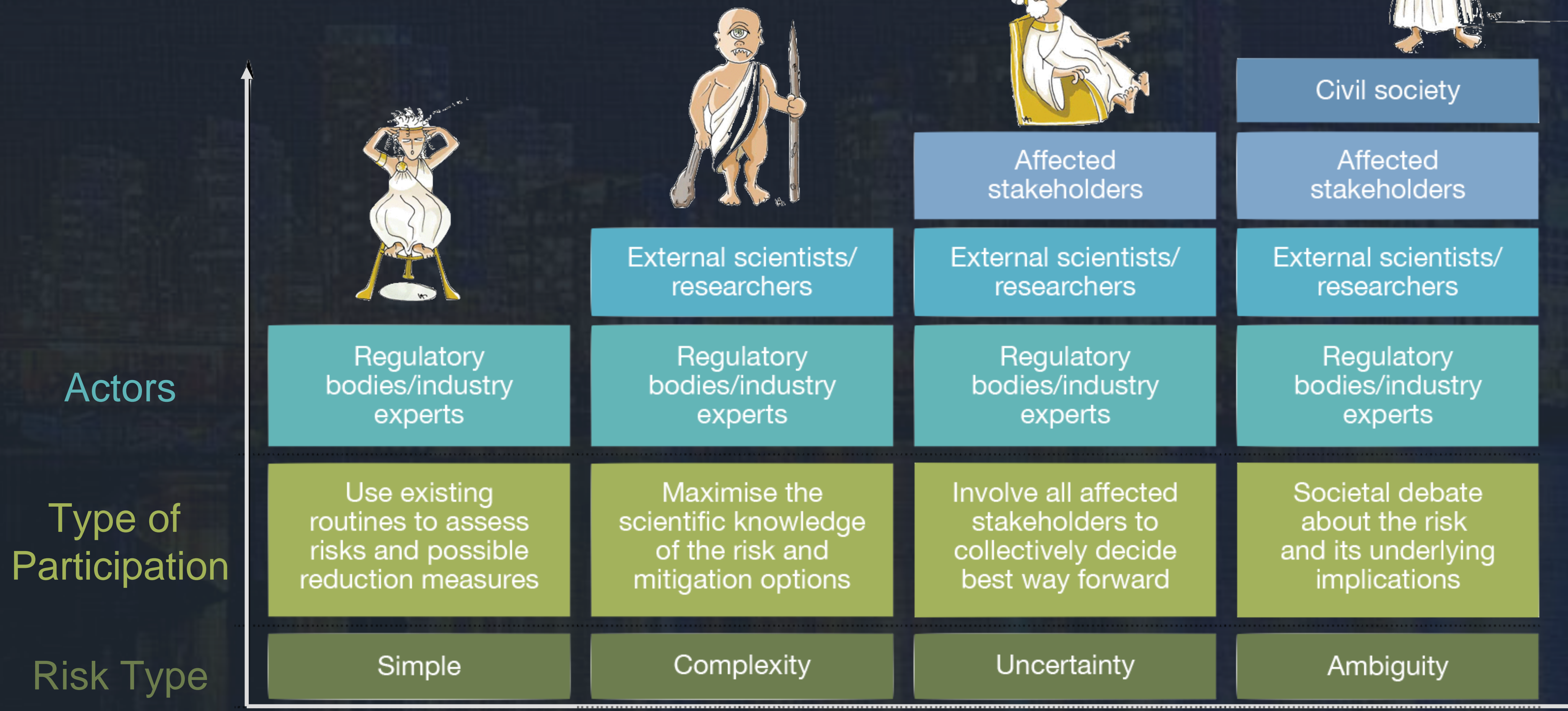
Commercial-Industrial



Low-Density Residential



Toward a regional risk governance framework for BC






As the dominant characteristic changes, so also will the type of stakeholder involvement need to change

A wide-angle aerial photograph of Vancouver, British Columbia, taken during the golden hour of sunset. The city's skyline is visible in the distance, with the mountains of the Pacific Northwest range in the background. The foreground shows a dense forest of evergreen trees, with a residential area and a large suspension bridge (the Lions Gate Bridge) visible in the middle ground. The water of the harbor is calm, reflecting the warm light of the setting sun.

Working Together to Reduce
Earthquake Risk in British Columbia

Murray Journey
Land and Minerals Sector, NRCan

National Benefit-Cost Ratio Per Peril <small>*BCR numbers in this study have been rounded</small>	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1

 Riverine Flood	7:1	5:1
 Hurricane Surge	Too few grants	7:1
 Wind	5:1	5:1
 Earthquake	3:1	4:1
 Wildland-Urban Interface Fire	3:1	4:1

NIBS 2017: Mitigation Saves

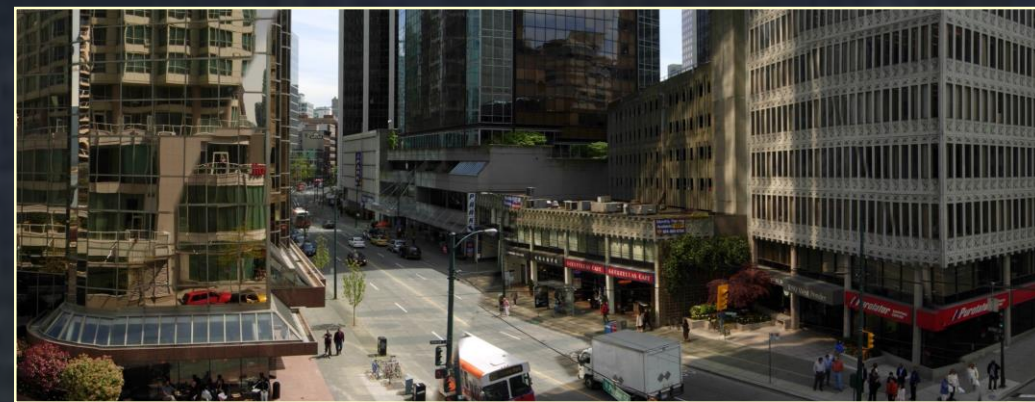
empowering risk reduction planning



Motivating Questions



What is the likelihood of experiencing a catastrophic earthquake in the next 50 yrs?



What are the underlying factors driving increasing disaster risk trends in Canada?



What are the likely impacts and consequences of a catastrophic earthquake?



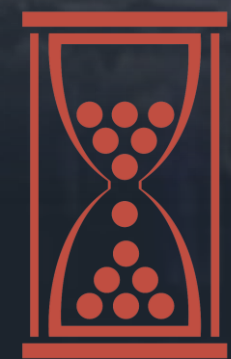
What are the financial incentives and co-benefits of investing in disaster risk reduction?



How can knowledge about earthquake risk be used to inform disaster resilience planning?

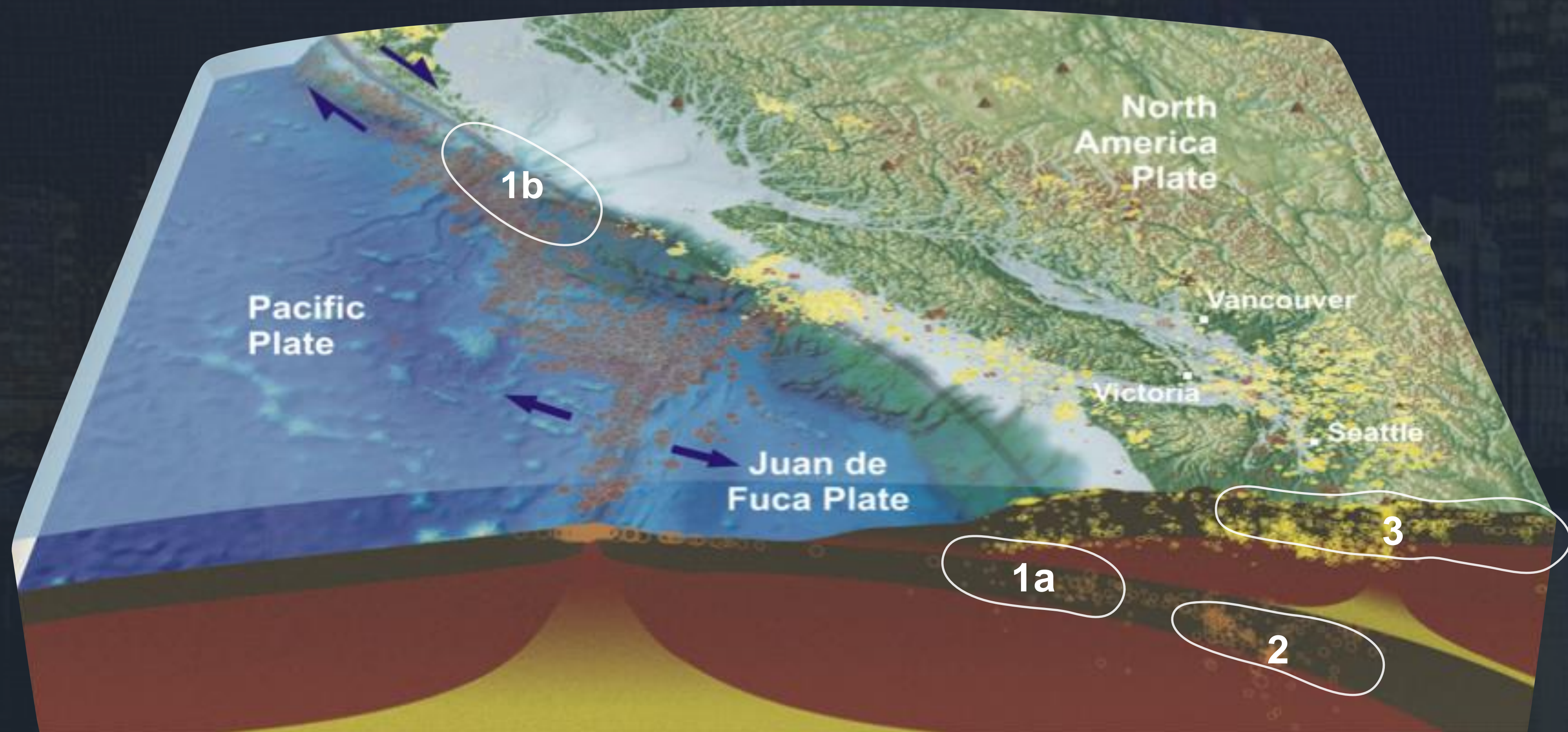


CC



What is the likelihood of experiencing a catastrophic earthquake in the next 50 yrs?

