Western Engineering

Microzonation of Urban Areas: Application to Toronto

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INTRODUCTION

This presentation reports on a microzonation study for the Toronto/Mississauga region.

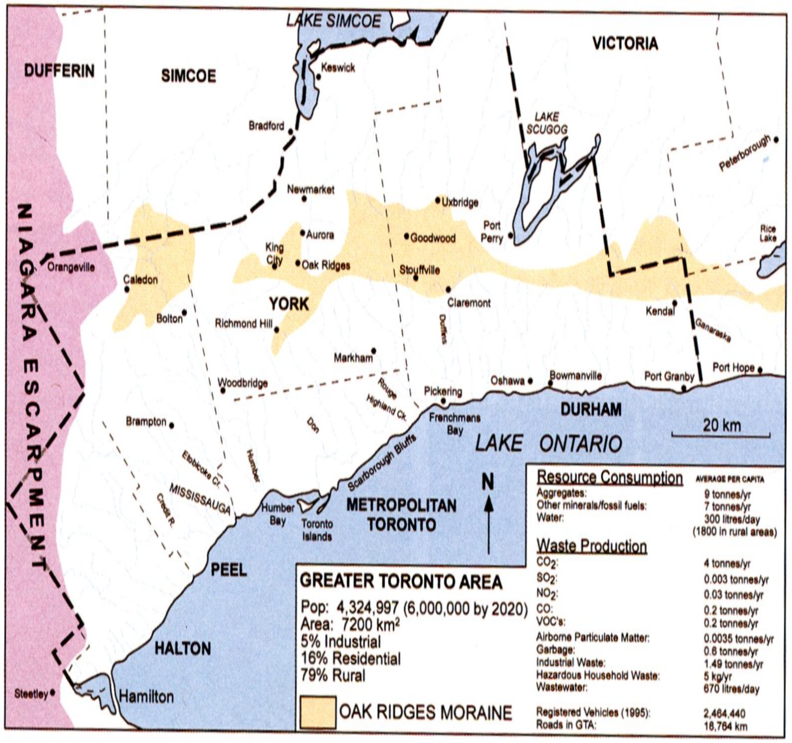
Main points of the presentation:

- new method for microzonation suitable for urban areas
- preliminary map of ground motion amplifications
- preliminary map of ground motion frequencies

First Phase

- First phase of the project covered the most populated part of GTA (approximately 1000 km^2)
- Most essential geological information has been gathered
- Efficient microzonation method suitable for large scale microzonation is developed.

Study area – part of Great Toronto Area



(Eyles, 2004)

Geological Conditions in the area of GTA

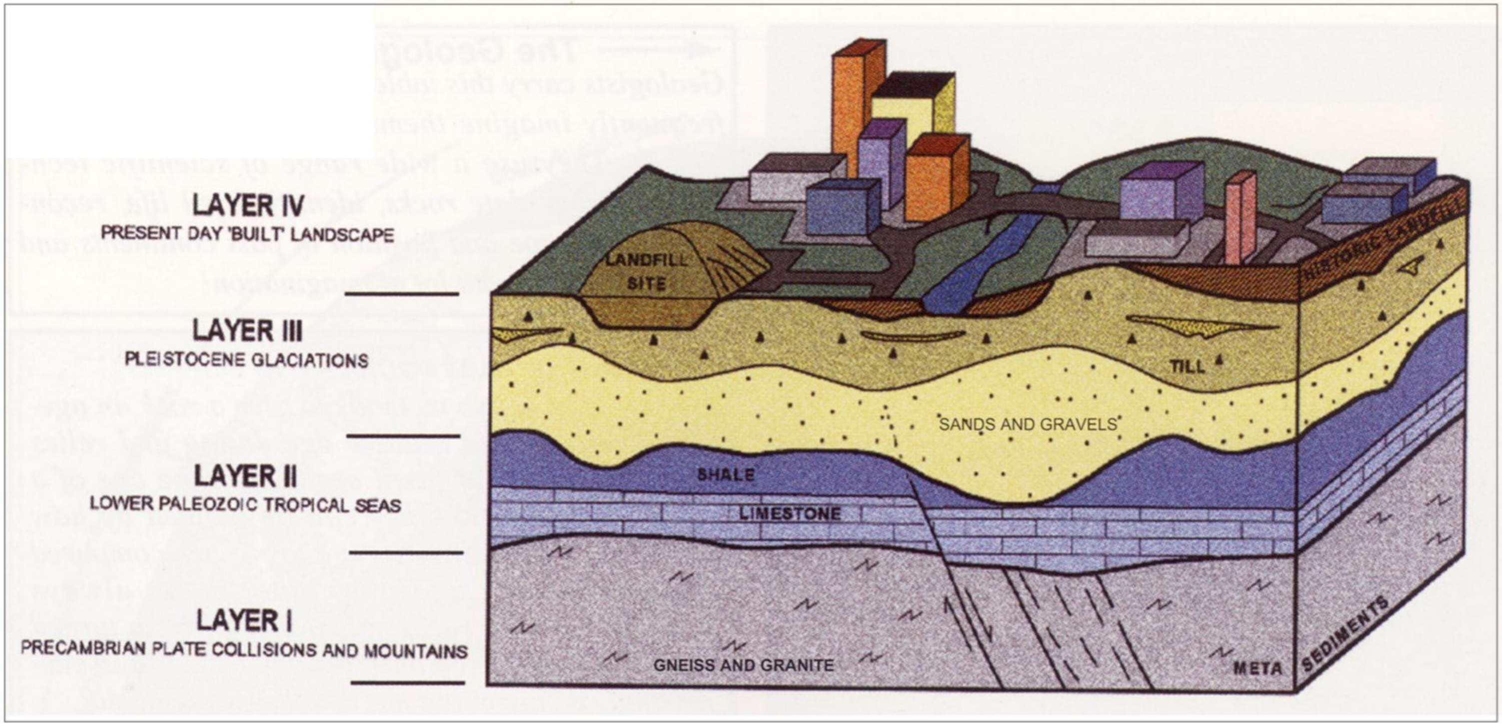
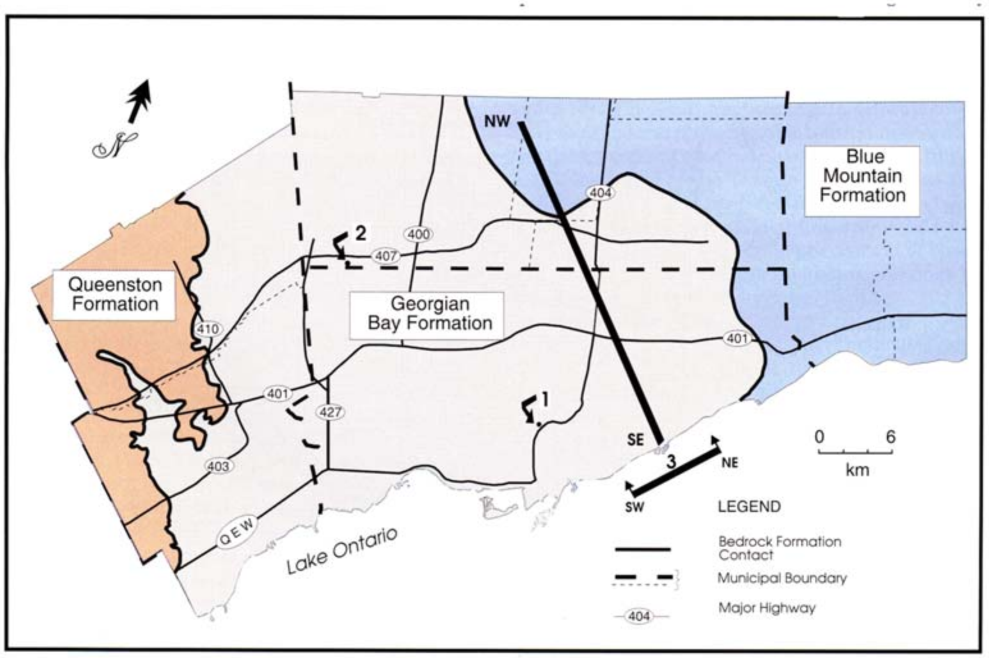


