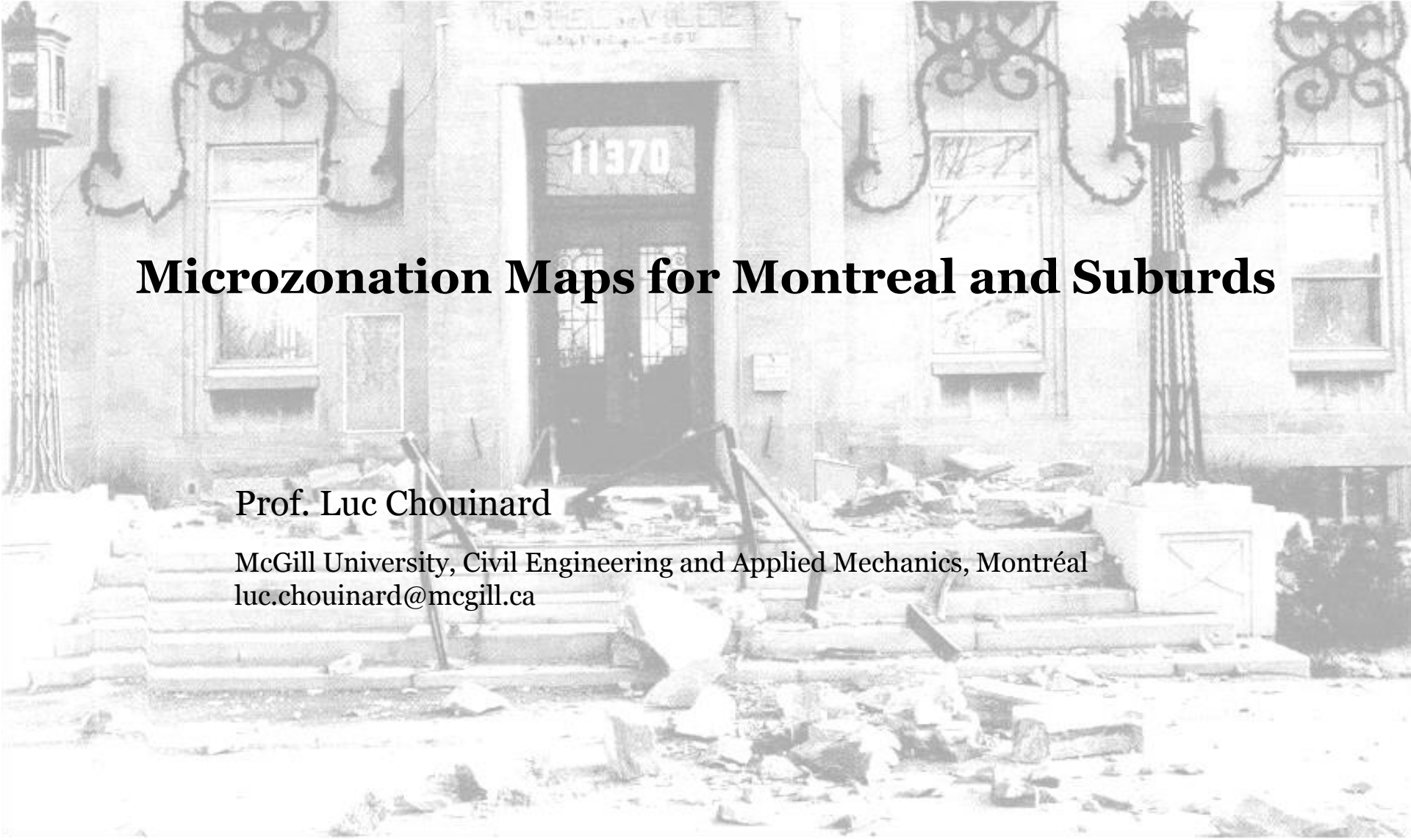

Microzonation Maps for Montreal and Suburds

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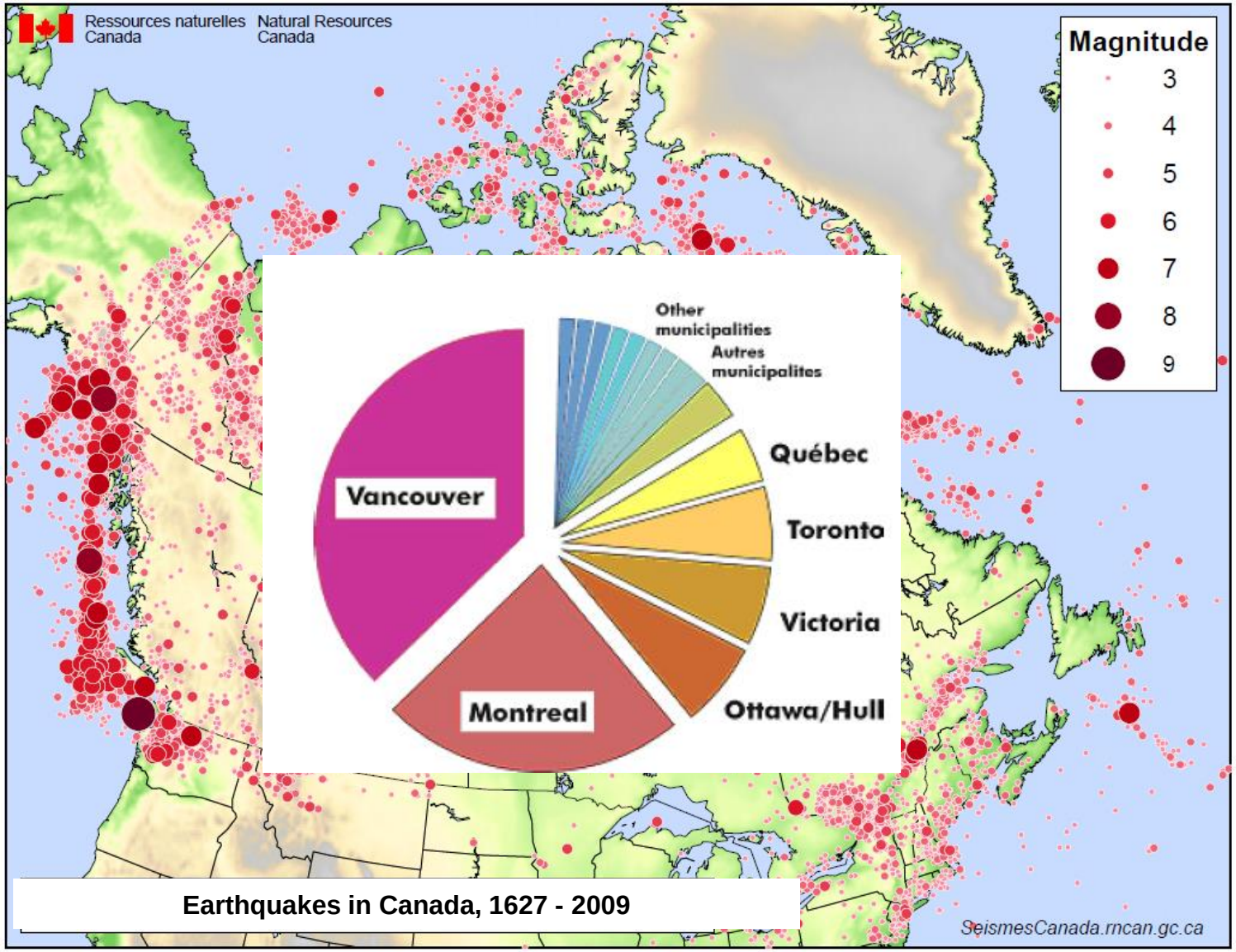
OUTLINE

- Earthquake history in the Greater Montreal
- Site amplification due to surface geology
- Site characterization
- Site-specific analysis
- Risk analysis