Seismic Source Zones in southwest British Columbia



1) Plate Boundary Earthquakes

- a) Cascadia Megathrust (M9.0)
- b) Queen Charlotte Fault (M7.2)


2) Deep Crustal Earthquakes

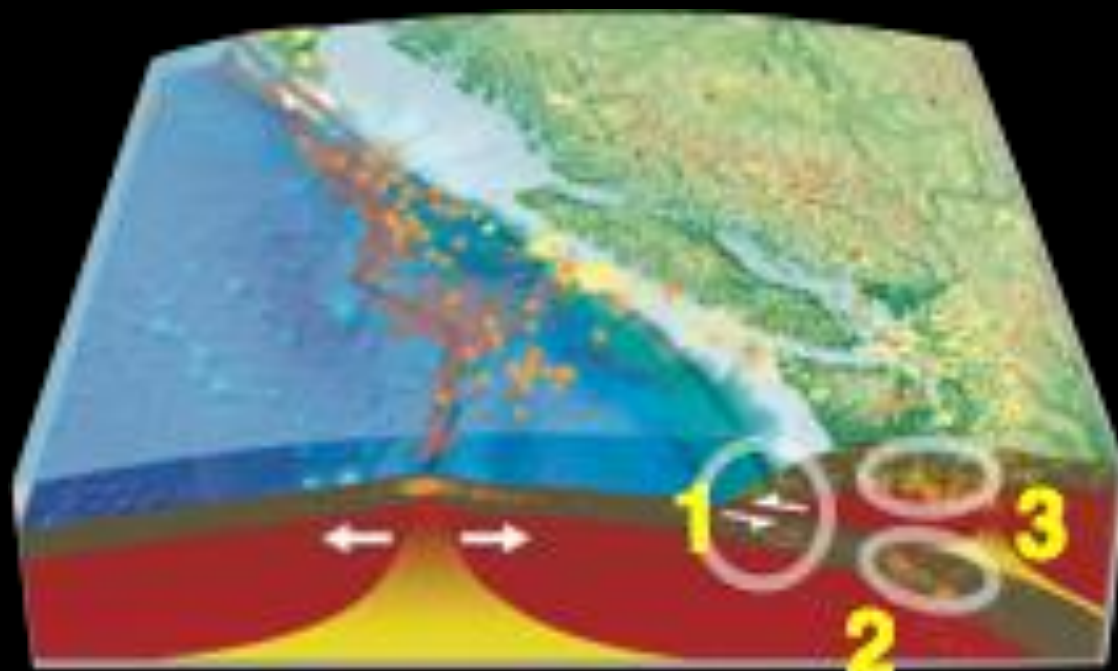
- a) Subduction Intraslab (M6.8)
30-50km depths

3) Shallow Crustal Earthquakes


- a) Boundary Bay (M7.3)
- b) Leech River (M7.3)
- c) Georgia Strait (M7.3)
- d) Beaufort Range (M7.3)

 Hazard Potential

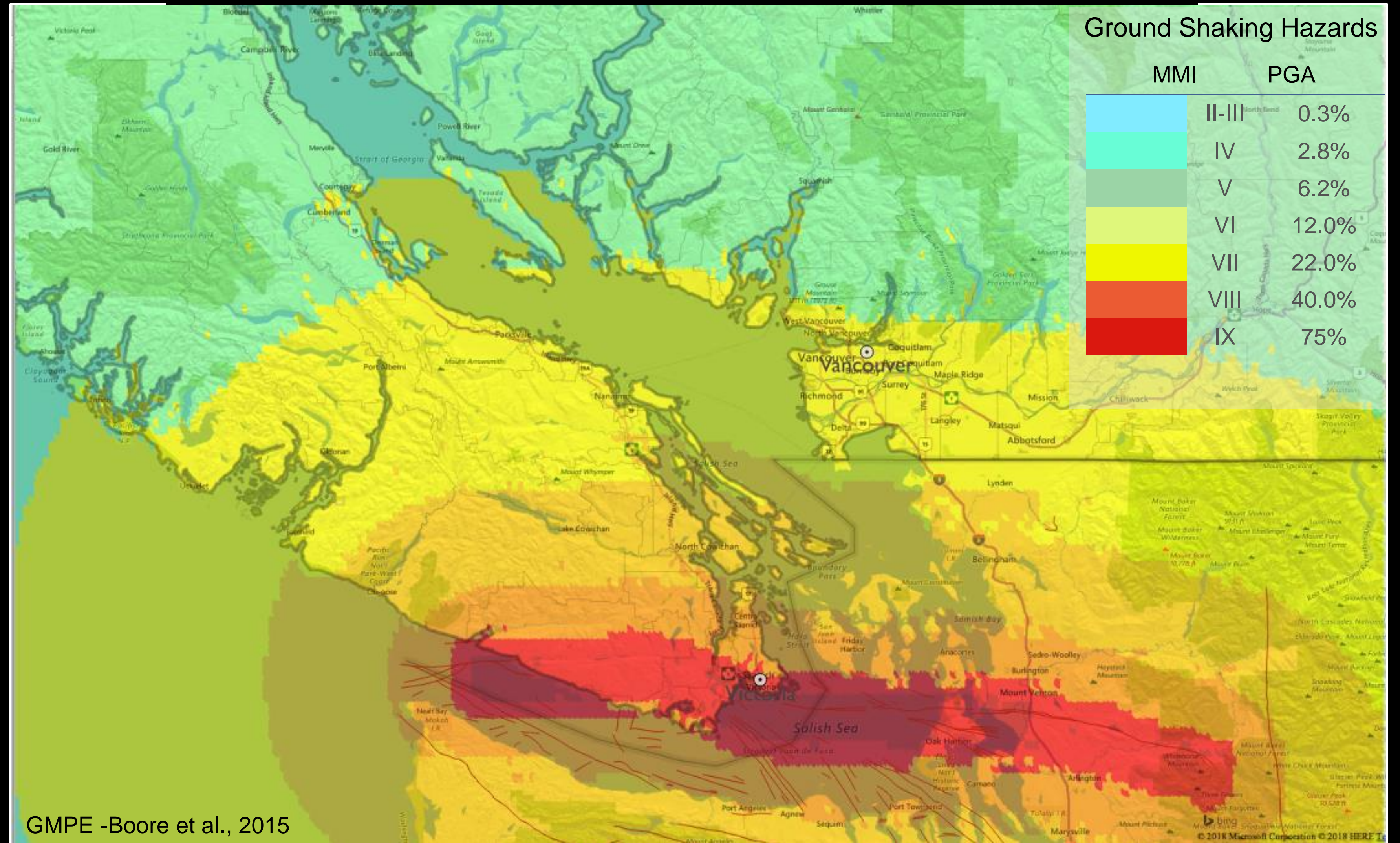
3 
Shallow Crustal



Location & recurrence uncertain in Canada; possible every few hundred to thousands of years

 < 7% over a 30 year time horizon
(Hyndman et al., 2003)

Leech River Shallow Crustal Earthquake Scenario (M7.3)

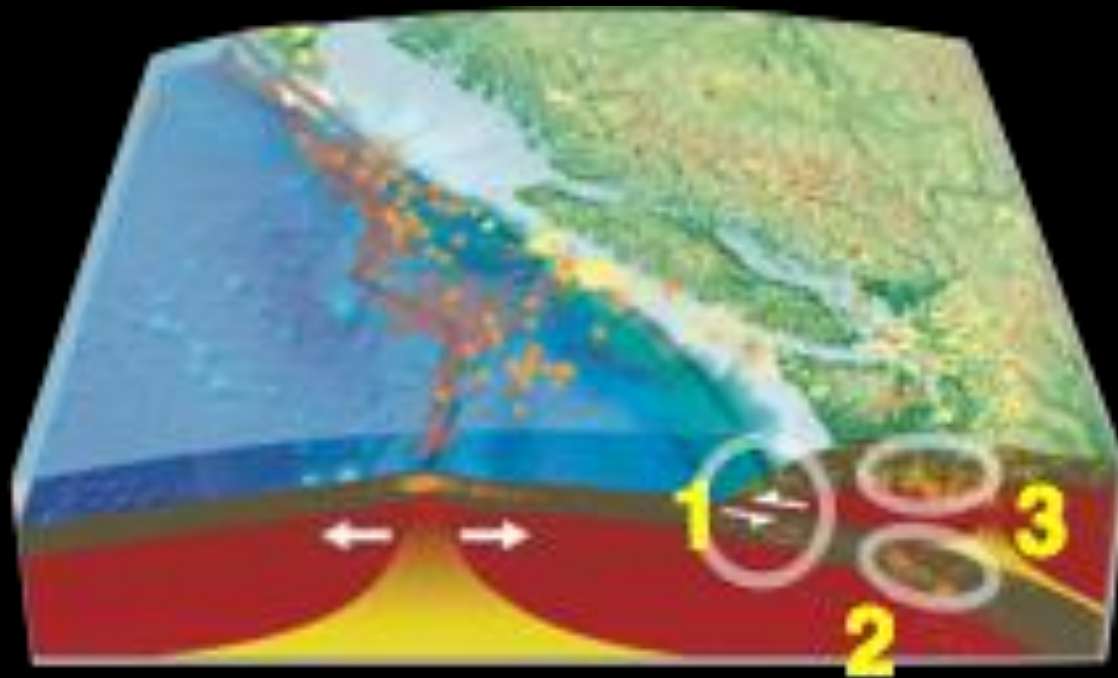


 Hazard Potential


Gulf Island Subduction Intraslab Earthquake Scenario (M6.8)