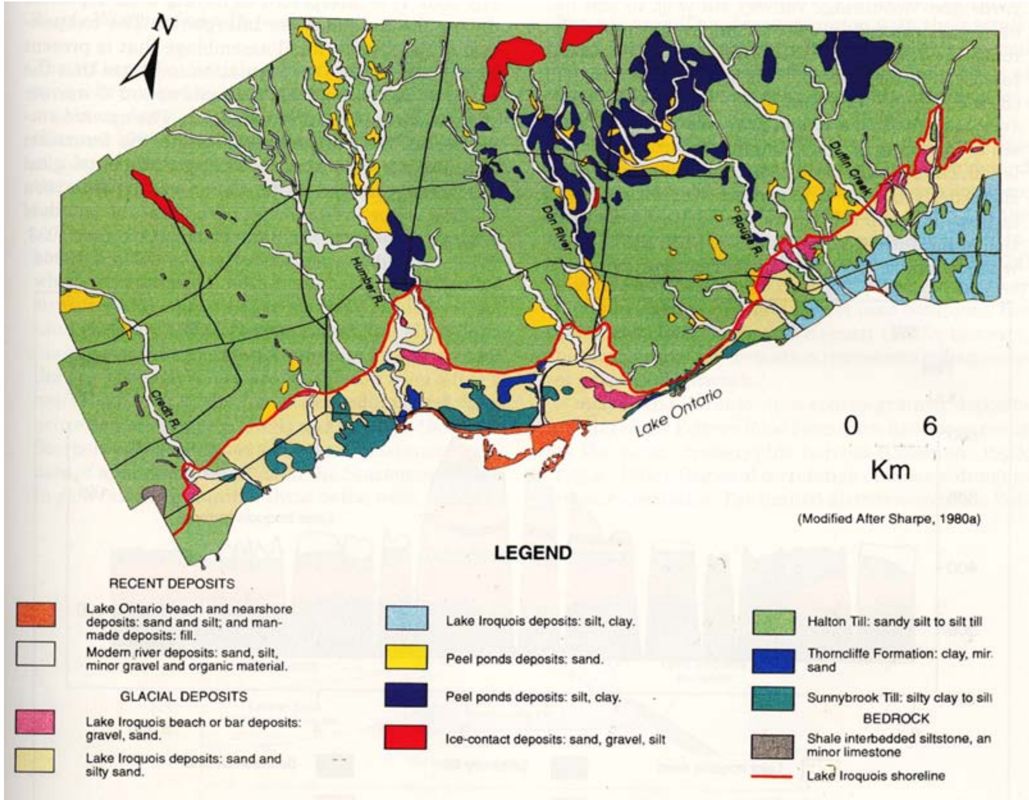
Illustration of major startigraphic layers in the GTA.