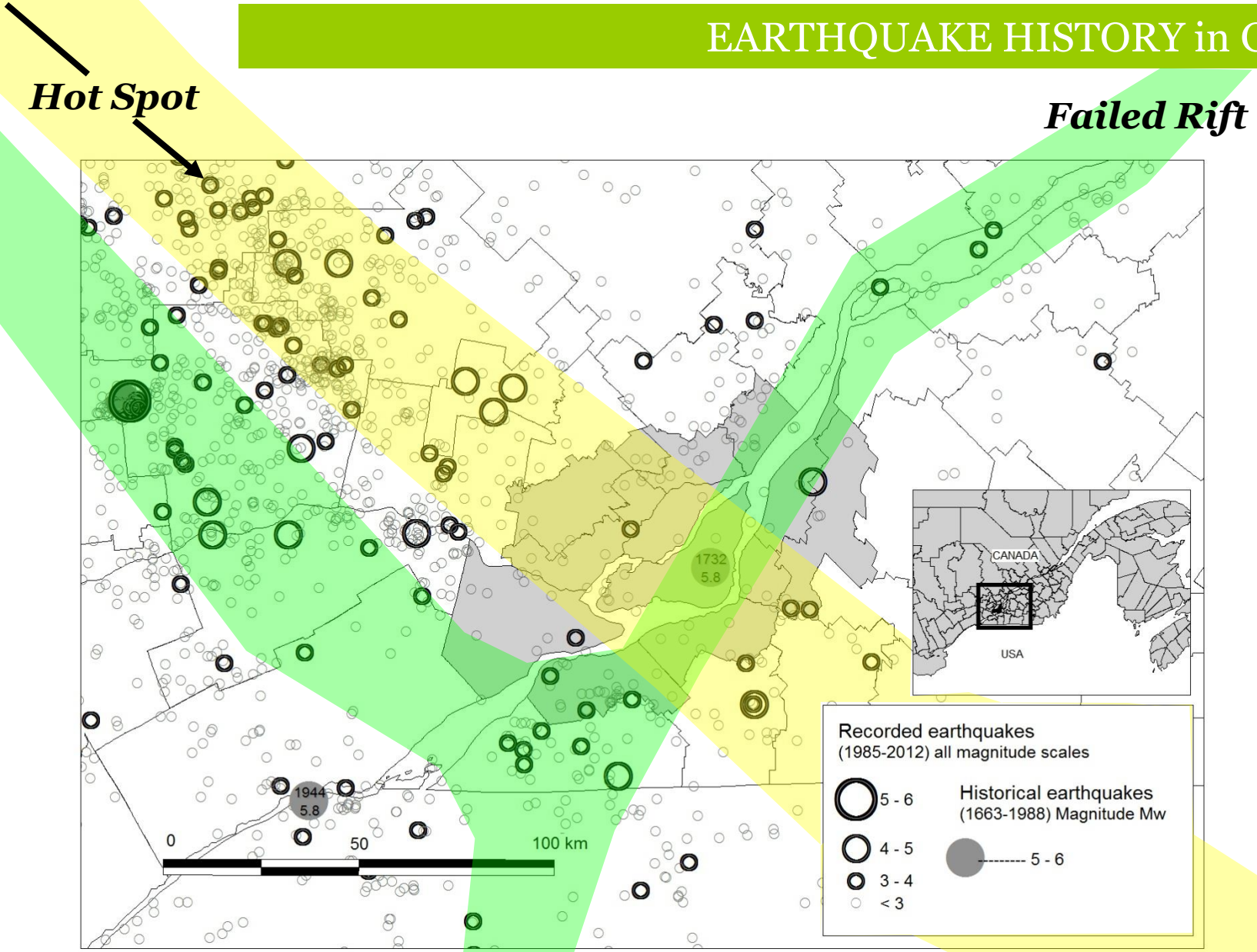
McGill

Earthquakes in Canada



Earthquakes in Canada, 1627 - 2009

EARTHQUAKE HISTORY in GM



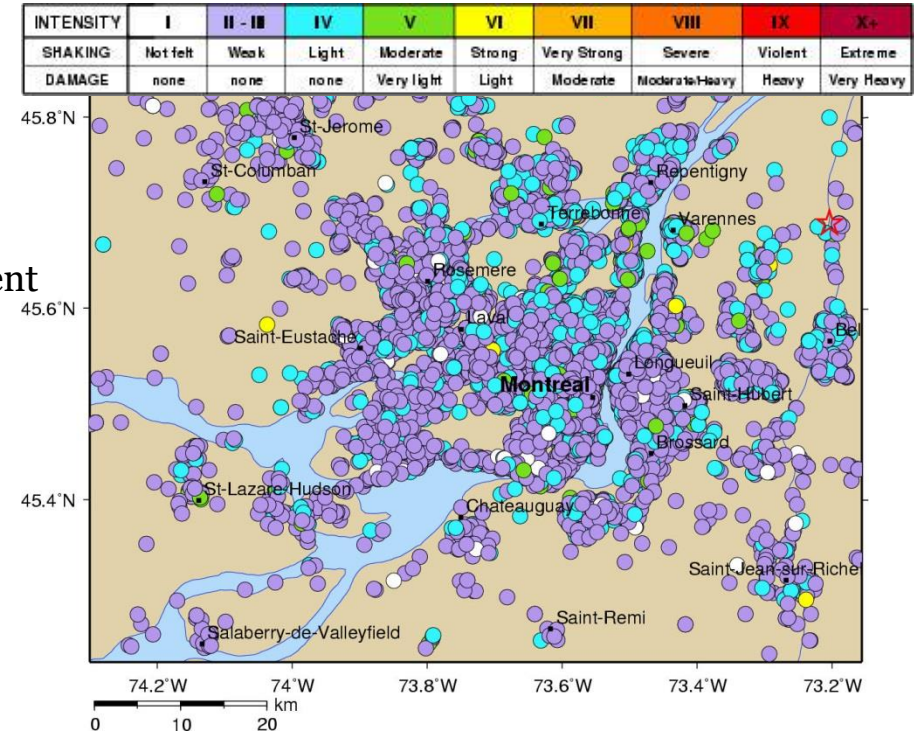
(Source: Earthquake Canada)

RECENT EARTHQUAKEs in GM

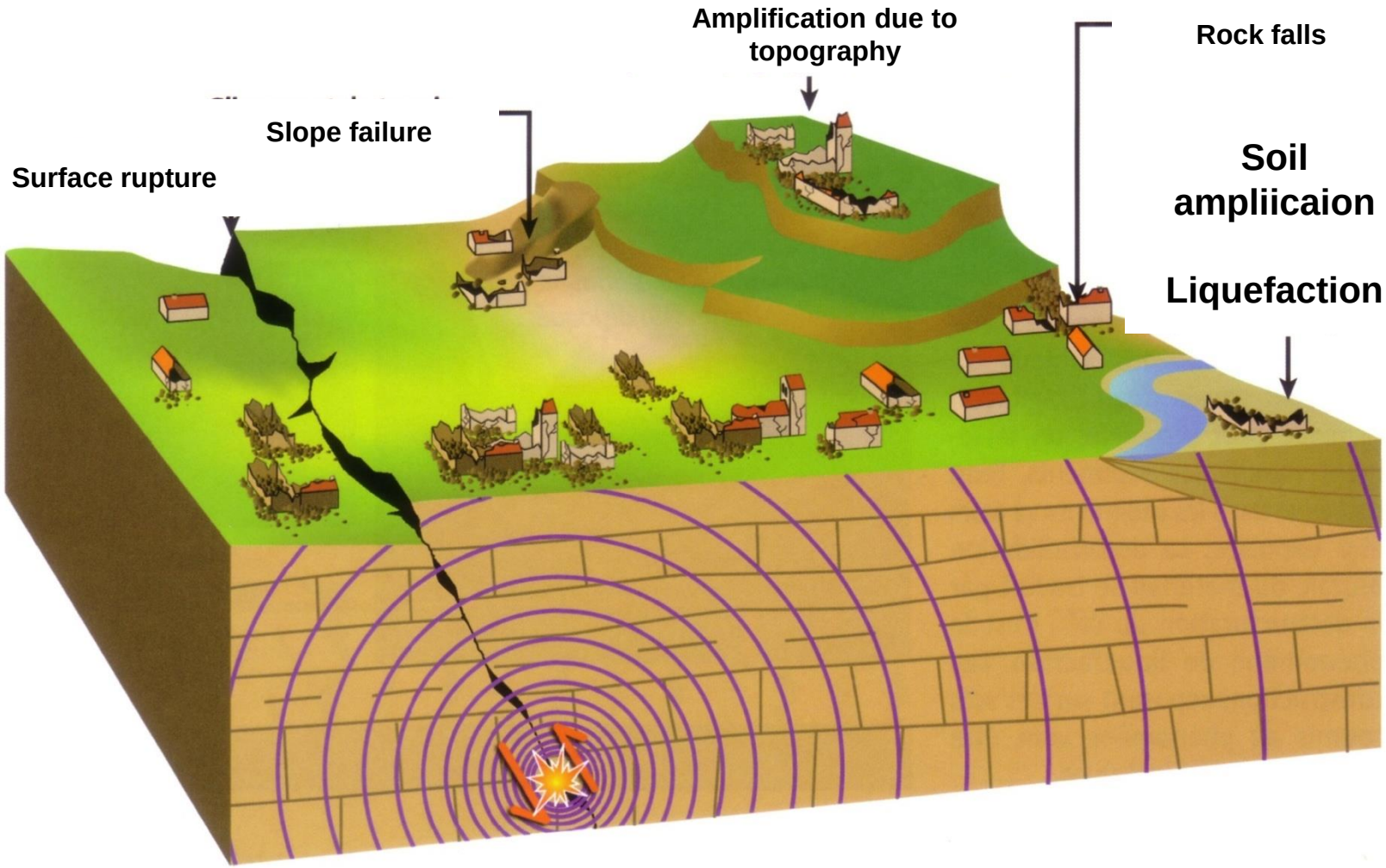
Event	Magnitude	Latitude	Longitude	Epicentral distance (km)	Number of reports	MMI= I-II	MMI=III	MMI=IV	MMI=V
2002/02/02	Mn3.8	46.06	-73.46	40-80	8		25%	75%	
2002/04/20	Mn5.5	44.53	-73.73	100-130	319		9%	87%	4%
2010/06/23	Mw5.0	45.90	-75.50	130-160	267	42%	40%	13%	2%
2012/10/10	Mn4.5	45.69	-73.20	22-68	3445	20%	10%	45%	22%
2012/11/06	Mn4.2	45.62	-75.03	85-120	326	39%	29%	30%	2%

DYFI map of the October 2012 event

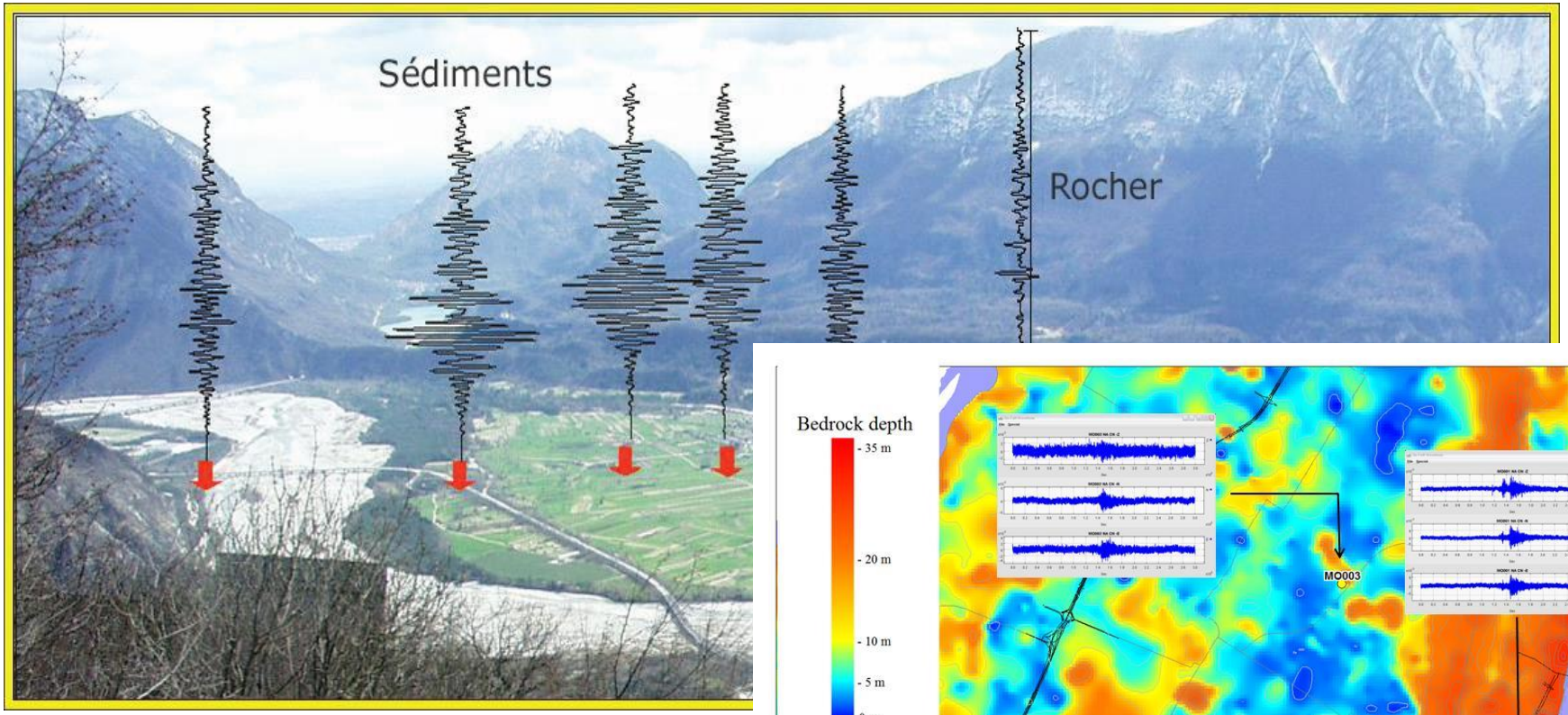
(Source: Earthquake Canada)