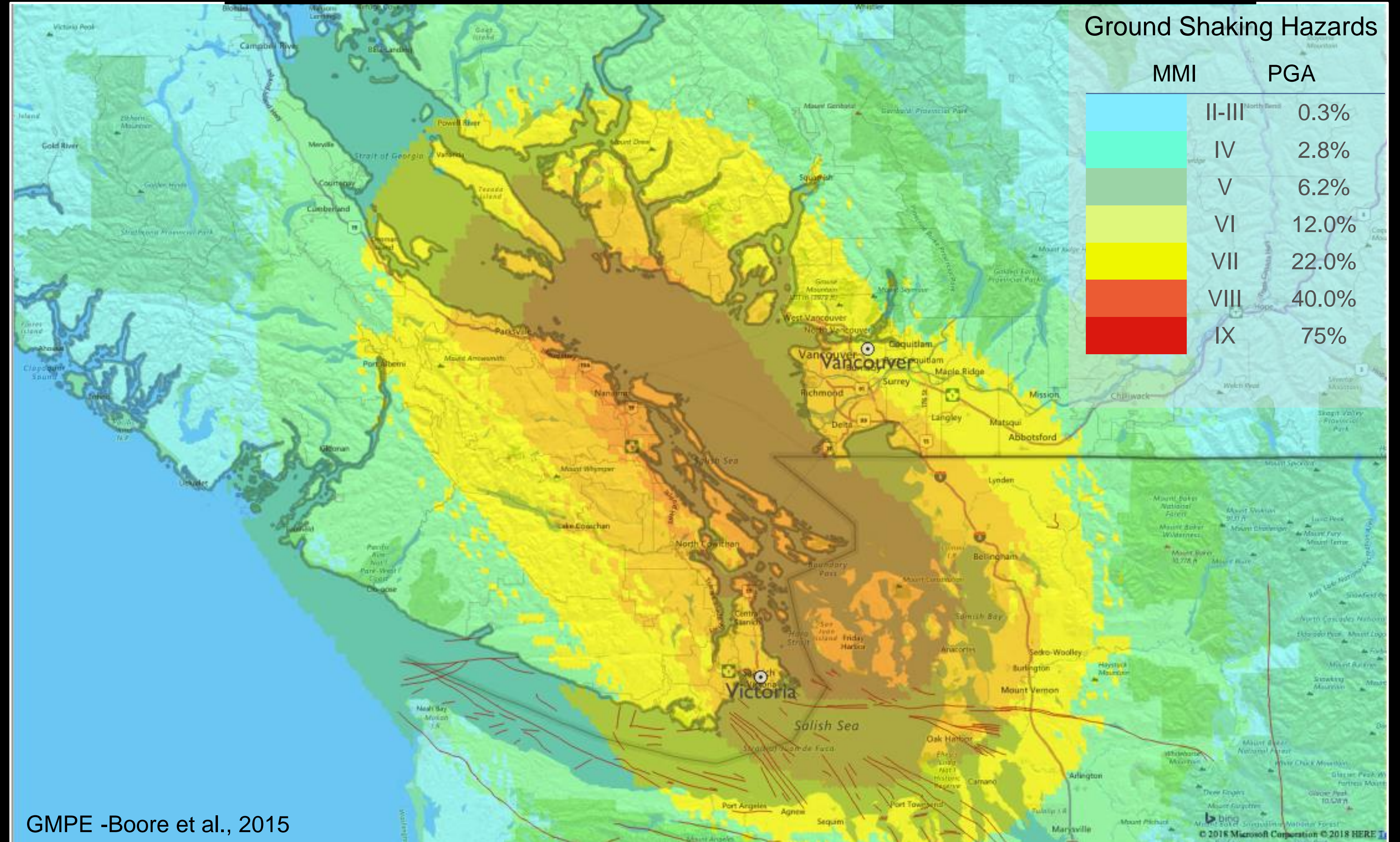
2 

Subduction Intraslab



Damaging earthquakes occur every 10-30 years in the Puget Sound area, and less frequently elsewhere.

 < 40 % over a 30 year time horizon (CREW, 2015)

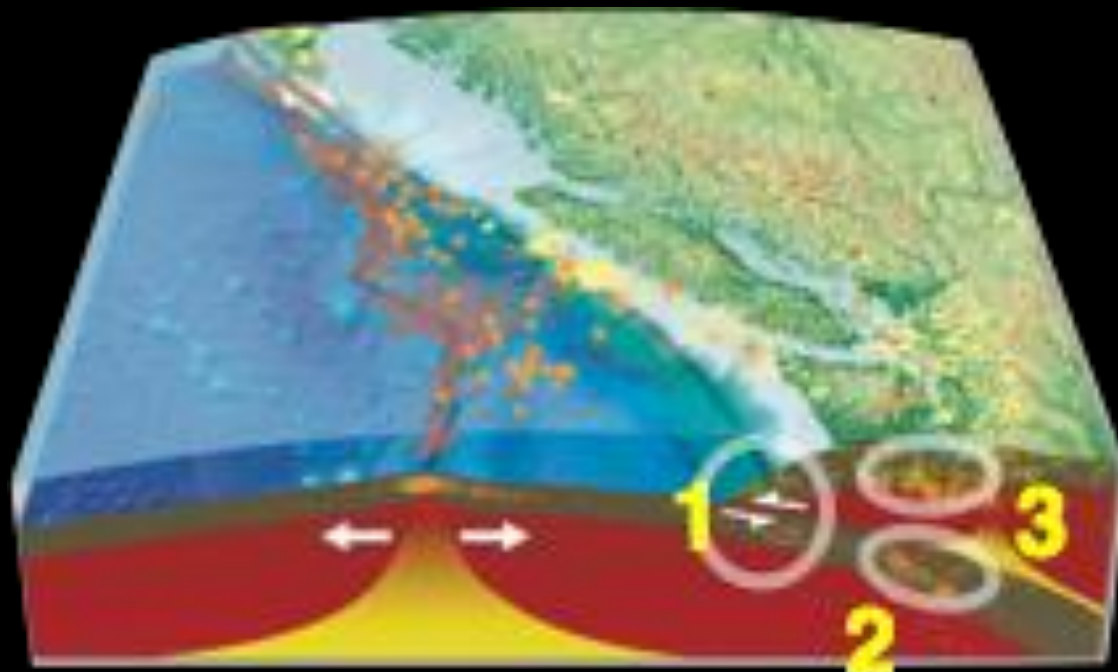


 Hazard Potential

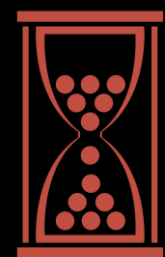
Cascadia Megathrust Earthquake Scenario (M9.0)



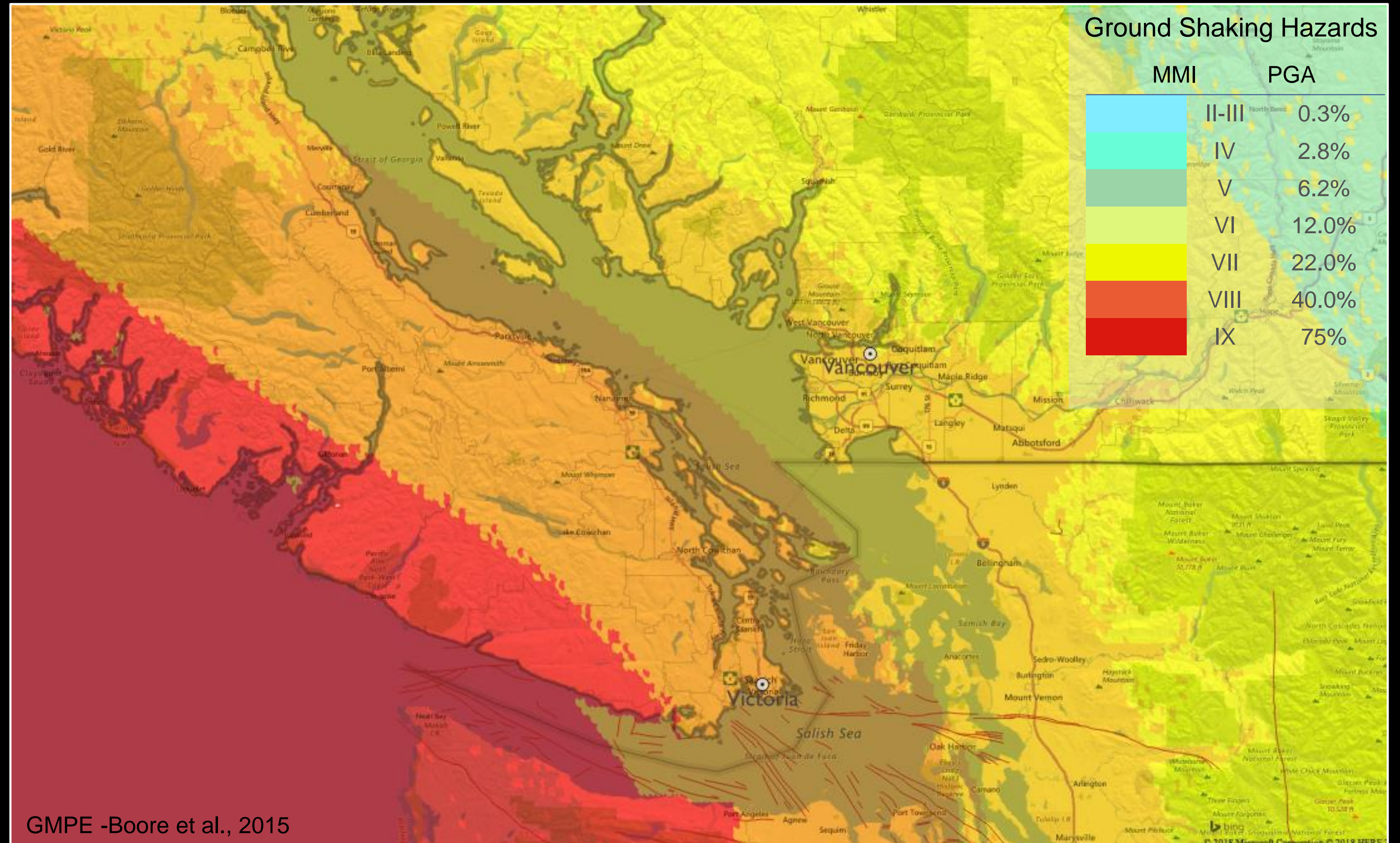
Plate Boundary

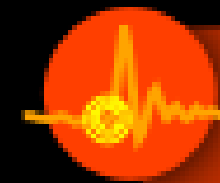


Geological evidence suggests an average of 500 years between major events.