Distribution of Paleozoic bedrock formations in the Toronto area



(Baker et al., 1998)

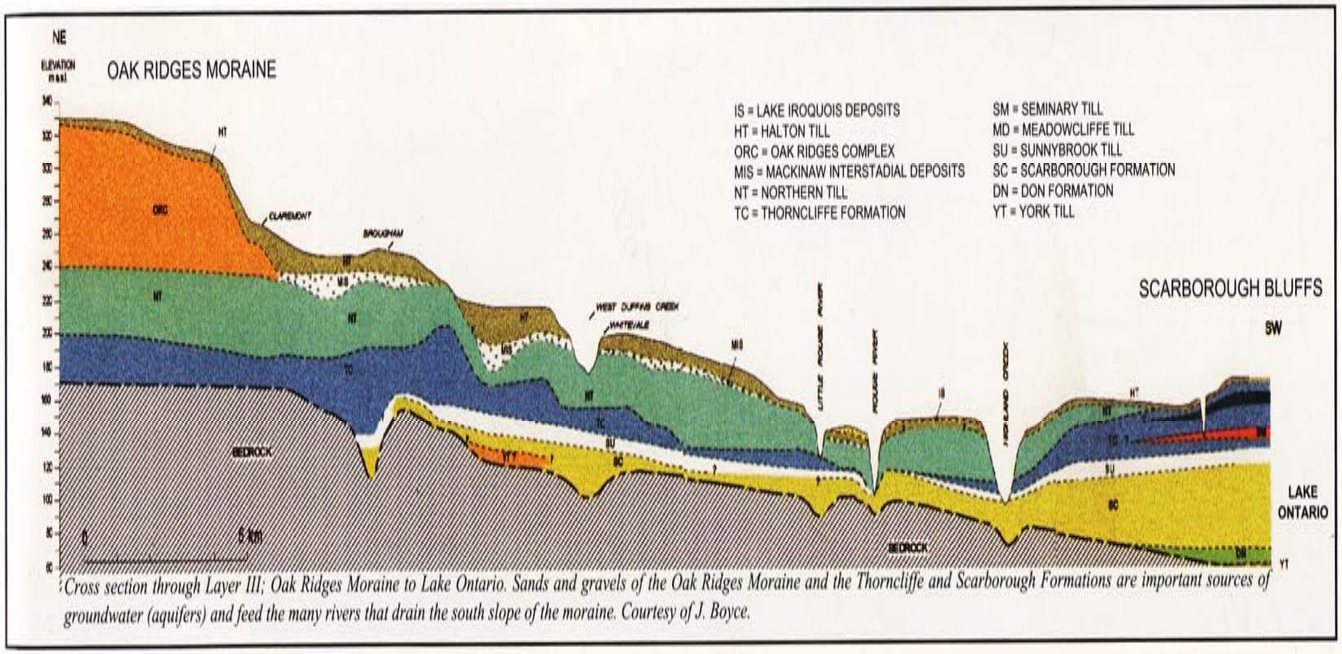
Quaternary geology of GTA



(Baker, 1998)

Cross section trough Layer 3:

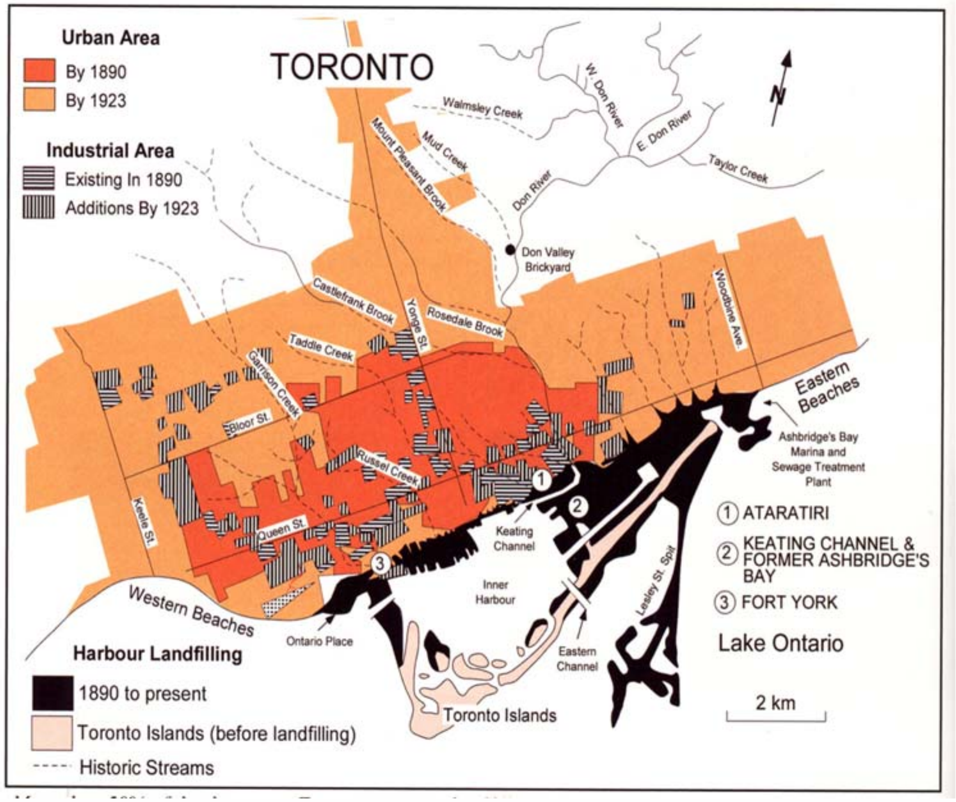
Oak Ridge Moraine to Lake Ontario



Cross section through Layer III; Oak Ridges Moraine to Lake Ontario. Sands and gravels of the Oak Ridges Moraine and the Thorncliffe and Scarborough Formations are important sources of groundwater (aquifers) and feed the many rivers that drain the south slope of the moraine. Courtesy of J. Boyce.