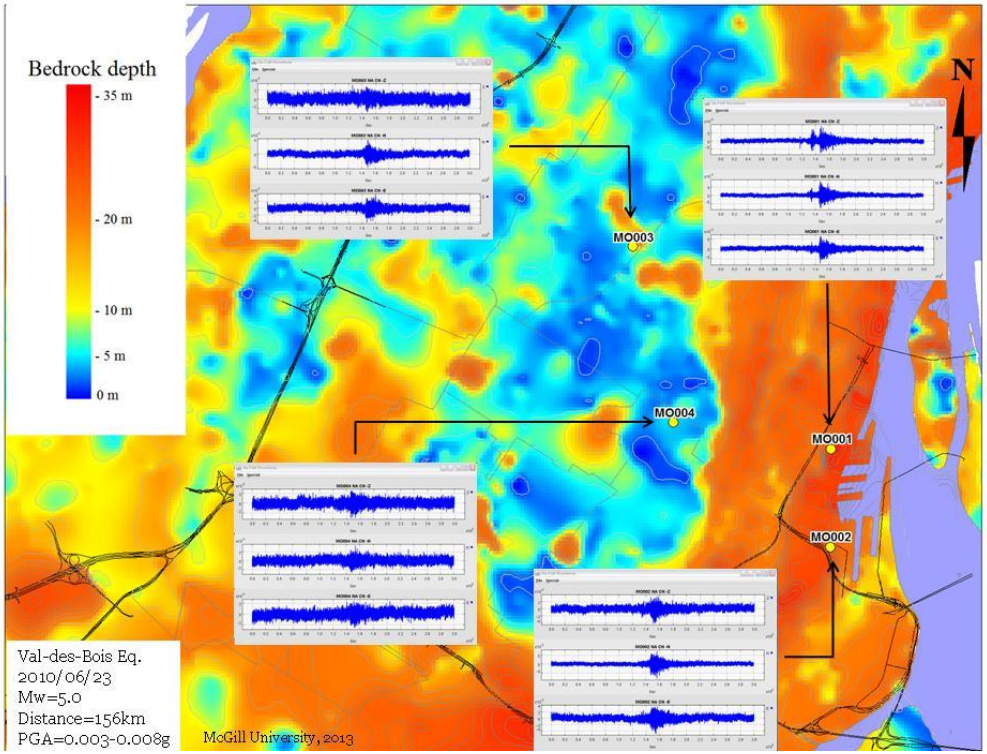


SITE EFFECTS



SITE AMPLIFICATION due to soft soils

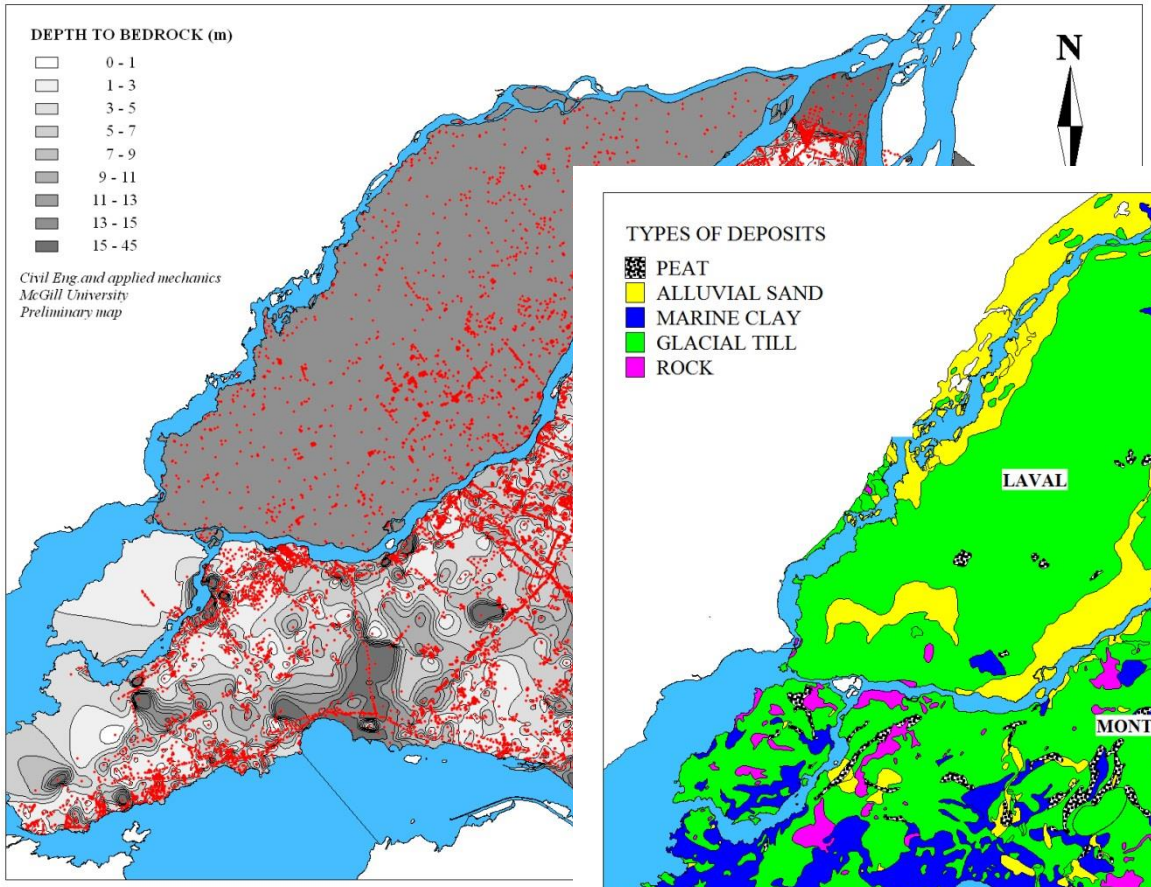


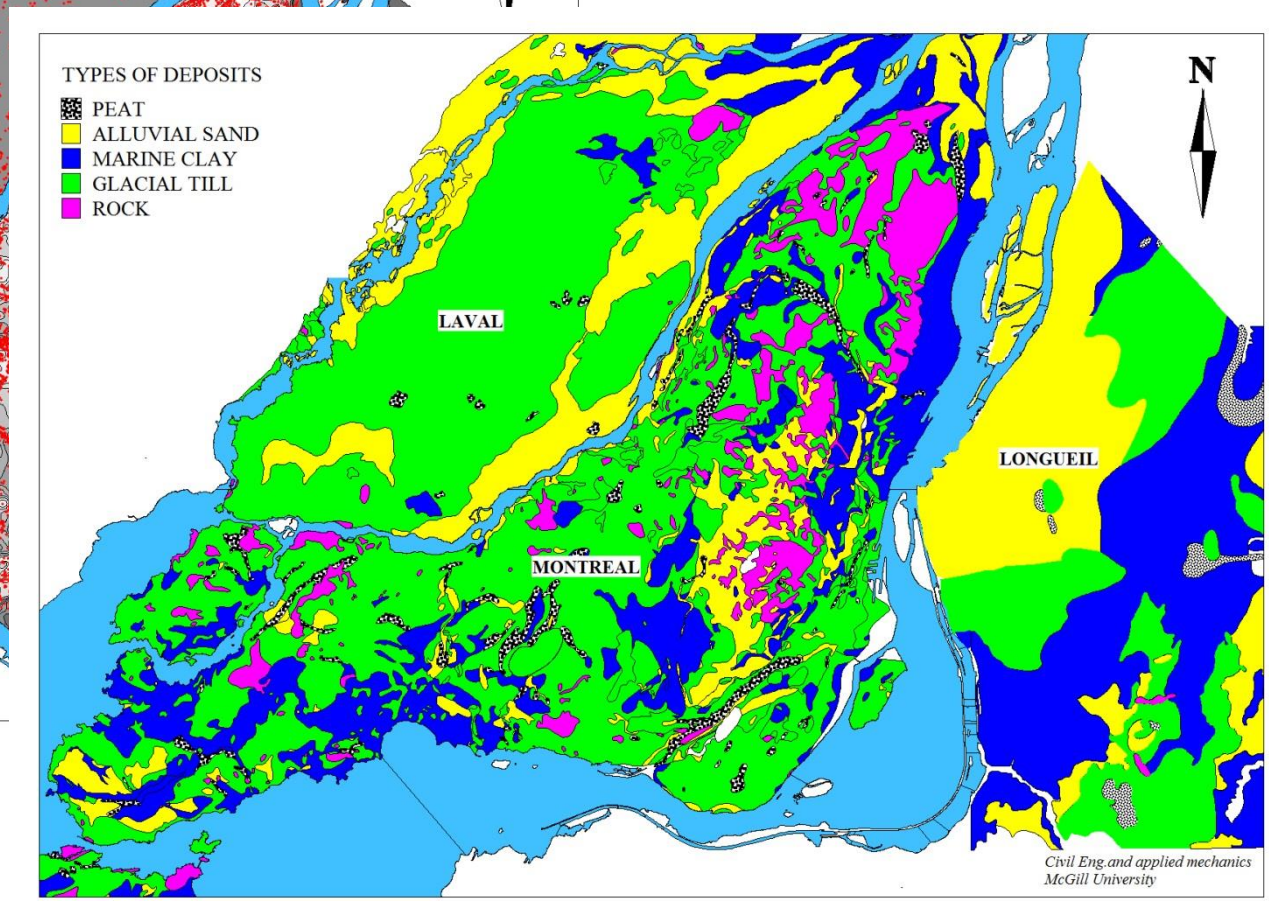


Accelerograms of the Val des Bois Eq.
(Source: Earthquake Canada)