~ 7 % chance over a 30 year time horizon (Goldfinger et al., 2012)





Hazard Potential

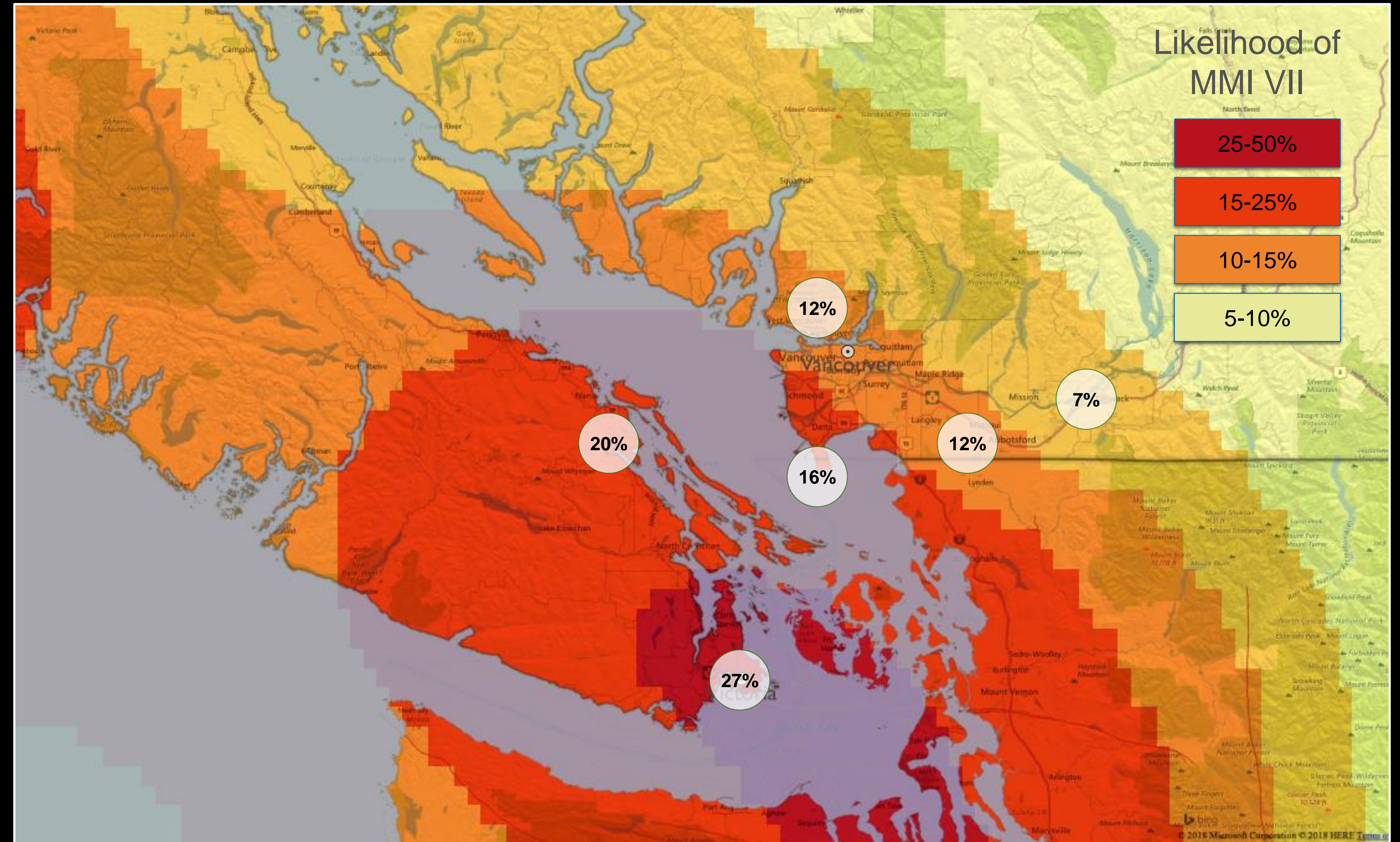
MMI Modified Mercalli Index

Intensity	Shaking	Physical Impacts
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
		Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.



Likelihood of experiencing a damaging earthquake (> MMI VII) in the next 50 years

Source: Trevor Allen, Tuna Onur and Mark Seemann, 2017 (in prep)





What is the overall profile of earthquake risk for
British Columbia ?

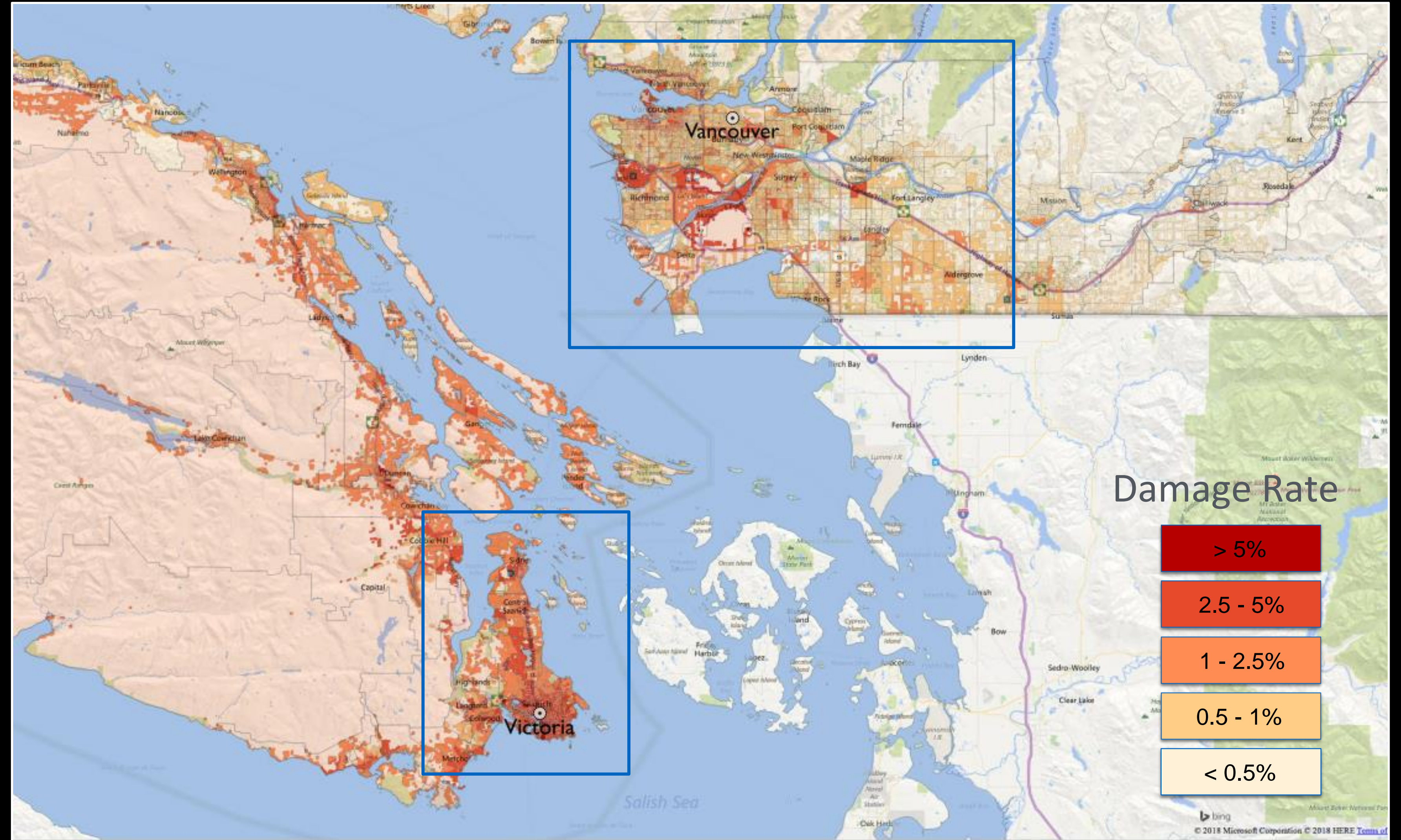
 Building Performance

Expected Damage Profile for all known Seismic Source Zones in BC

Source: Geological Survey of Canada, 2018 (in prep)

Damage Rate

Bldg Class	Eq Des L..	Damage Rate
Concrete	HC	1.0%
	MC	4.4%
	LC	24.5%
	PC	21.0%
Manufactured	HC	11.4%
	MC	12.0%
	LC	9.3%
	PC	7.4%
Precast	HC	0.4%
	MC	1.9%
	LC	9.9%
	PC	14.7%
RMasonry	HC	0.2%
	MC	3.2%
	LC	14.8%
	PC	12.0%
Steel	HC	1.2%
	MC	6.3%
	LC	29.8%
	PC	34.5%
URMasonry	LC	5.3%
	PC	7.5%
Wood	HC	0.2%
	MC	0.9%
	LC	5.1%
	PC	11.2%