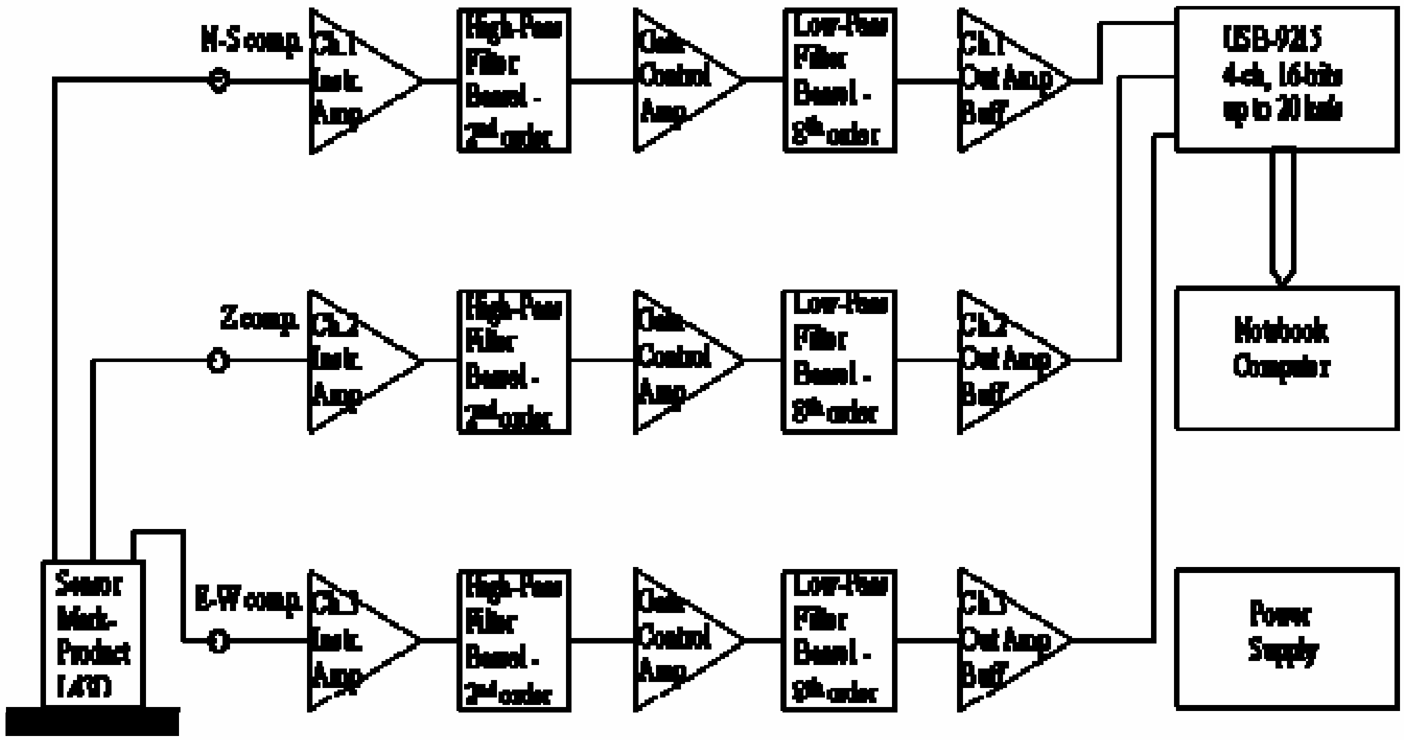
(Eyles, 2004)

Man-made Landscape in Toronto



(acc. to Eyles, 2004)