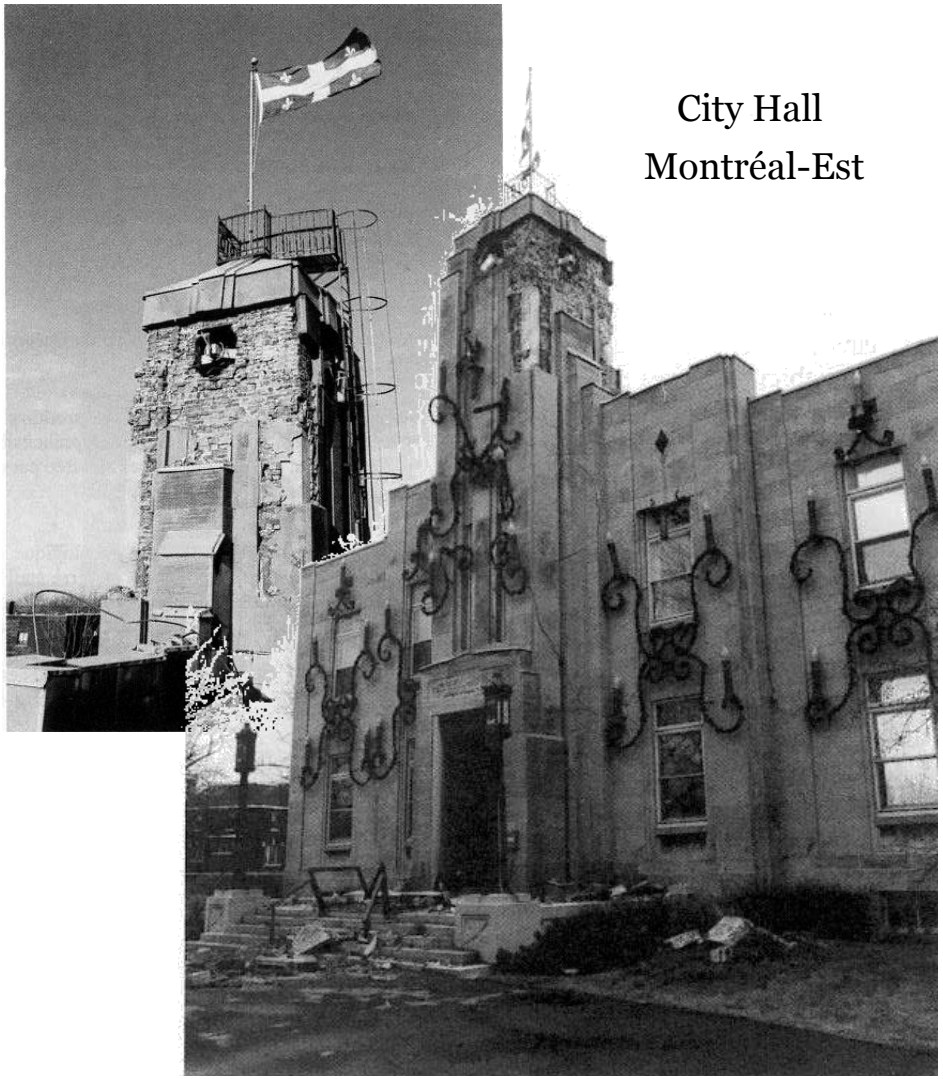
SITE AMPLIFICATION due to soft soils

Thickness of soft soil and surface geology mapping

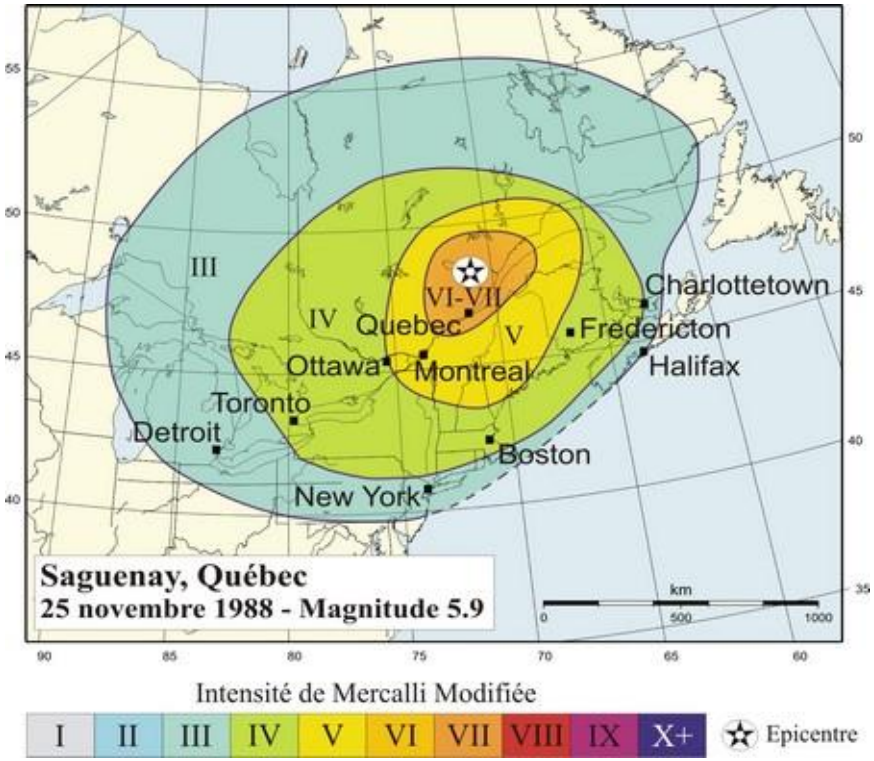




Saguenay earthquake



City Hall
Montréal-Est



Distance > 300 km
17 m soft clay deposit
Older buiilding

Source: Tinawi et al. (1988) et CGC

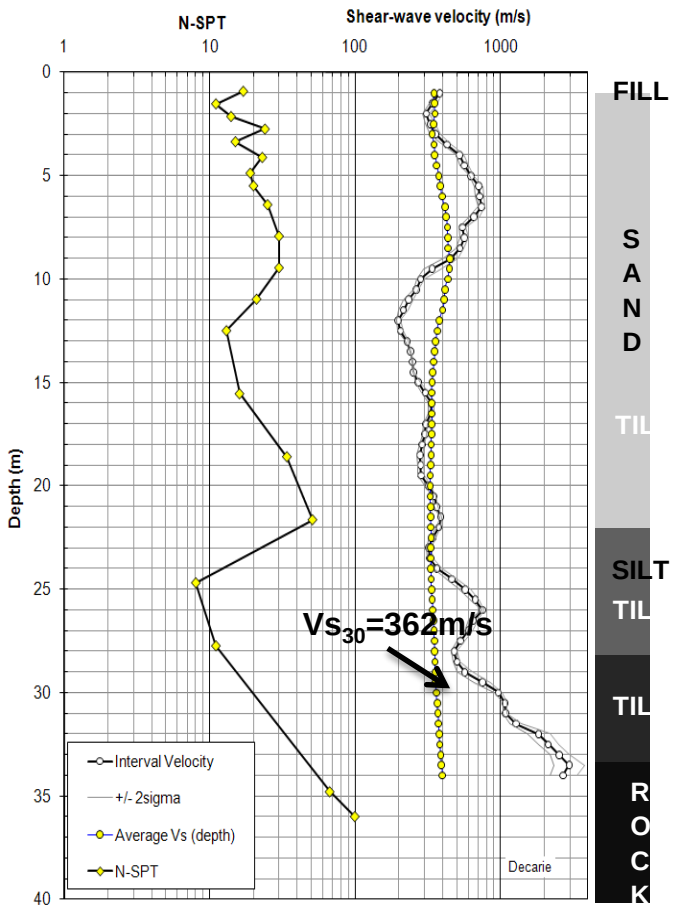
Site classification in the CNBC2010

Site Class	Ground Profile Name	Average Properties in Top 30 m, as per Appendix A		
		Average Shear Wave Velocity, $\overline{V}_s$ (m/s)	Average Standard Penetration Resistance, $\overline{N}_{60}$	*Soil* Undrained Shear Strength, s_u
A	Hard *rock*	$\overline{V}_S > 1500$	n/a	n/a
B	*Rock*	$760 < \overline{V}_S \leq 1500$	n/a	n/a
C	Very dense *soil* and soft *rock*	$360 < \overline{V}_S < 760$	$\overline{N}_{60} > 50$	$s_u > 100$ kPa
D	Stiff *soil*	$180 < \overline{V}_S < 360$	$15 \leq \overline{N}_{60} \leq 50$	50 kPa $< s_u \leq 100$ kPa
E	Soft *soil*	$\overline{V}_S < 180$	$\overline{N}_{60} < 15$	$s_u < 50$ kPa
		Any profile with more than 3 m of *soil* with the following characteristics: ▪ plasticity index: PI > 20 ▪ moisture content: w ≥ 40%, and ▪ undrained shear strength: $s_u < 25$ kPa		
F	Other *soils*(1)	Site-specific evaluation required		

Notes to Table 4.1.8.4.A.:

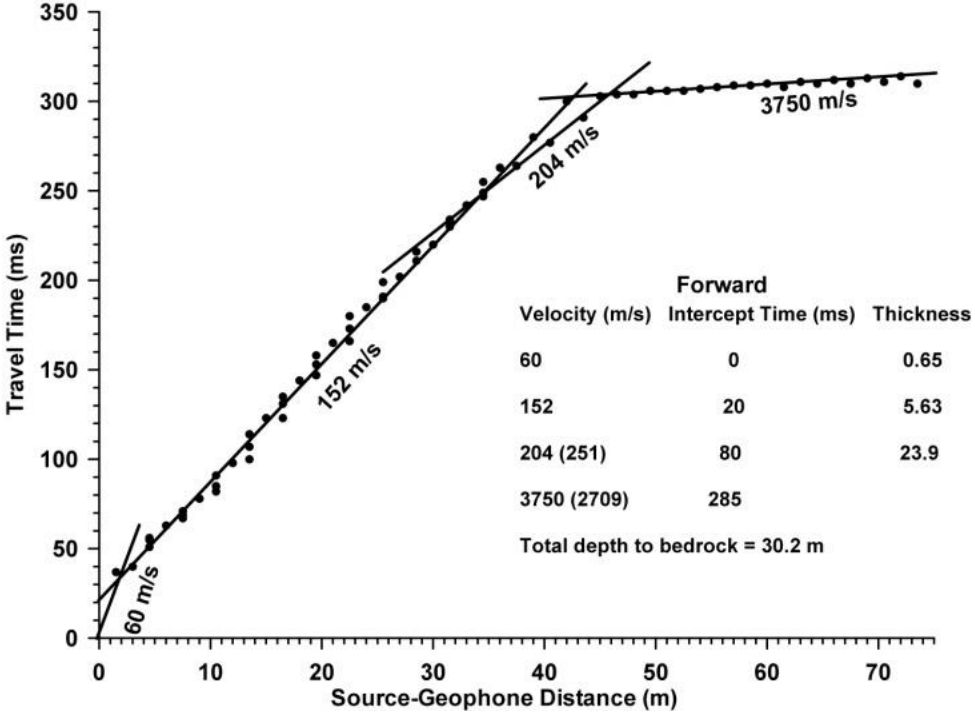
(1) Other *soils* include:
- (a) liquefiable *soils*, quick and highly sensitive clays, collapsible weakly cemented *soils*, and other *soils* susceptible to failure or collapse under seismic loading,
- (b) peat and/or highly organic clays greater than 3 m in thickness,
- (c) highly plastic clays (PI > 75) more than 8 m thick, and
- (d) soft to medium stiff clays more than 30 m thick.

Shear wave velocity measurement guidelines for Canadian seismic site characterization in soil and rock, J.A. Hunter and H.L. Crow (Editors), Geological Survey of Canada, OFR-7078.

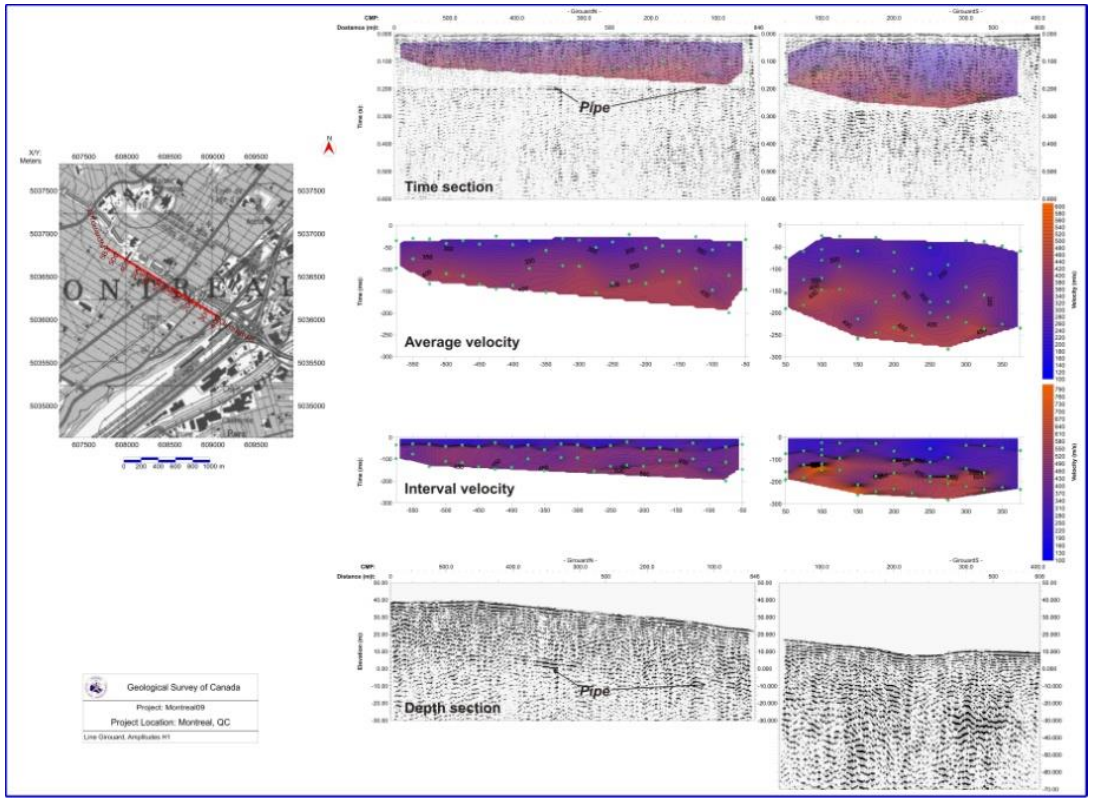


Borehole survey:
Sismique réfraction et réflection

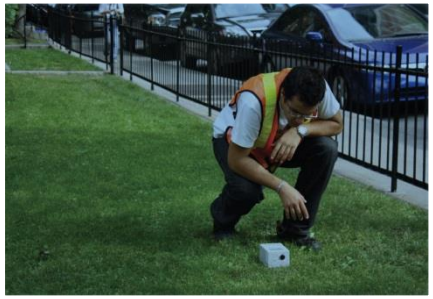
Seismic reflection and refraction

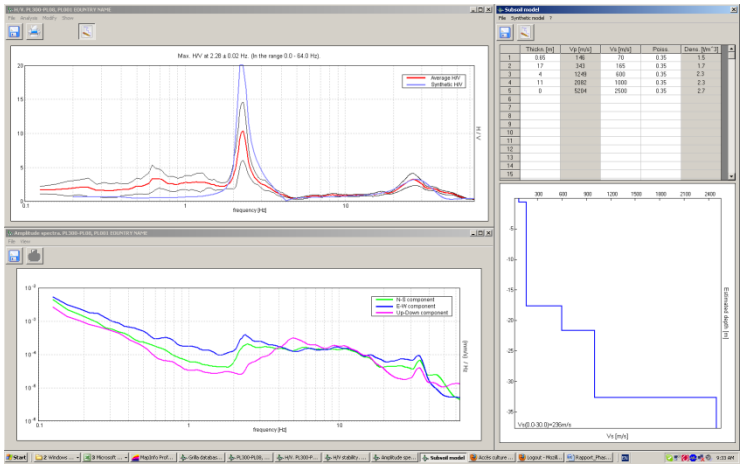


LAND STREAMER
Sesmic reflection and refraction

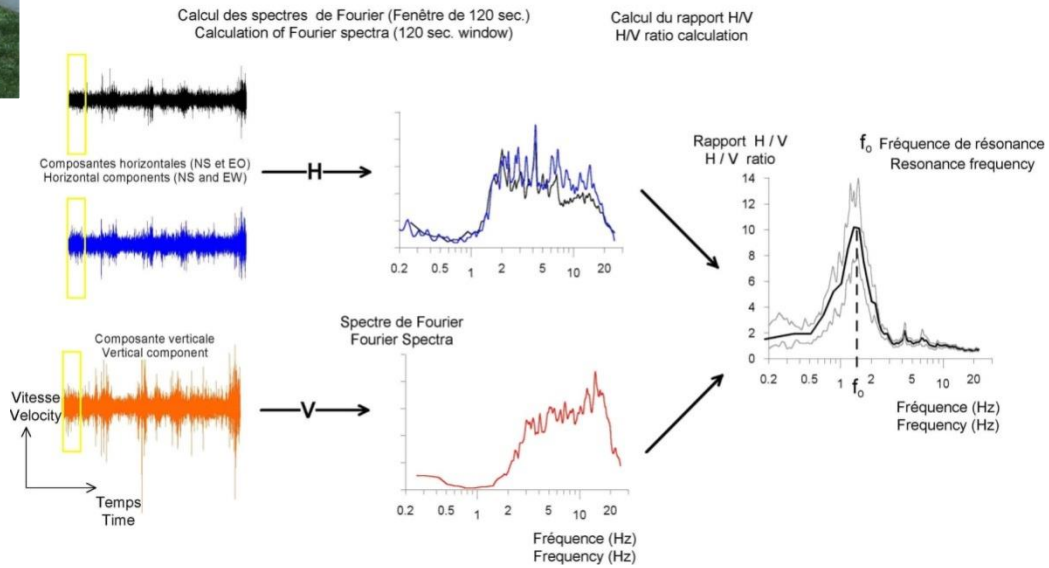


Ambient Noise (H/V)