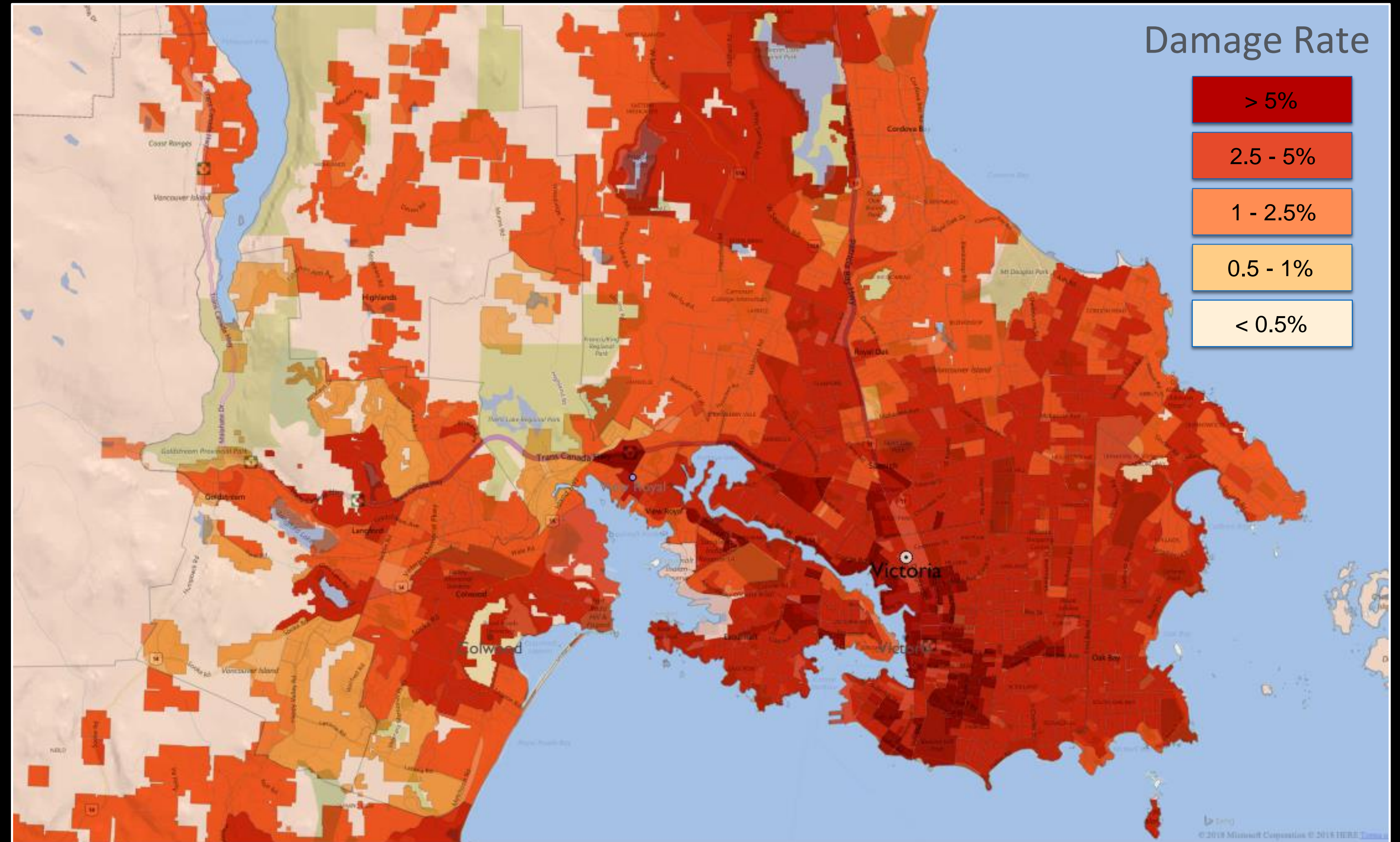
 Building Performance

Expected Damage Profile for all known Seismic Source Zones in BC

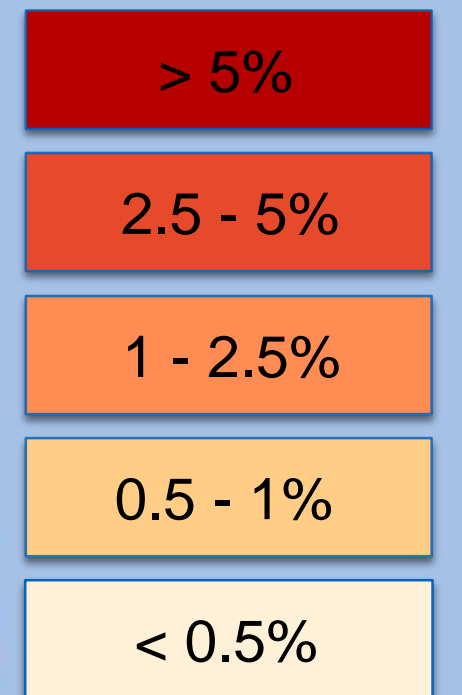
Source: Geological Survey of Canada, 2018 (in prep)

Damage Rate

Bldg Class	Eq Des L..	Damage Rate
Concrete	HC	1.0%
	MC	4.4%
	LC	24.5%
	PC	21.0%
Manufactured	HC	11.4%
	MC	12.0%
	LC	9.3%
	PC	7.4%
Precast	HC	0.4%
	MC	1.9%
	LC	9.9%
	PC	14.7%
RMasonry	HC	0.2%
	MC	3.2%
	LC	14.8%
	PC	12.0%
Steel	HC	1.2%
	MC	6.3%
	LC	29.8%
	PC	34.5%
URMasonry	LC	5.3%
	PC	7.5%
Wood	HC	0.2%
	MC	0.9%
	LC	5.1%
	PC	11.2%



Damage Rate



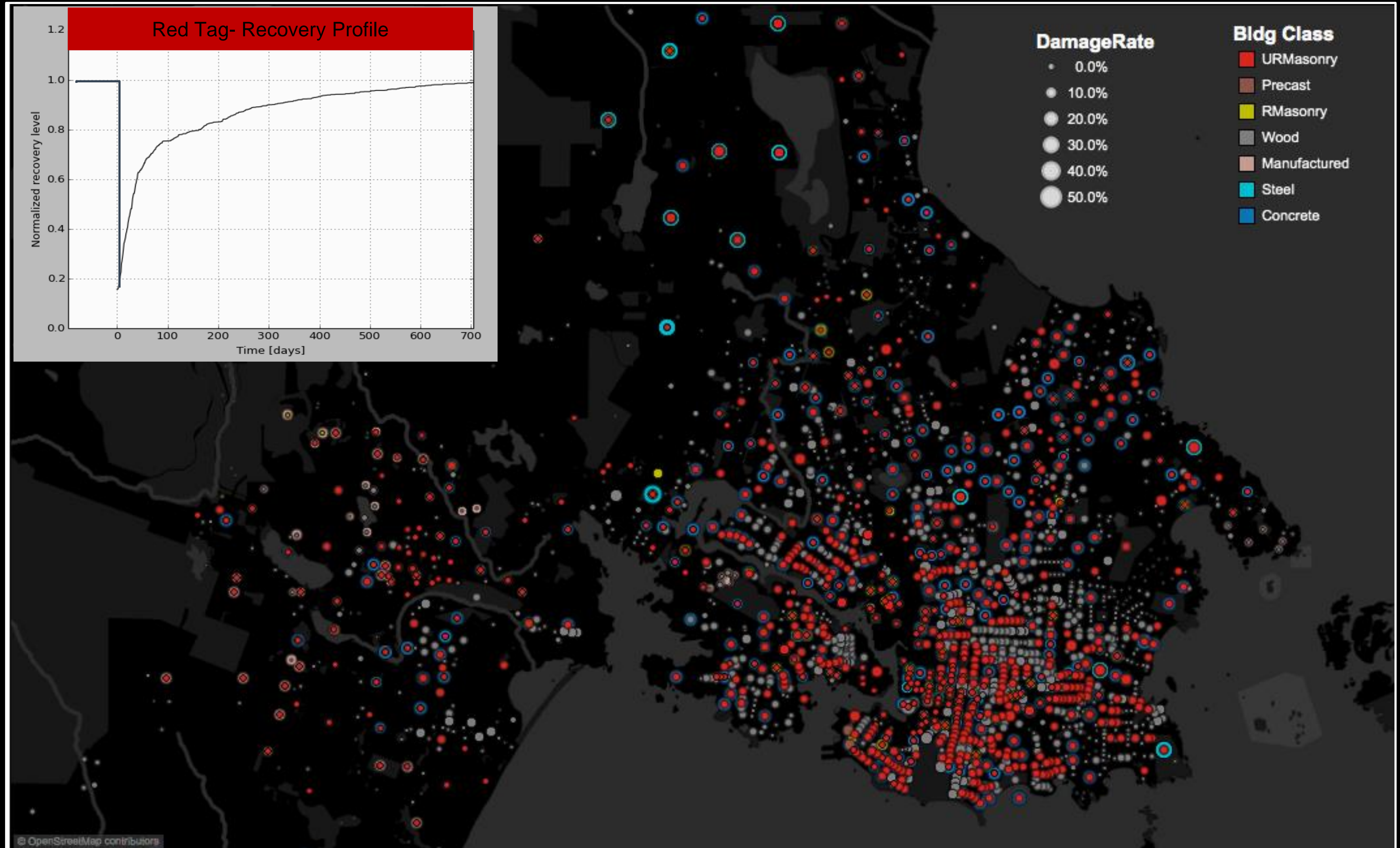
 Building Performance

Expected Damage Profile for all known Seismic Source Zones in BC

Source: Geological Survey of Canada, 2018 (in prep)

Damage Rate

Bldg Class	Eq Des L..	Damage Rate
Concrete	HC	1.0%
	MC	4.4%
	LC	24.5%
	PC	21.0%
Manufactured	HC	11.4%
	MC	12.0%
	LC	9.3%
	PC	7.4%
Precast	HC	0.4%
	MC	1.9%
	LC	9.9%
	PC	14.7%
RMasonry	HC	0.2%
	MC	3.2%
	LC	14.8%
	PC	12.0%
Steel	HC	1.2%
	MC	6.3%
	LC	29.8%
	PC	34.5%
URMasonry	LC	5.3%
	PC	7.5%
Wood	HC	0.2%
	MC	0.9%
	LC	5.1%
	PC	11.2%