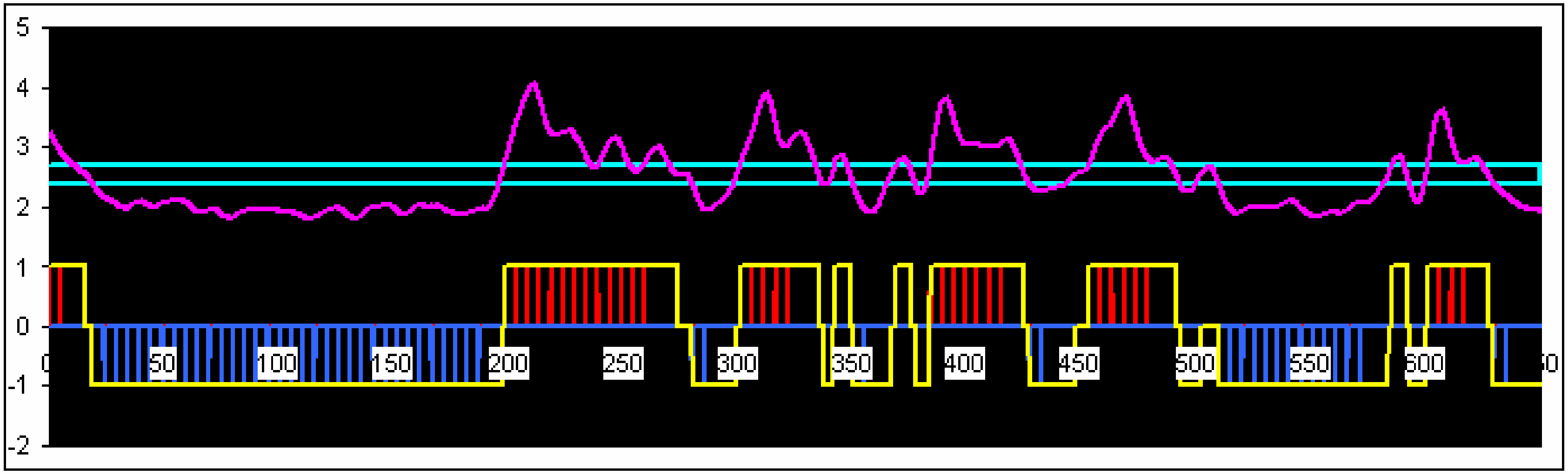
Seismic equipment made in Phase 1



Second Phase

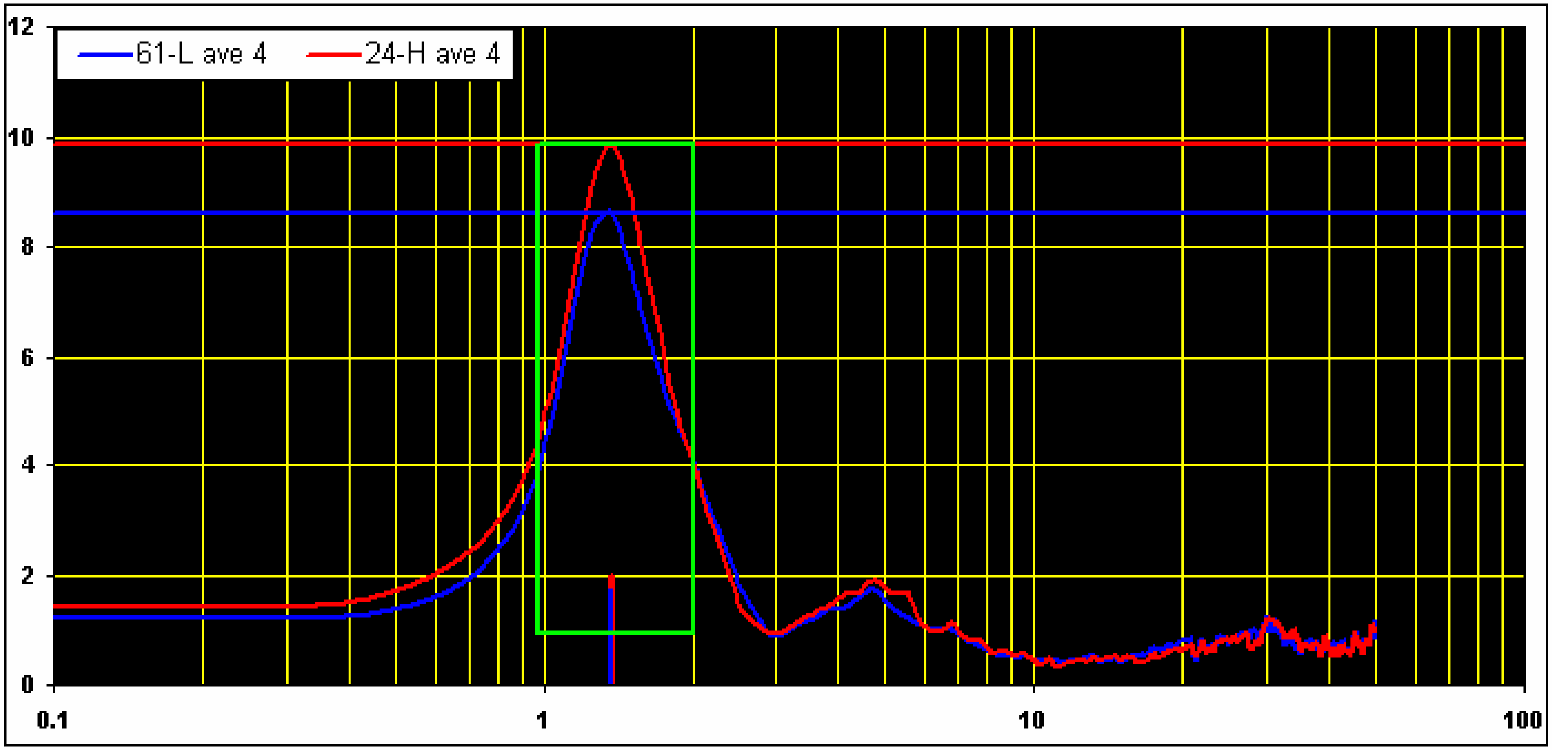
- Second phase covered Most of GTA (100 x 40 km) by a grid of 310 points.
- Ambient noise measured at the grid nodes.
- Frequency of the earthquake loading and its amplitude affect the amount of earthquake damage to different types of buildings.
- Data was processed to obtain frequency and amplitude of peaks of the horizontal-to-vertical ratio of the ground 'noise'.

Separating of the low and high level vibrations in the time domain



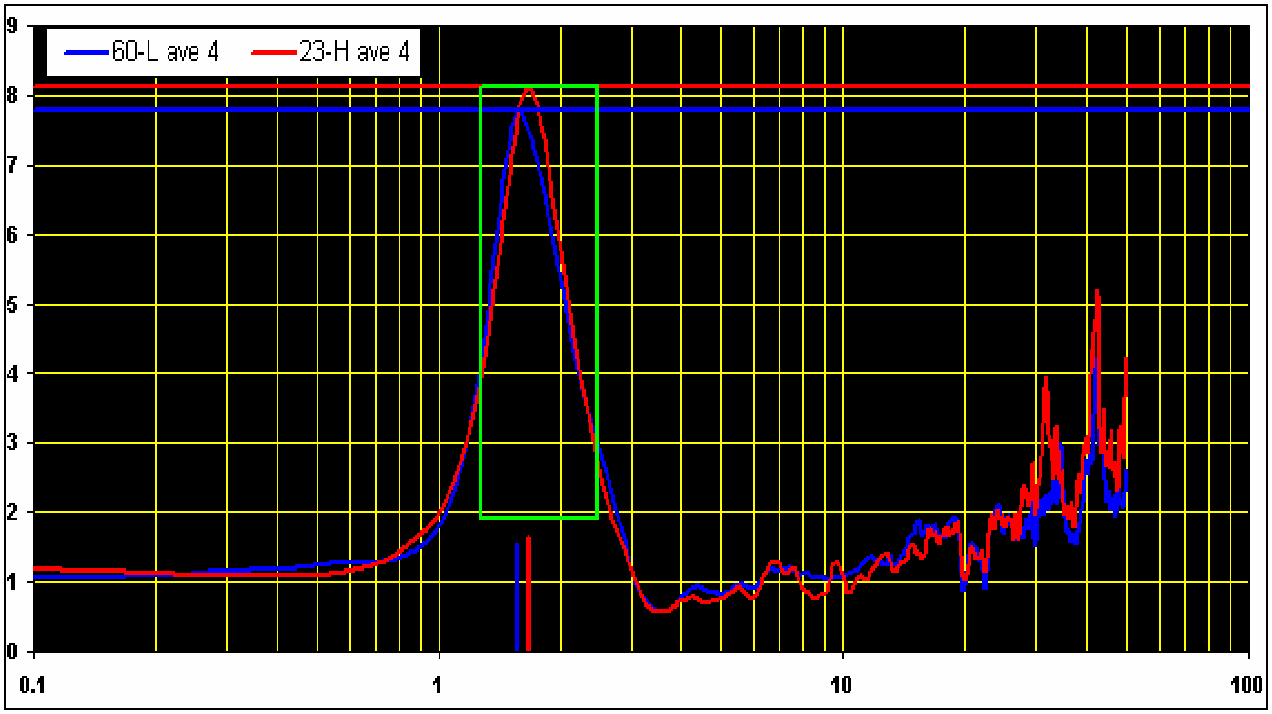
- The magenta line gives the averaged RMS value of the vibrations
- Yellow line gives envelop for low (blue) and high (red) levels for HVSR calculations
- The cyan line represents separating threshold level
- High level of vibration usually is due to nearby traffic