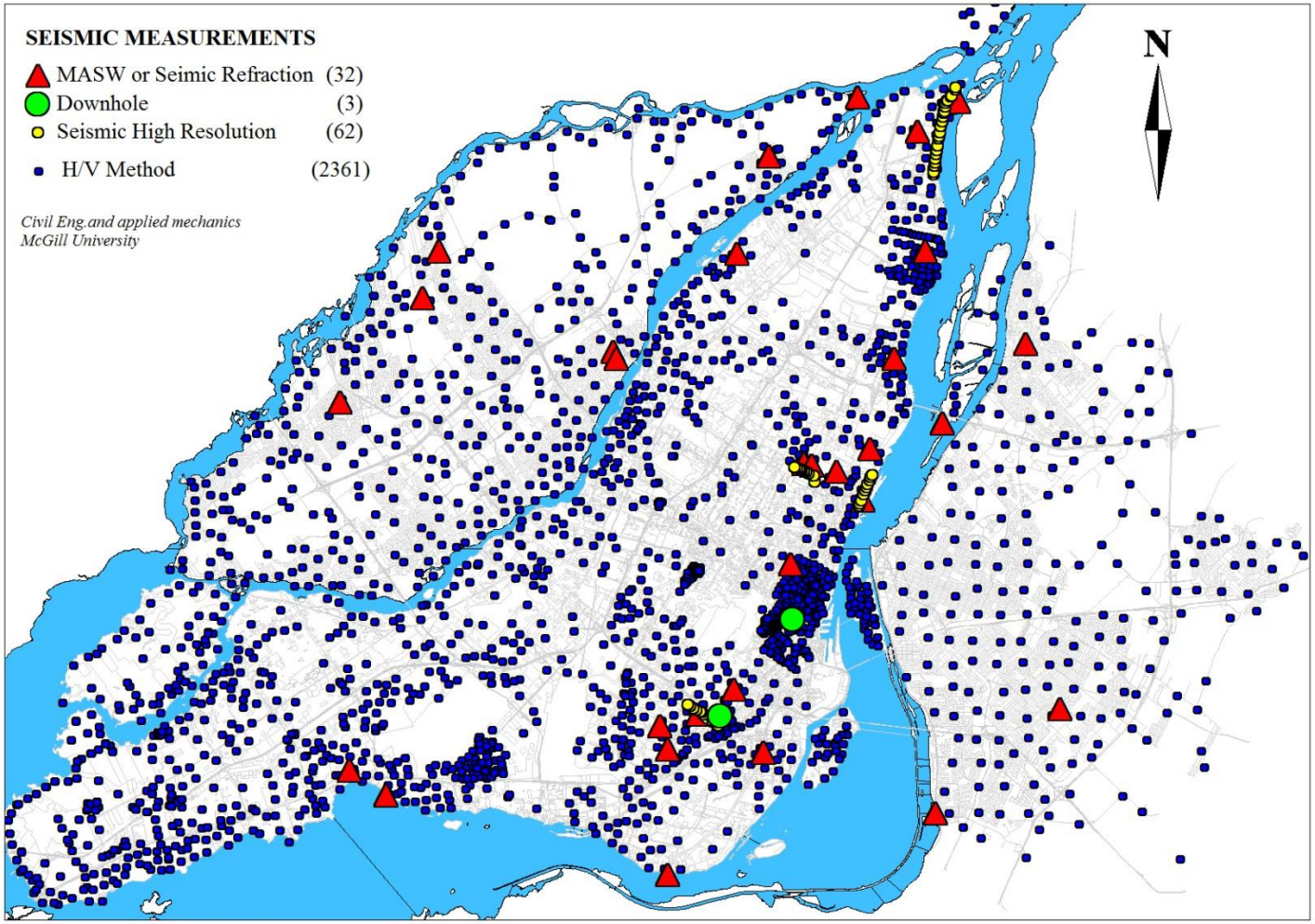




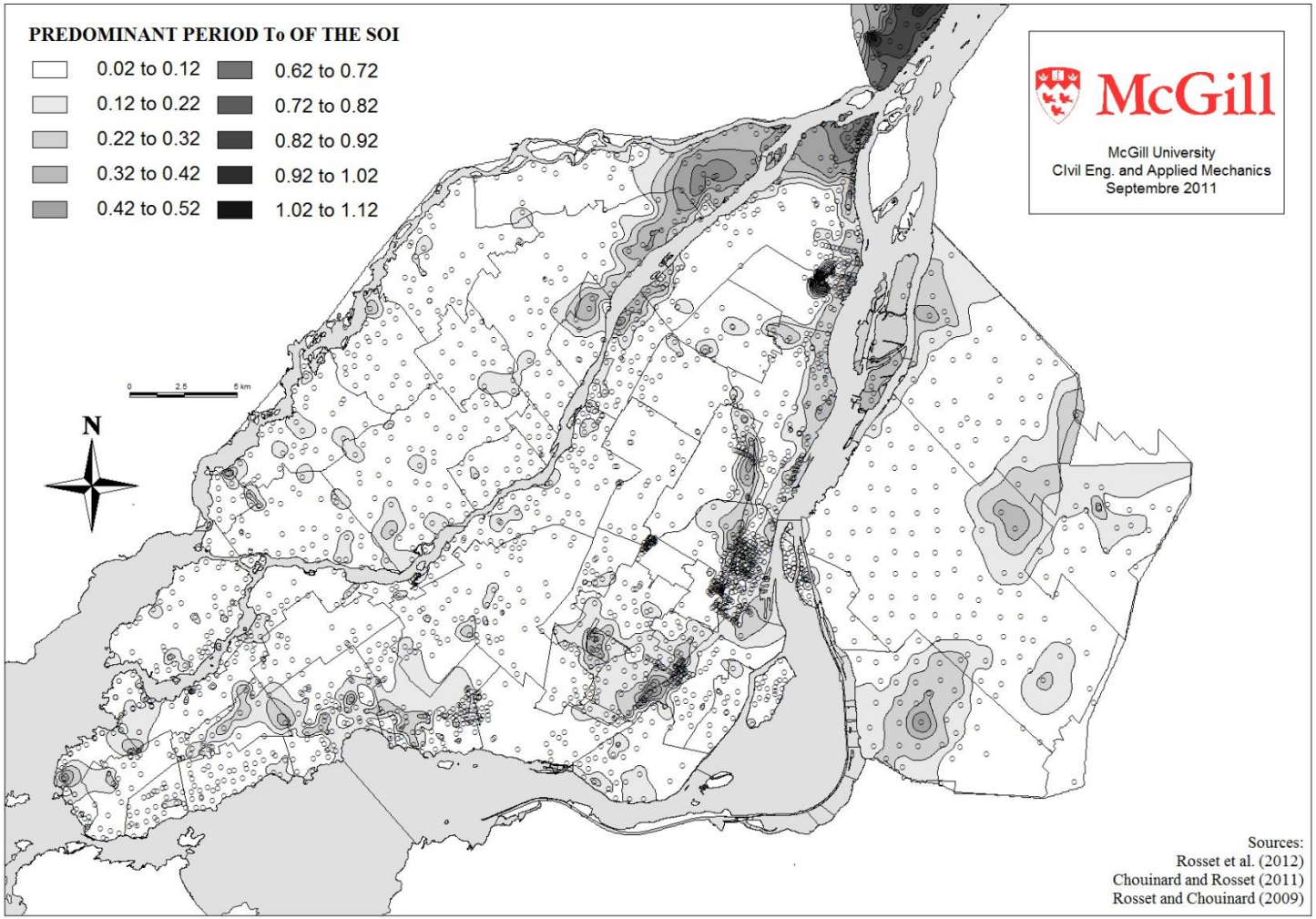
H/V forward modeling



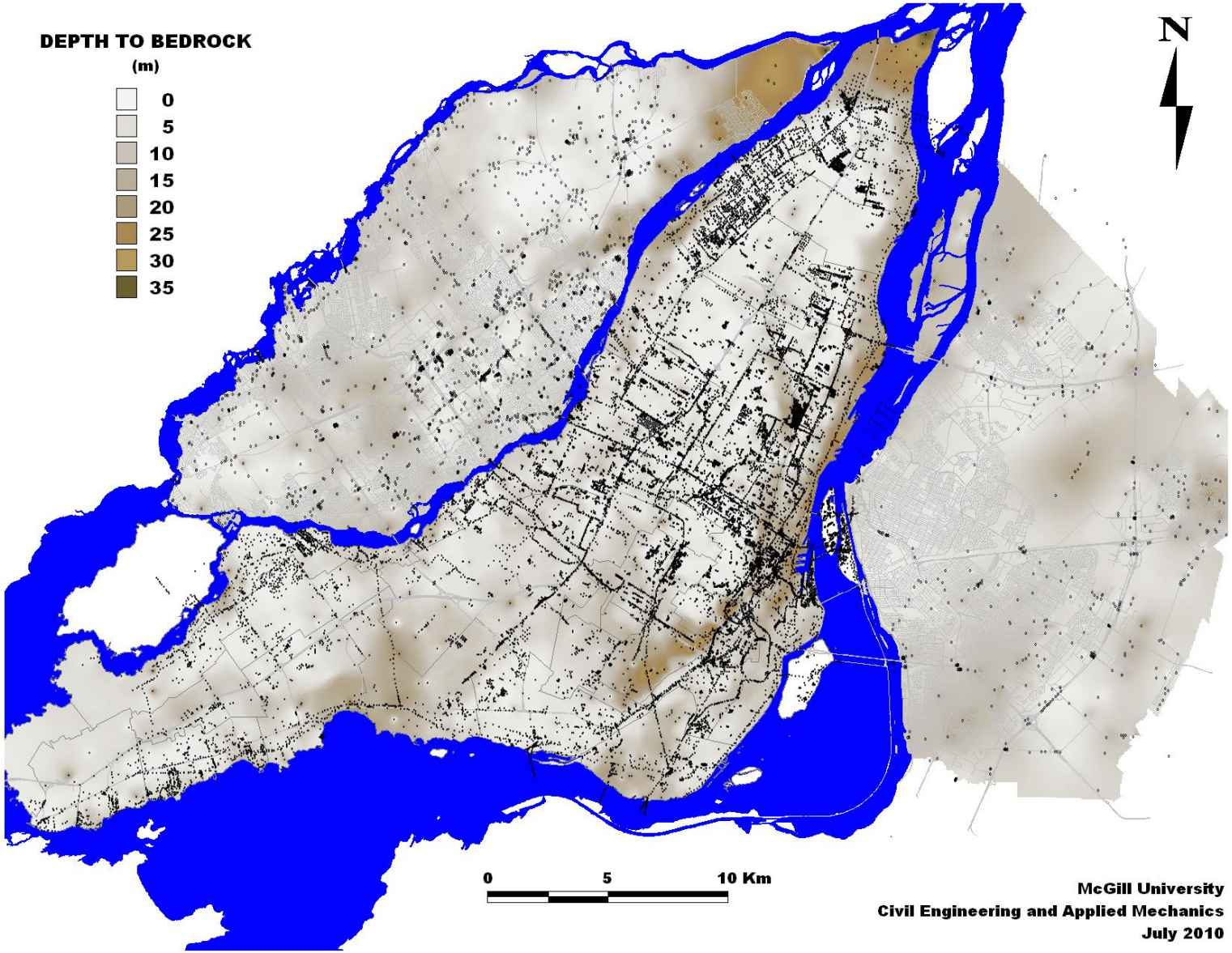
Sites investigated using invasive and non-invasive seismic measurements methods