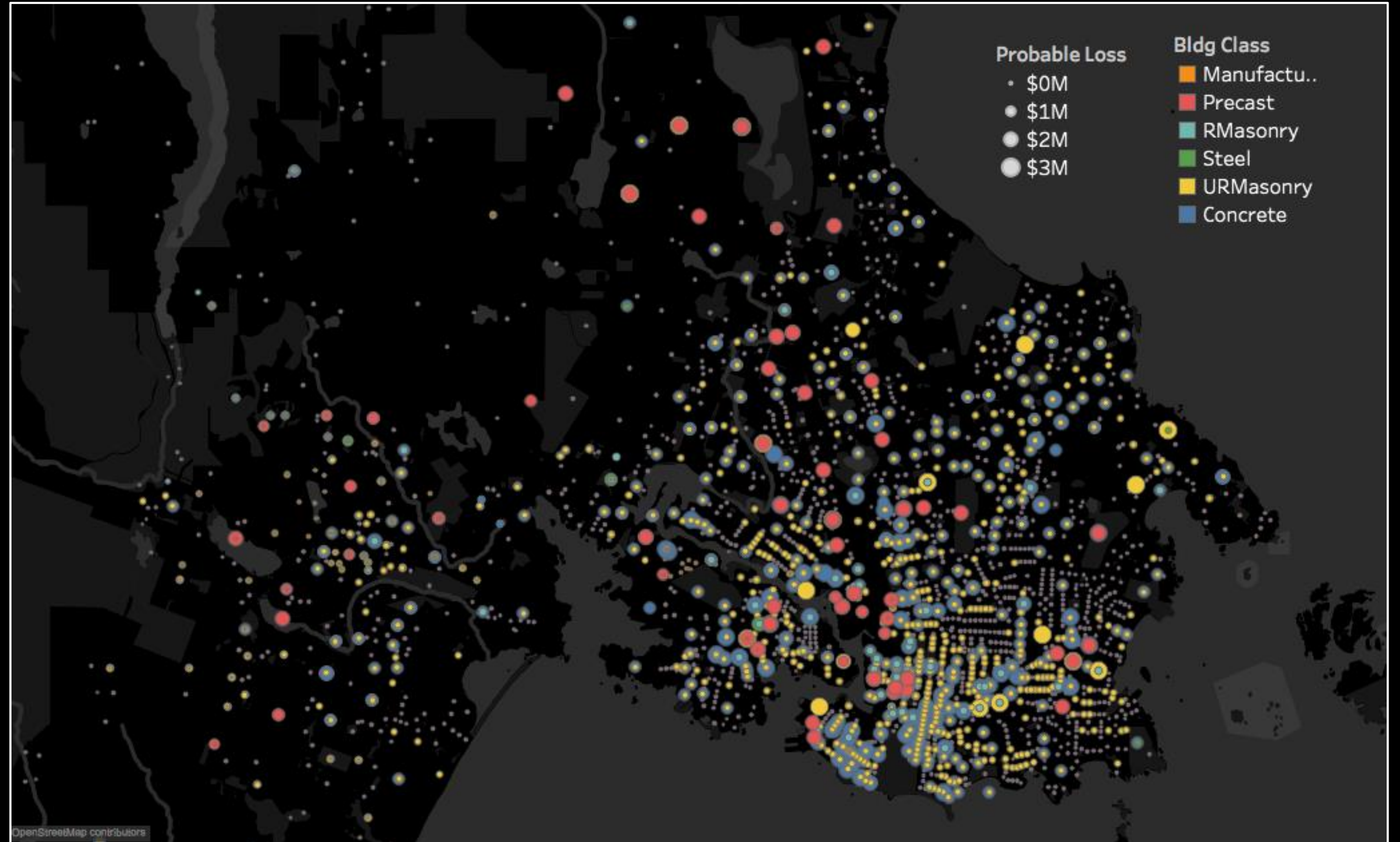
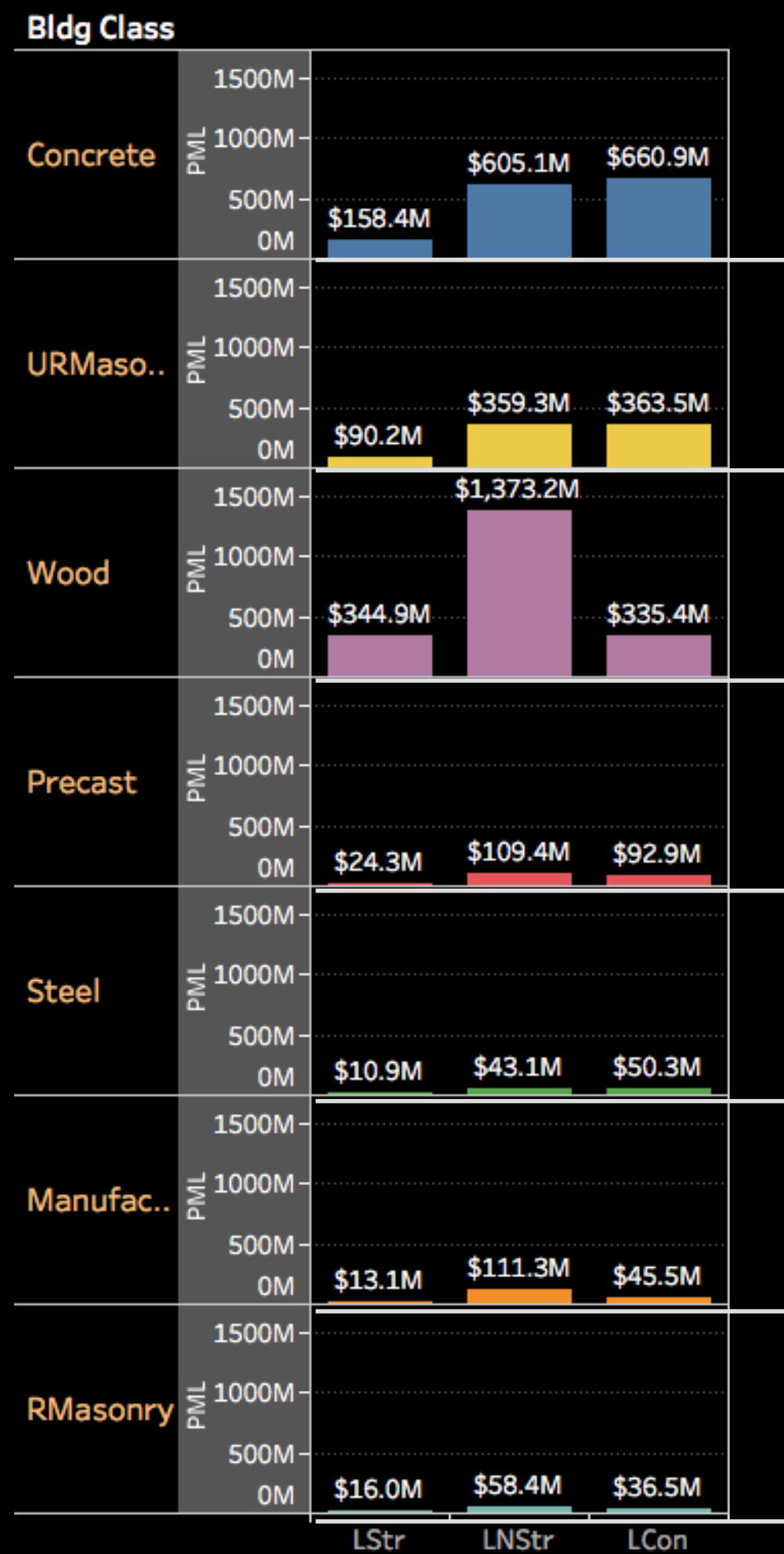


Financial Loss (PML)

Expected Loss Profile for all known Seismic Source Zones in BC

Source: Geological Survey of Canada, 2018 (in prep)

Probable Loss



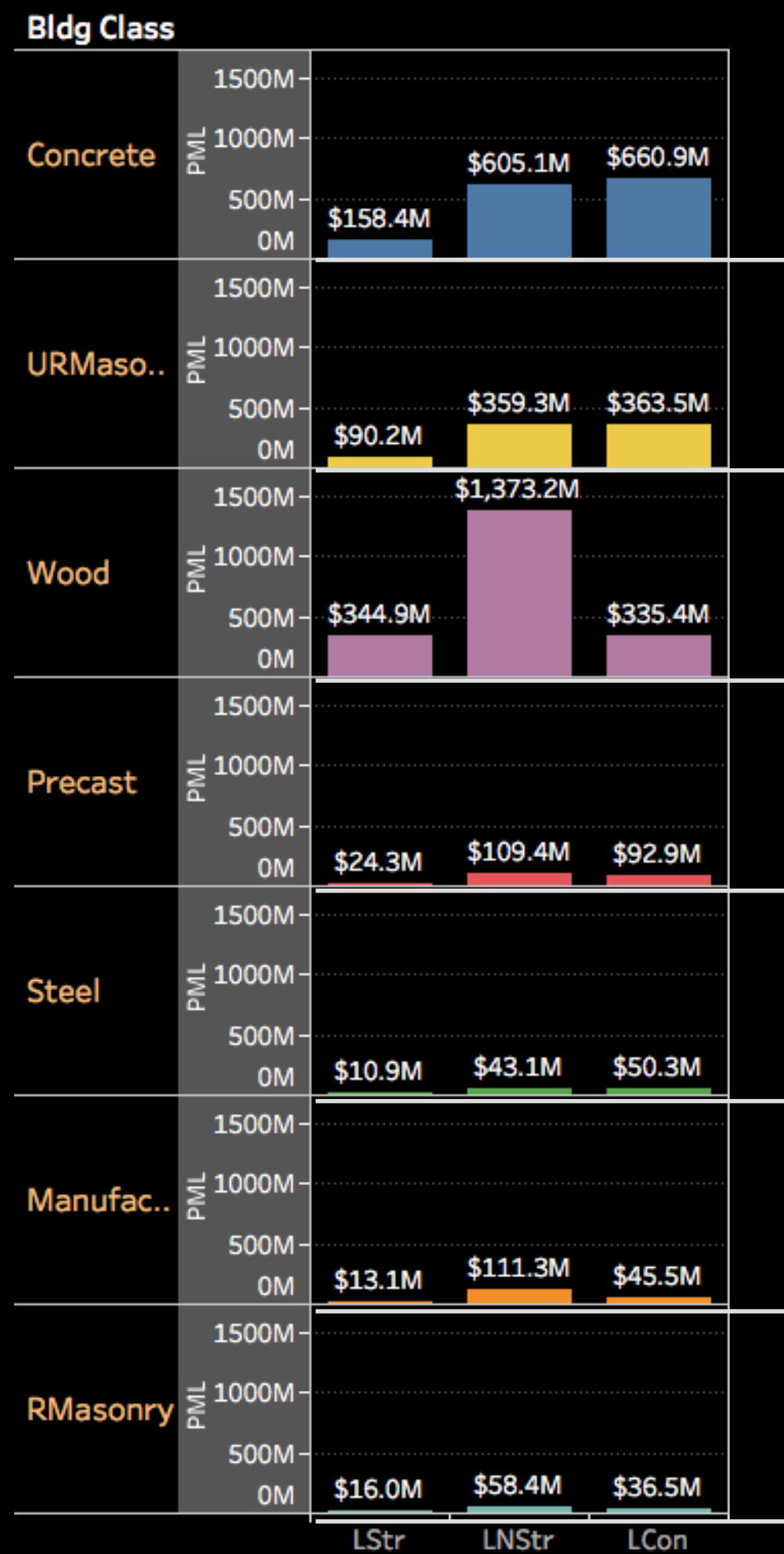


Financial Loss (PML)