Horizontal to Vertical Spectral Ratio (HVSR)



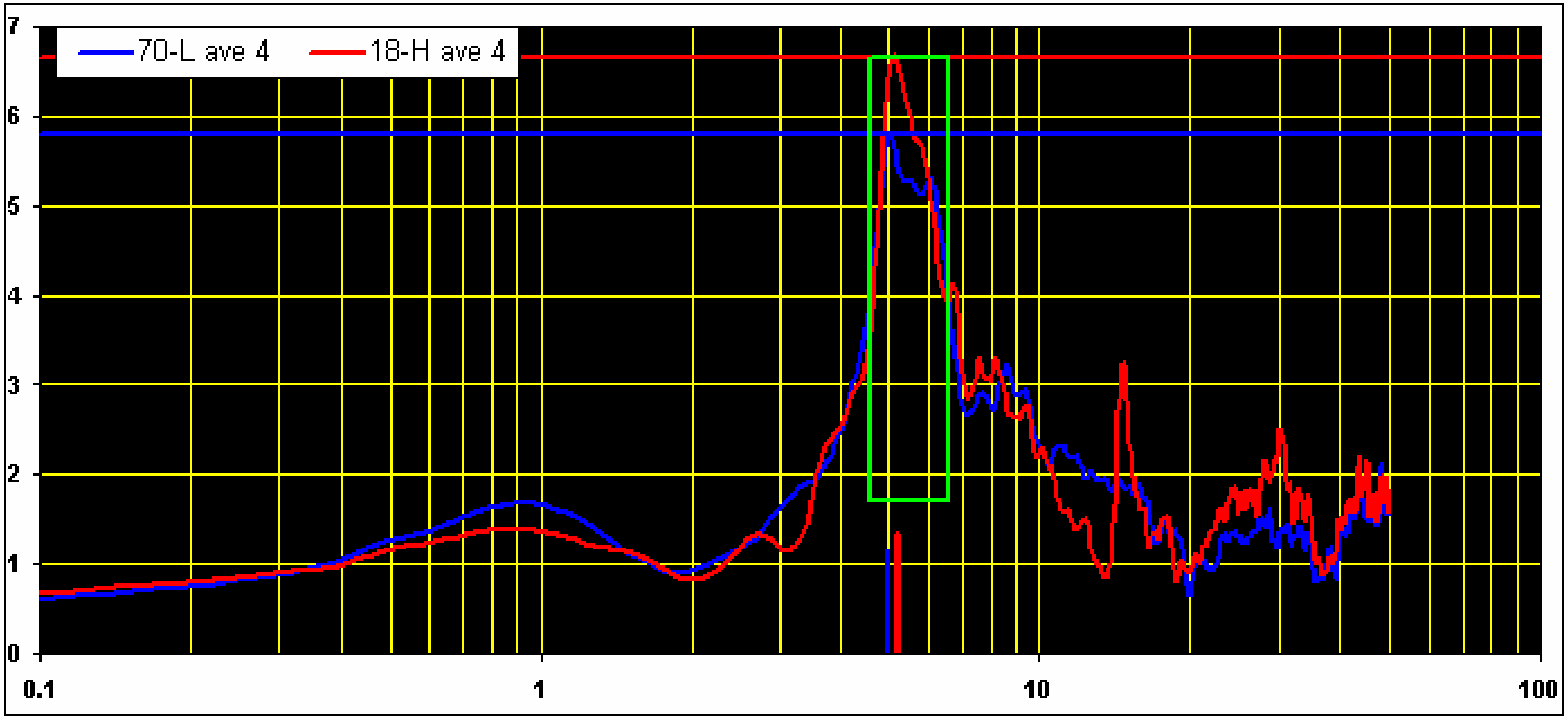
- Classic HVSR with predominant frequency 1.5 Hz.
- On vertical abscise is presented the amplification factor

Horizontal to Vertical Spectral Ratio (HVSR)