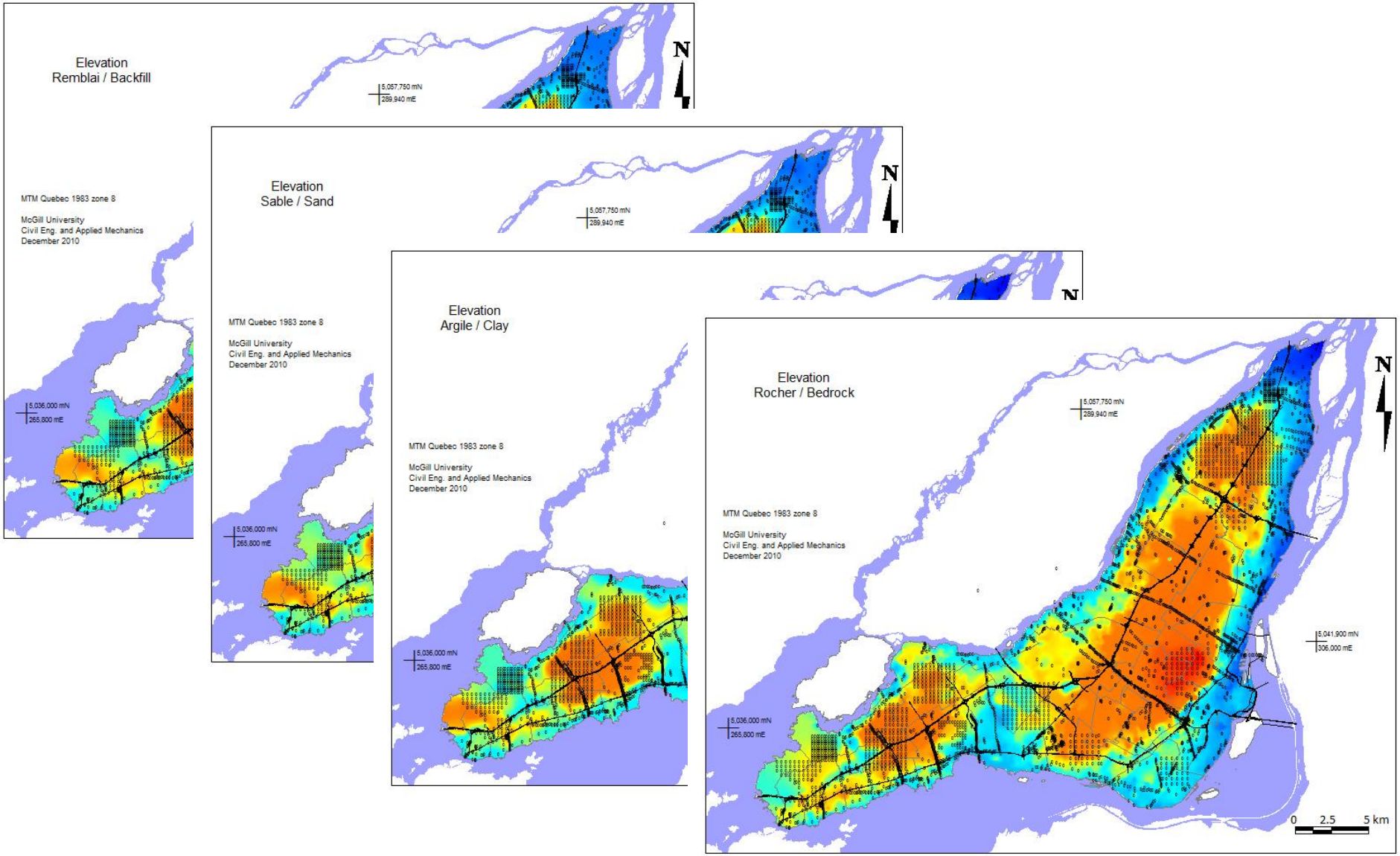
Fundamental period of resonance T_0 using H/V method