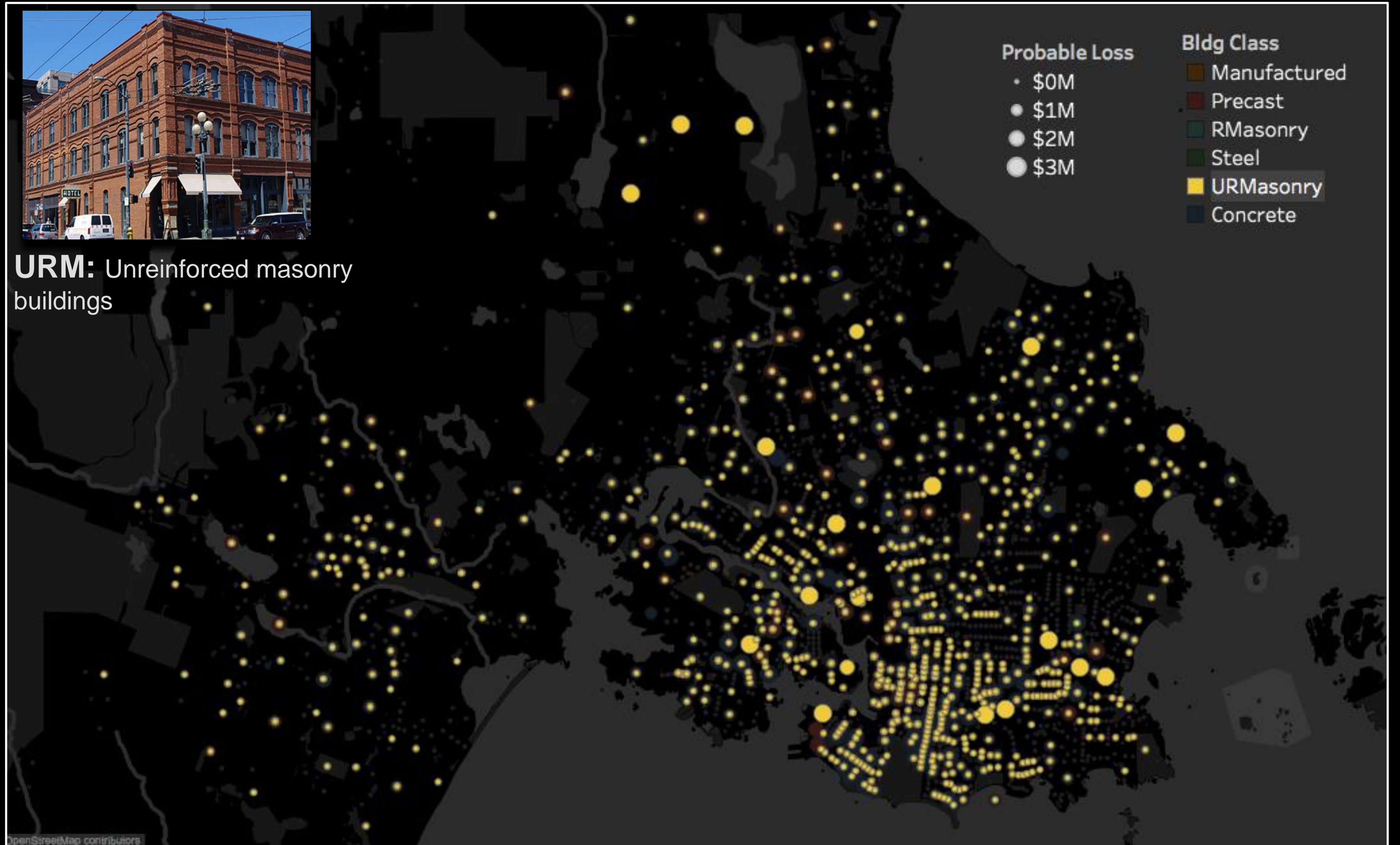
Expected Loss Profile for all known Seismic Source Zones in BC

Source: Geological Survey of Canada, 2018 (in prep)

Probable Loss



URM: Unreinforced masonry buildings





What is the loss reduction potential through proactive investments in structural mitigation?

Evaluating Risk Reduction Strategies



- 1) Risk assessment process must be driven by policy priorities
- 2) Performance measures are the bridge between science & policy
- 3) Evaluating risk reduction potential is the stimulus for action

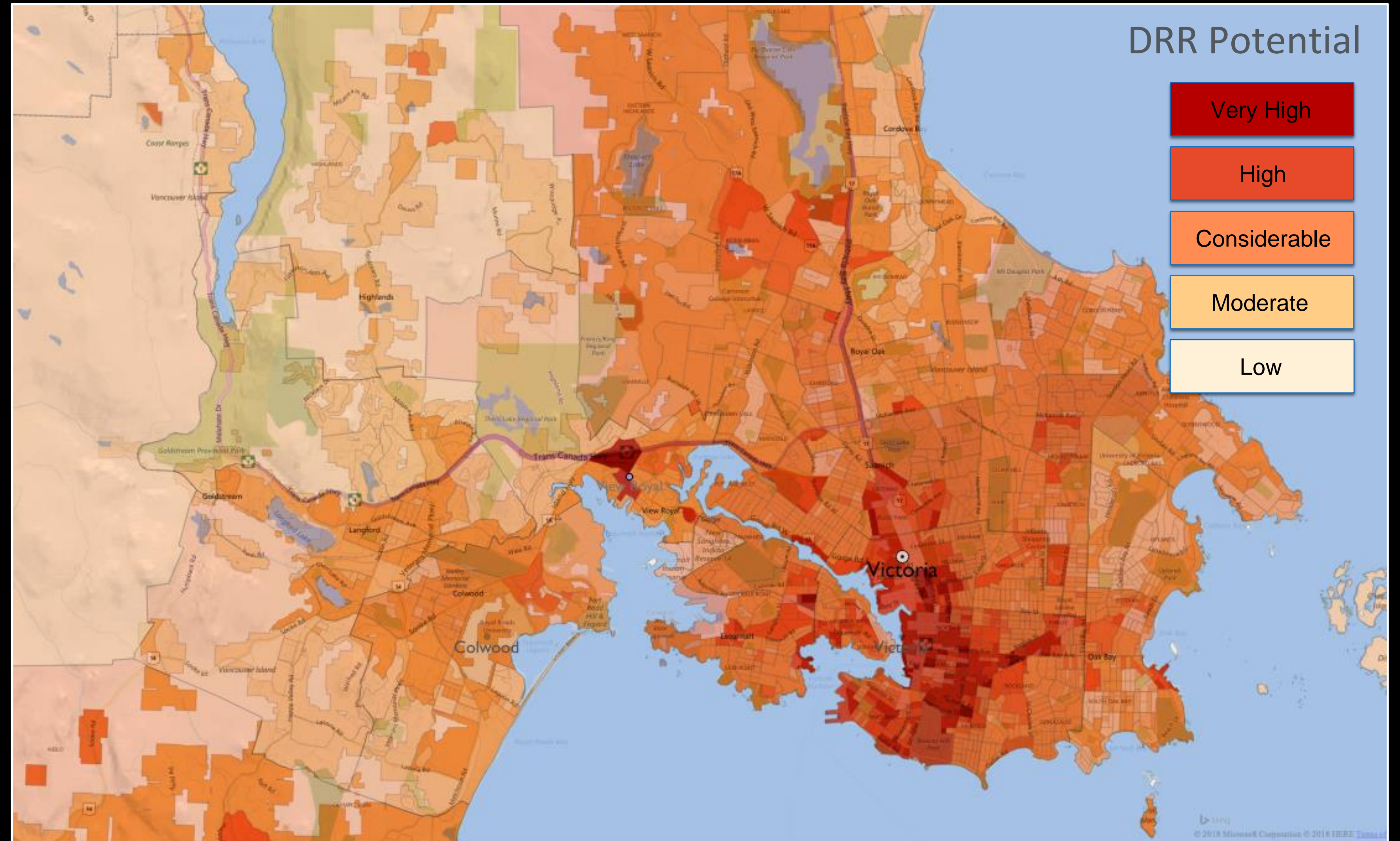
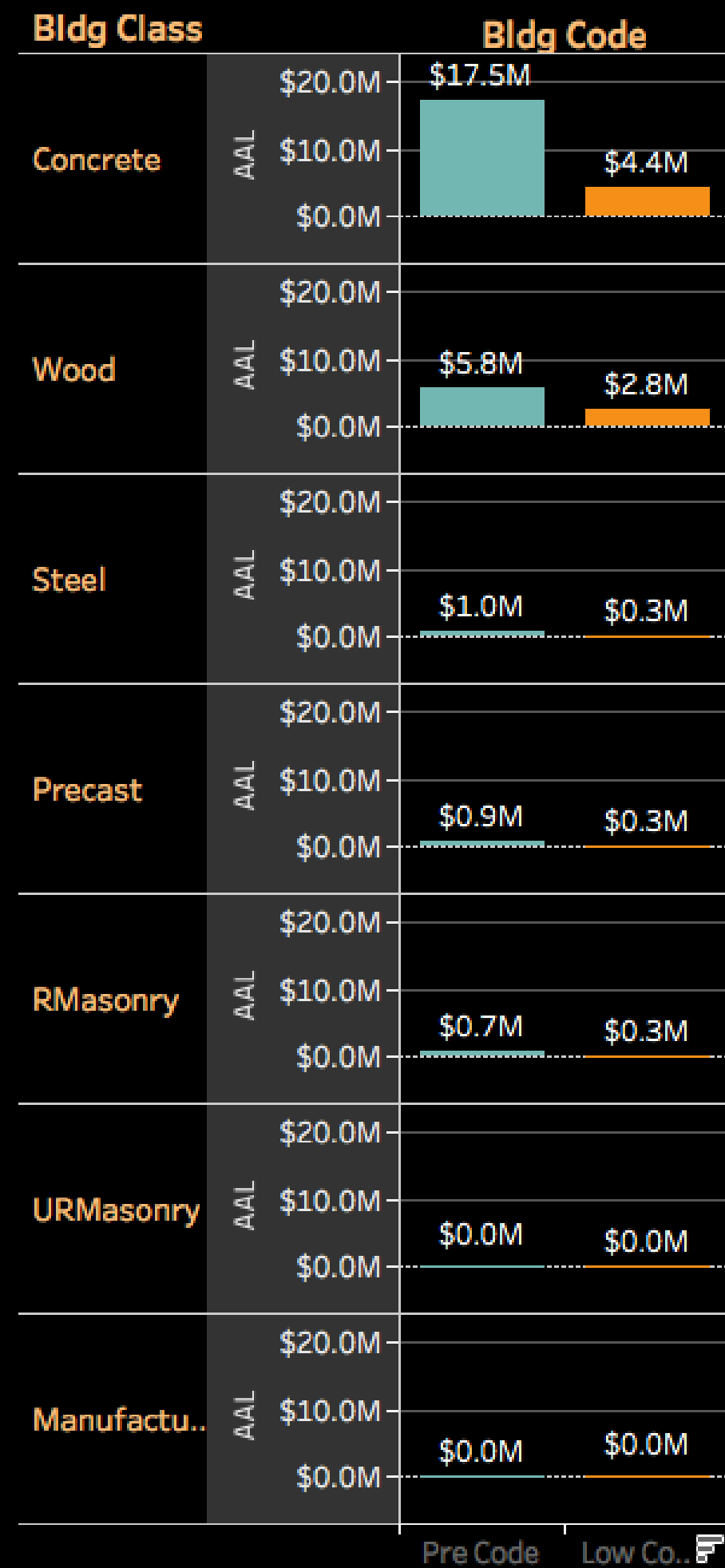