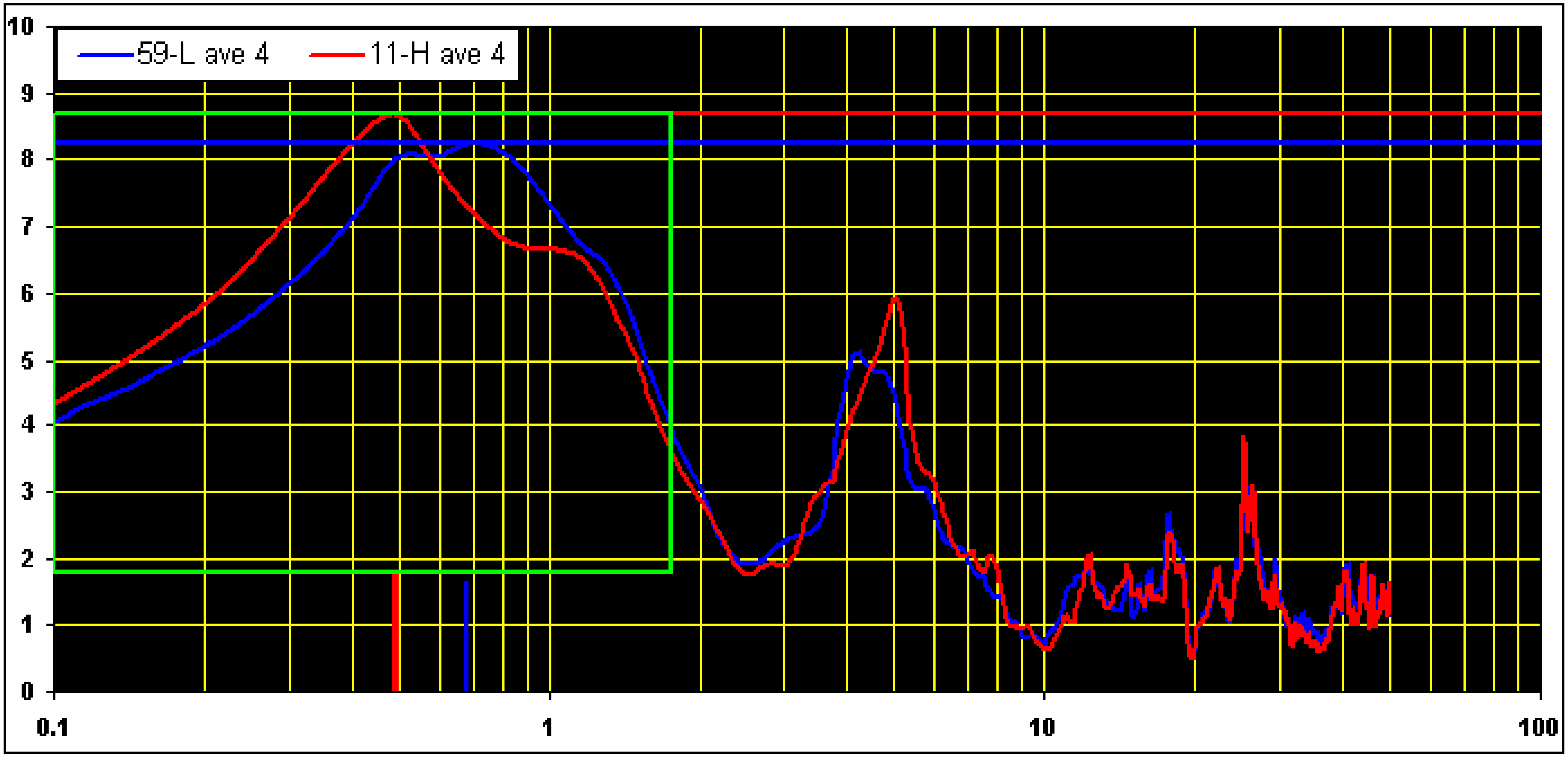
- HVSR with 1.7 Hz and high frequency resonances