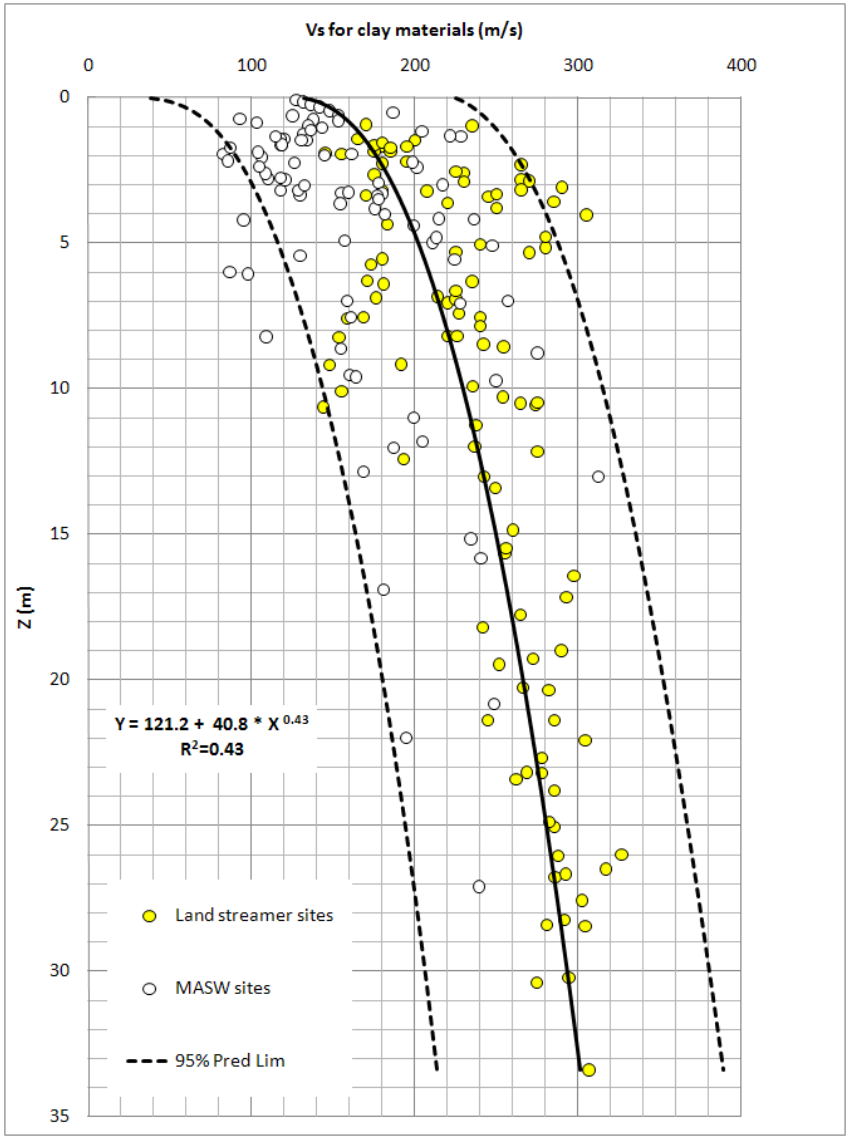
Depth to bedrock

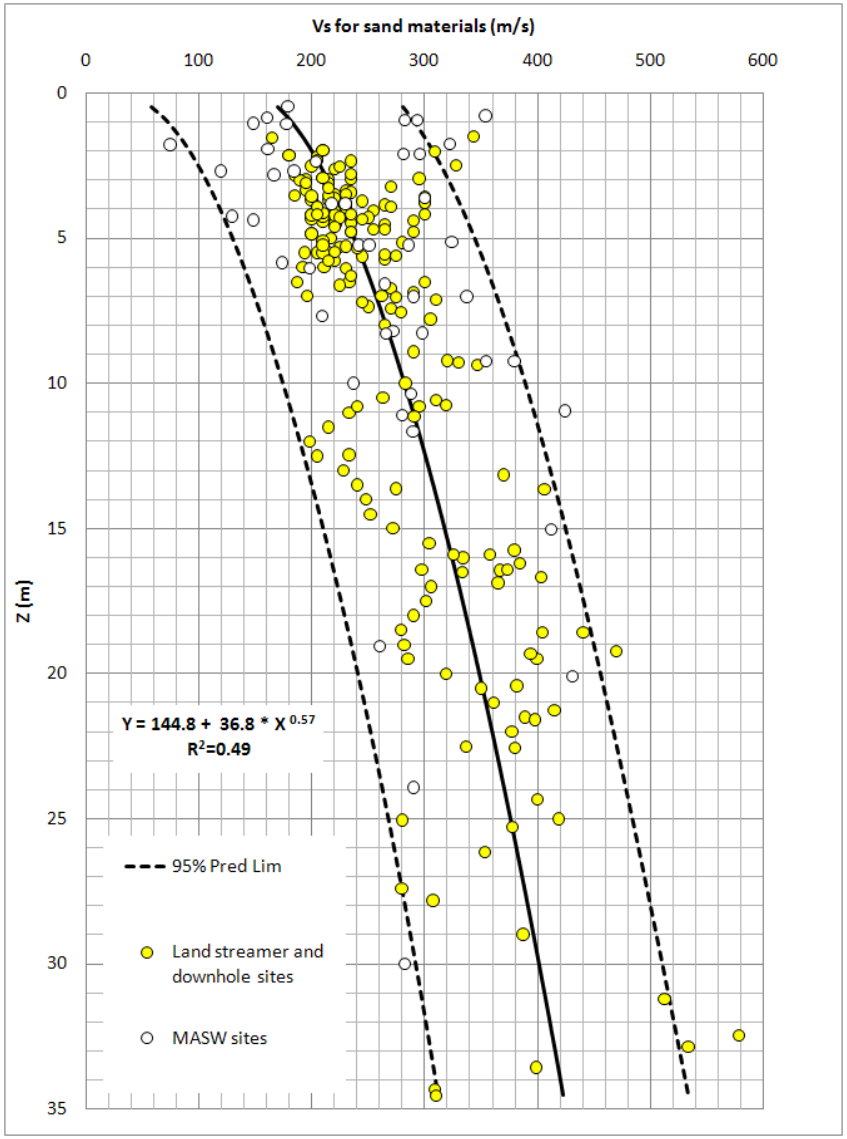


3D Surface Geology Model

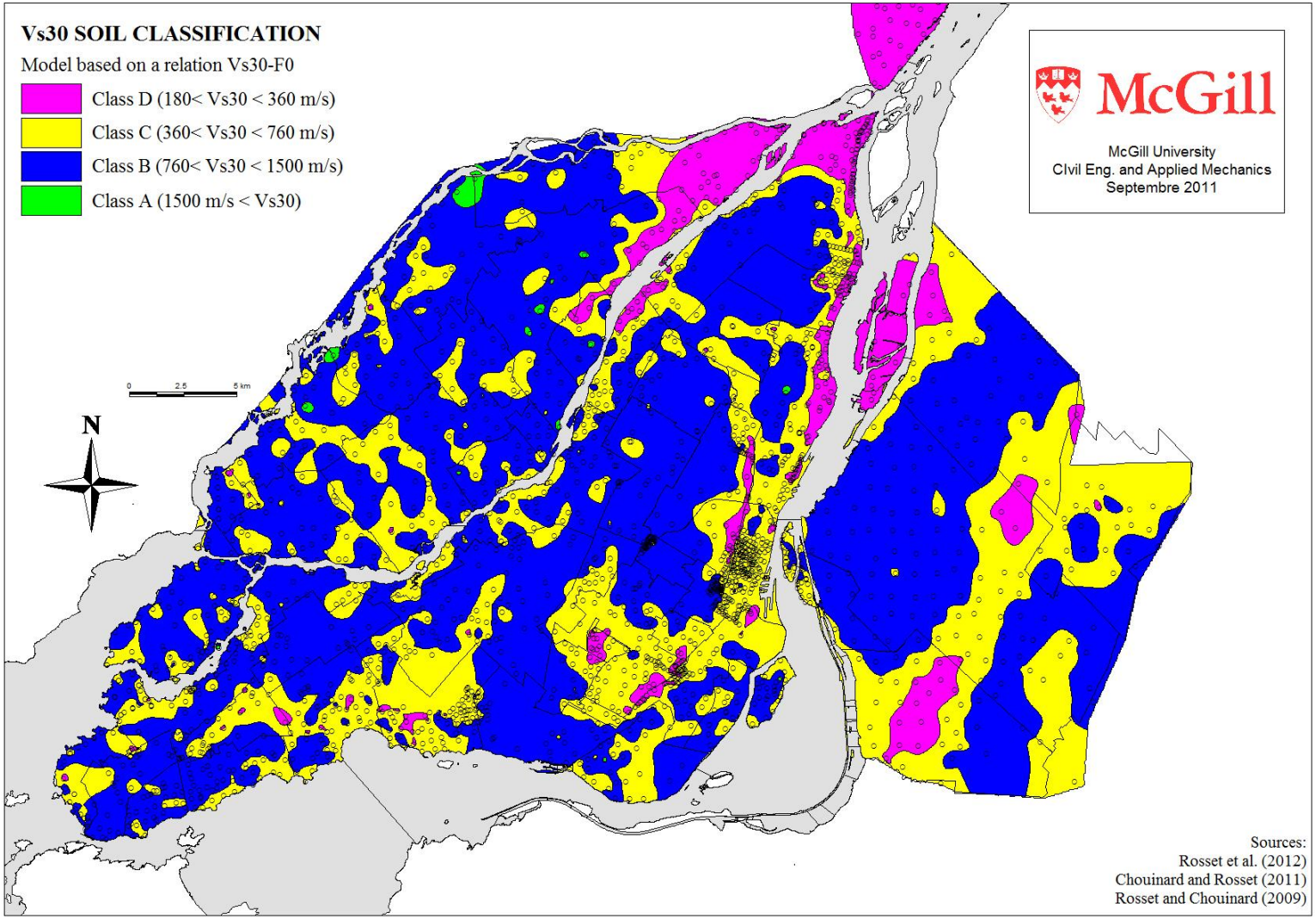


Depth-velocity curves

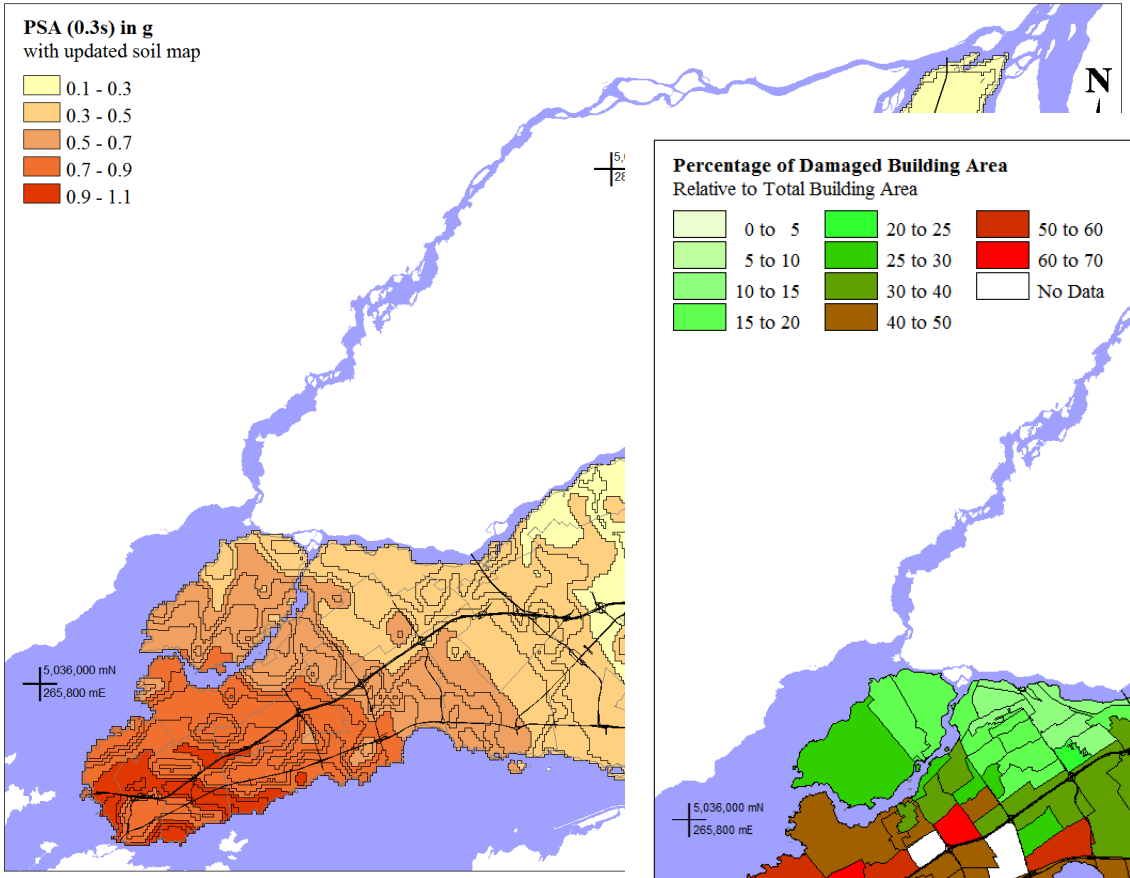


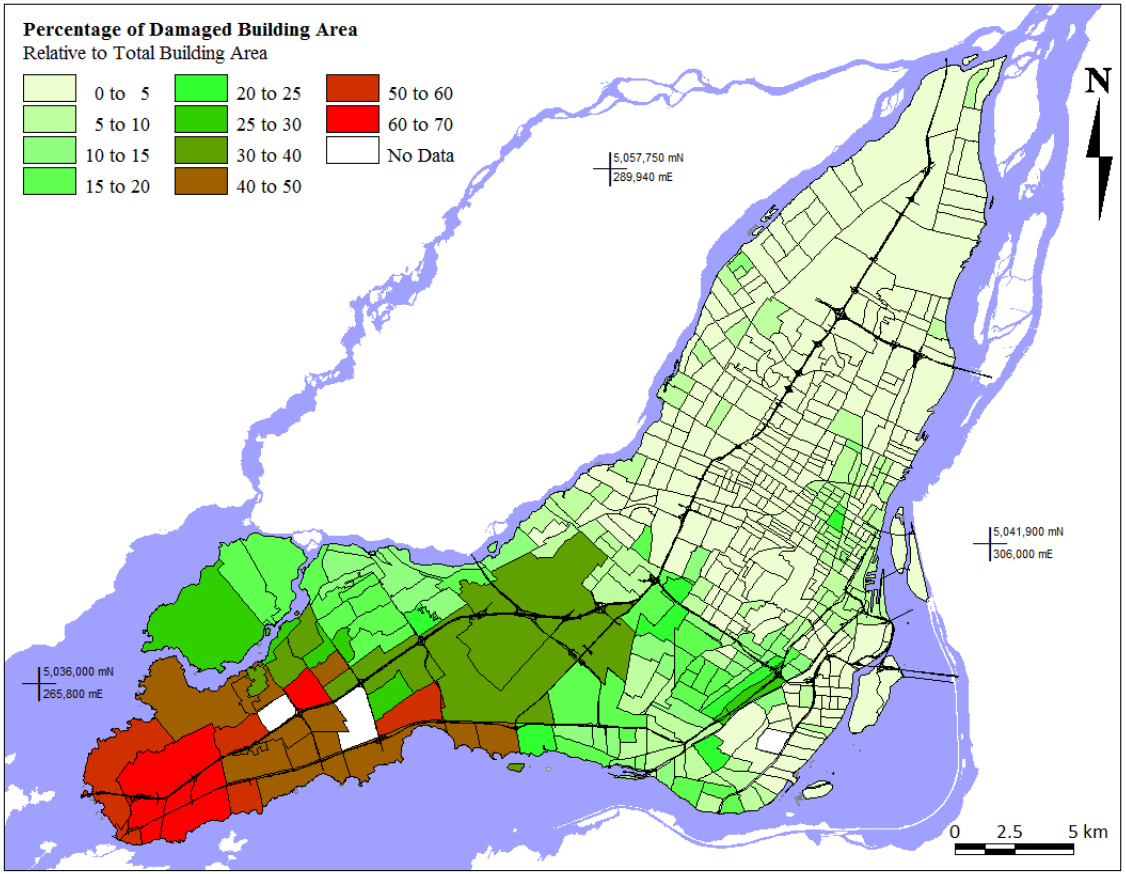


Soil classes based on T_0 using H/V method



Damage estimate can be performed using a specific seismic scenario





(Source: Yu, 2011)

DISCUSSION

GM is in a moderate seismic zone where the occurrence of a large earthquake can have signiificant imapct

Site classification mapping following the NBCC2010 is available but needs to be completed improved and expanded.

Map shows zones with expected site amplification

- Evaluation of vulnerability of existing buildings

-Evaluate risks for various seismic scenarios

-Develop more accurate Shake Maps