Financial Loss (PML)

Opportunities for Loss Reduction Through Proactive Investment in Seismic Retrofits

Source: Geological Survey of Canada, 2018 (in prep)

Loss Reduction Potential

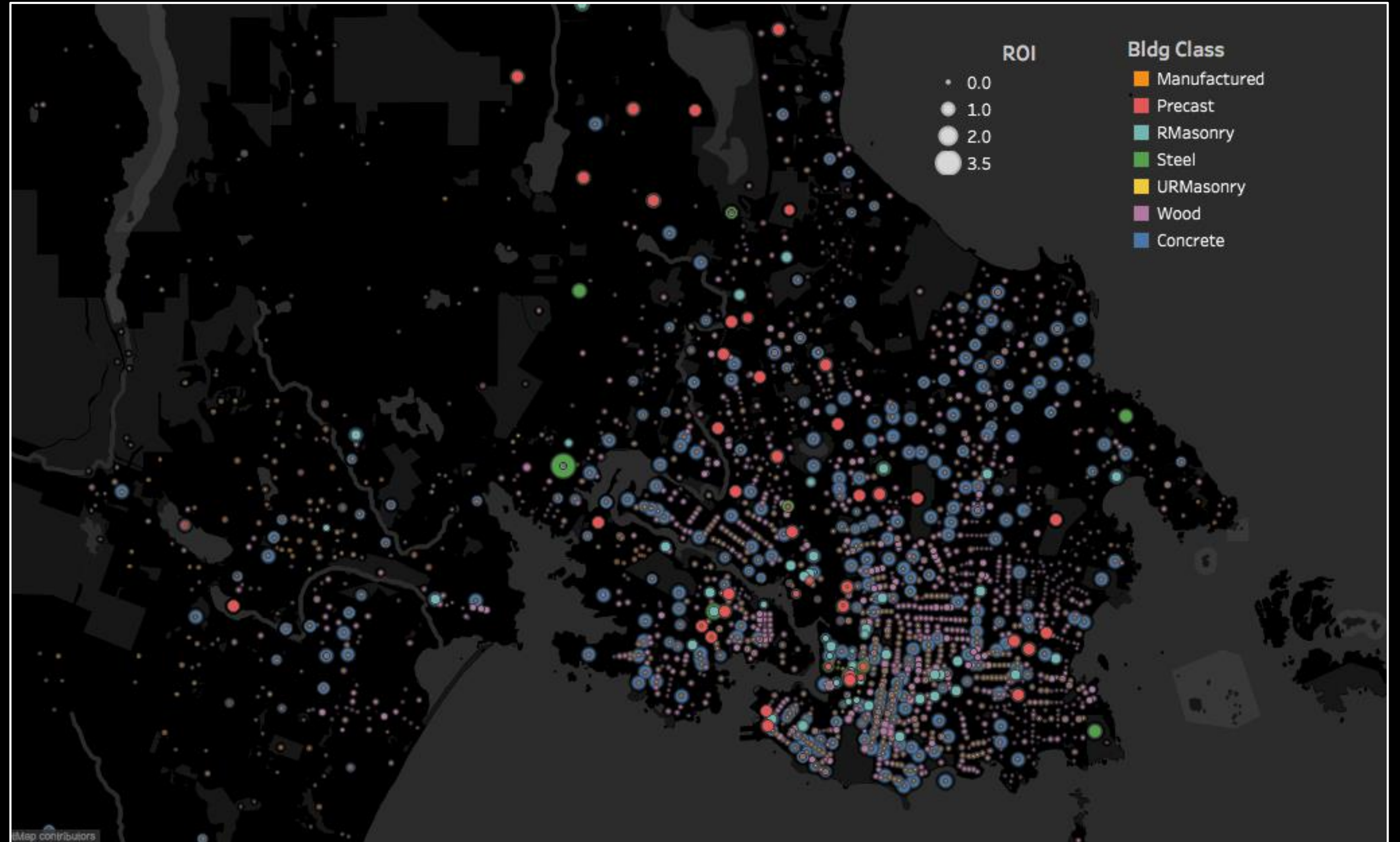
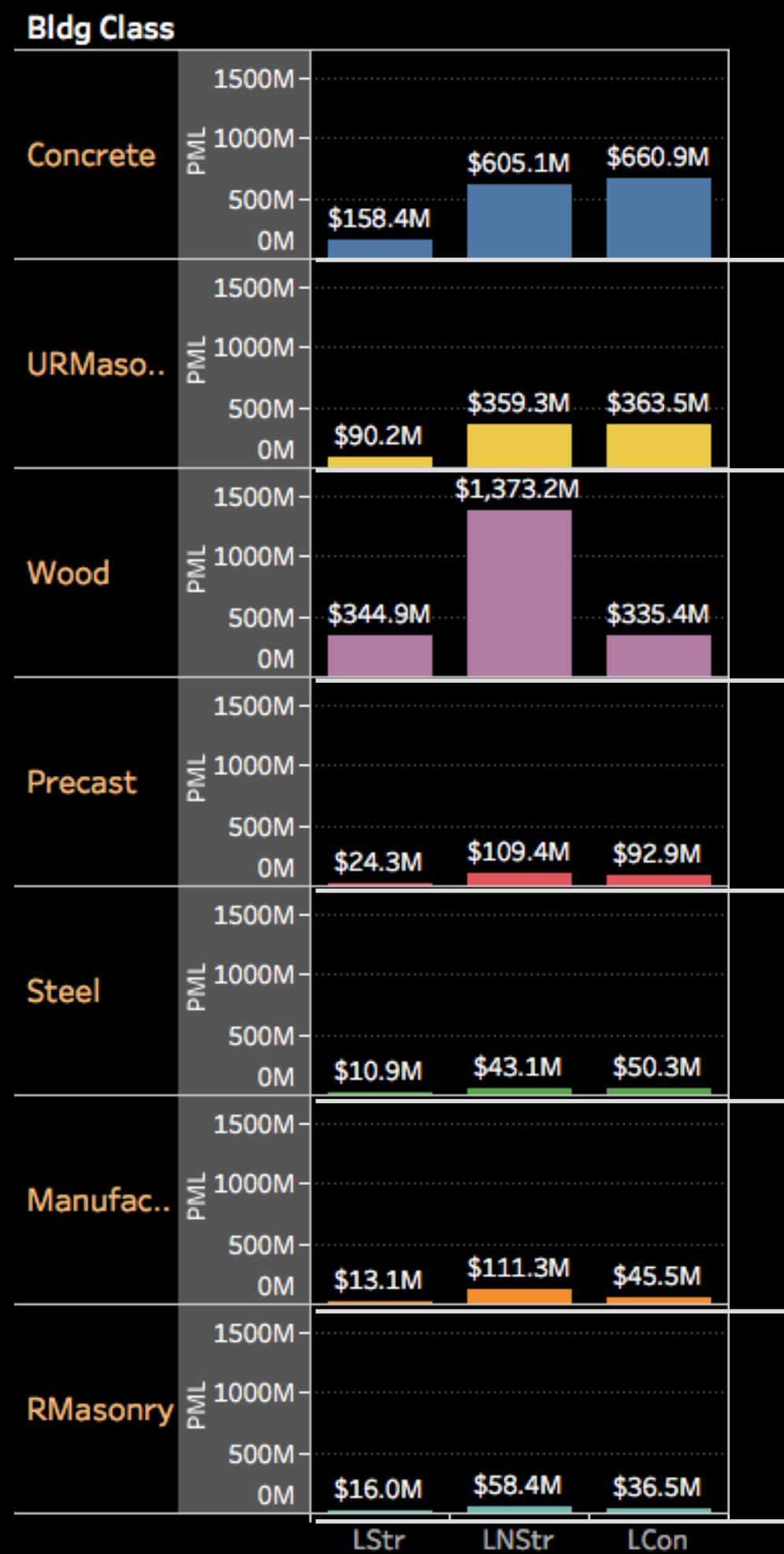


Financial Loss (ROI)

Opportunities for Loss Reduction Through Proactive Investment in Seismic Retrofits

Source: Geological Survey of Canada, 2018 (in prep)

Return on Investment



\$ Financial Loss (ROI)

Average Annual Loss