Horizontal to Vertical Spectral Ratio (HVSR) plots



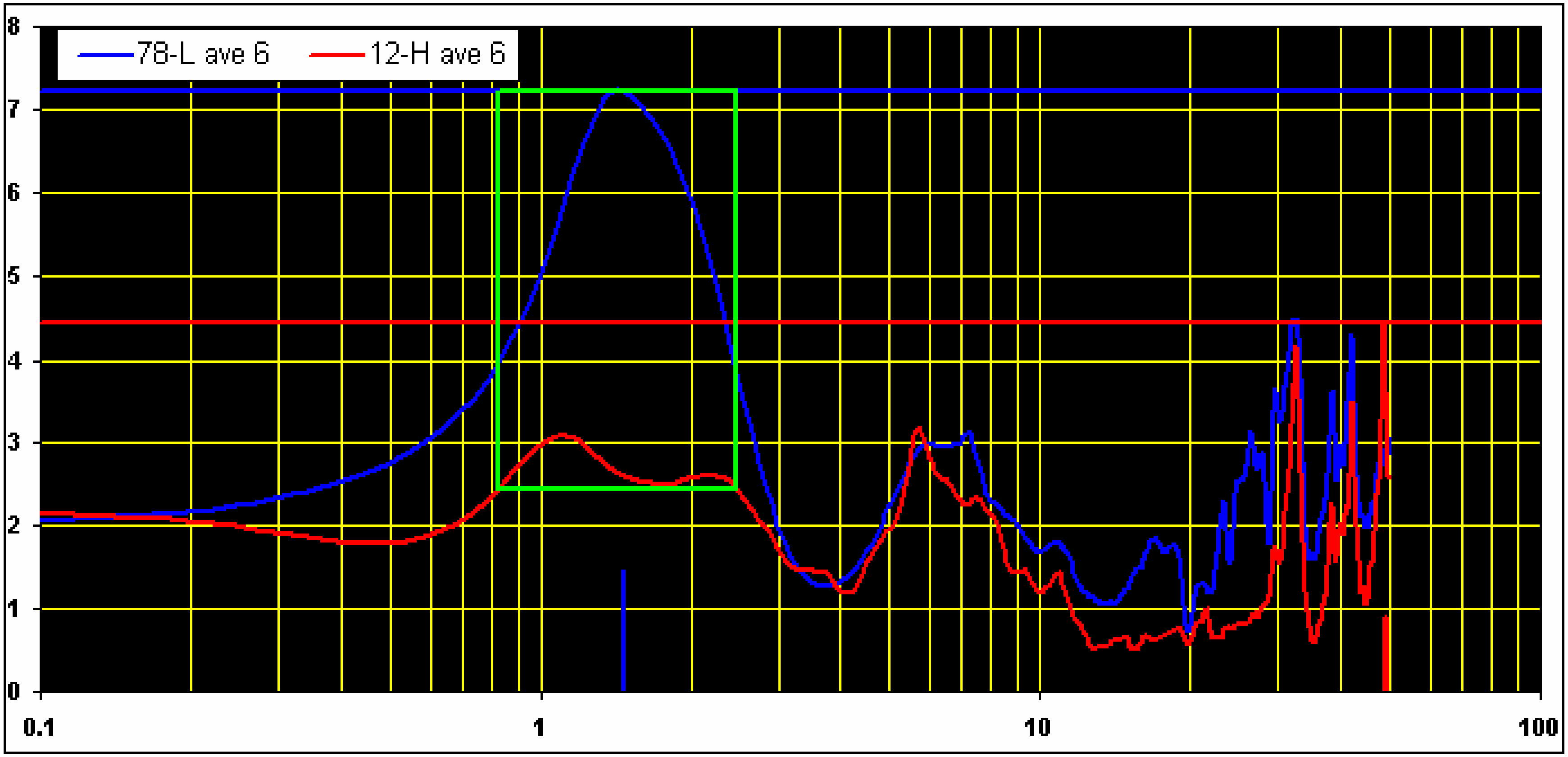
- HVSR with high frequency resonances

Horizontal to Vertical Spectral Ratio (HVSR) plots



- HVSR with low and middle frequency resonances

Horizontal to Vertical Spectral Ratio (HVSR) plots

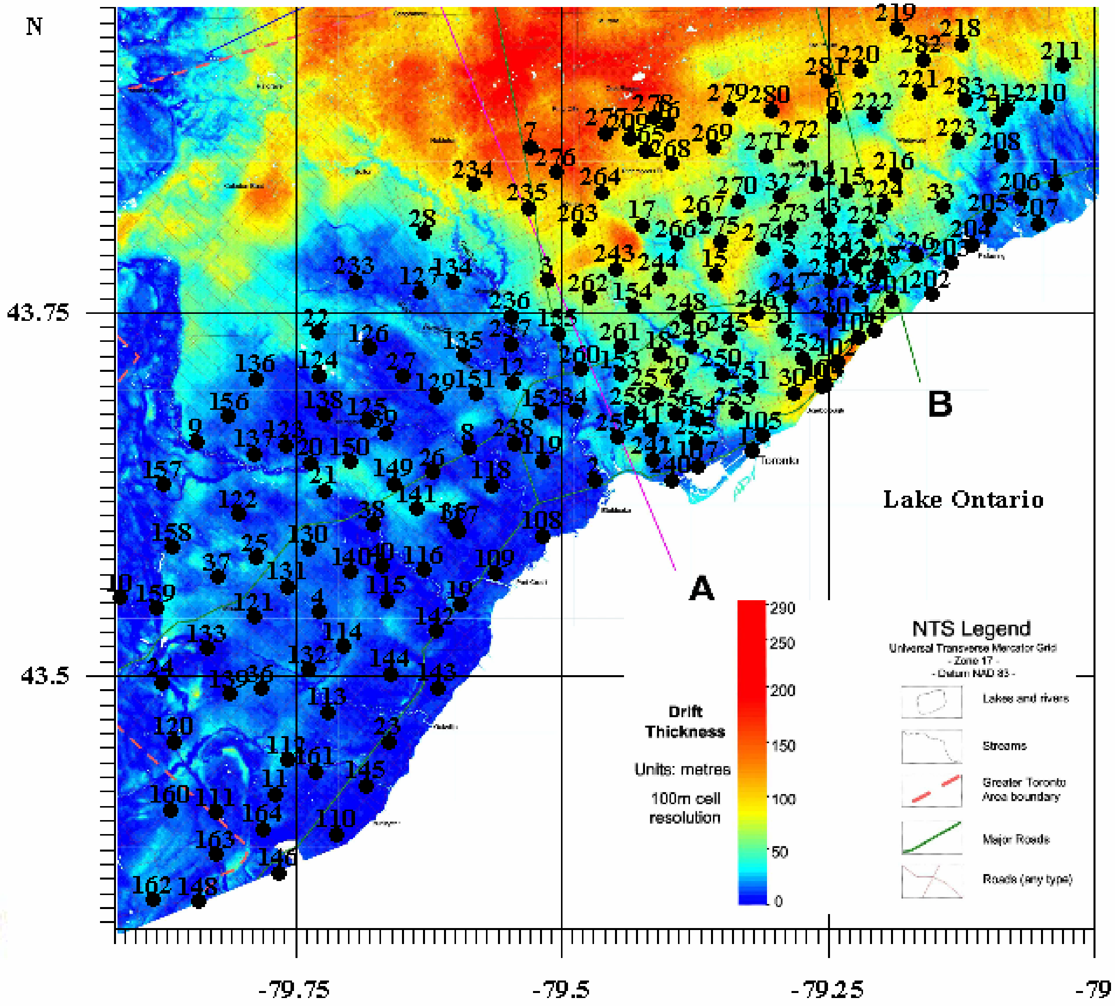


- High level HVSR has no frequency resonances at low frequency.

Overview of Results

- Amplitude amplification more than 12.
- Large amplitude amplification can mean much increased seismic loading in certain areas of Toronto compared to the rest of the city.
- Predominant frequencies varying from 0.2 to 14 Hz.
- This means that a range of building types/heights can be affected differently according to their location in Toronto.

Points of HVSR measurement in Toronto Area



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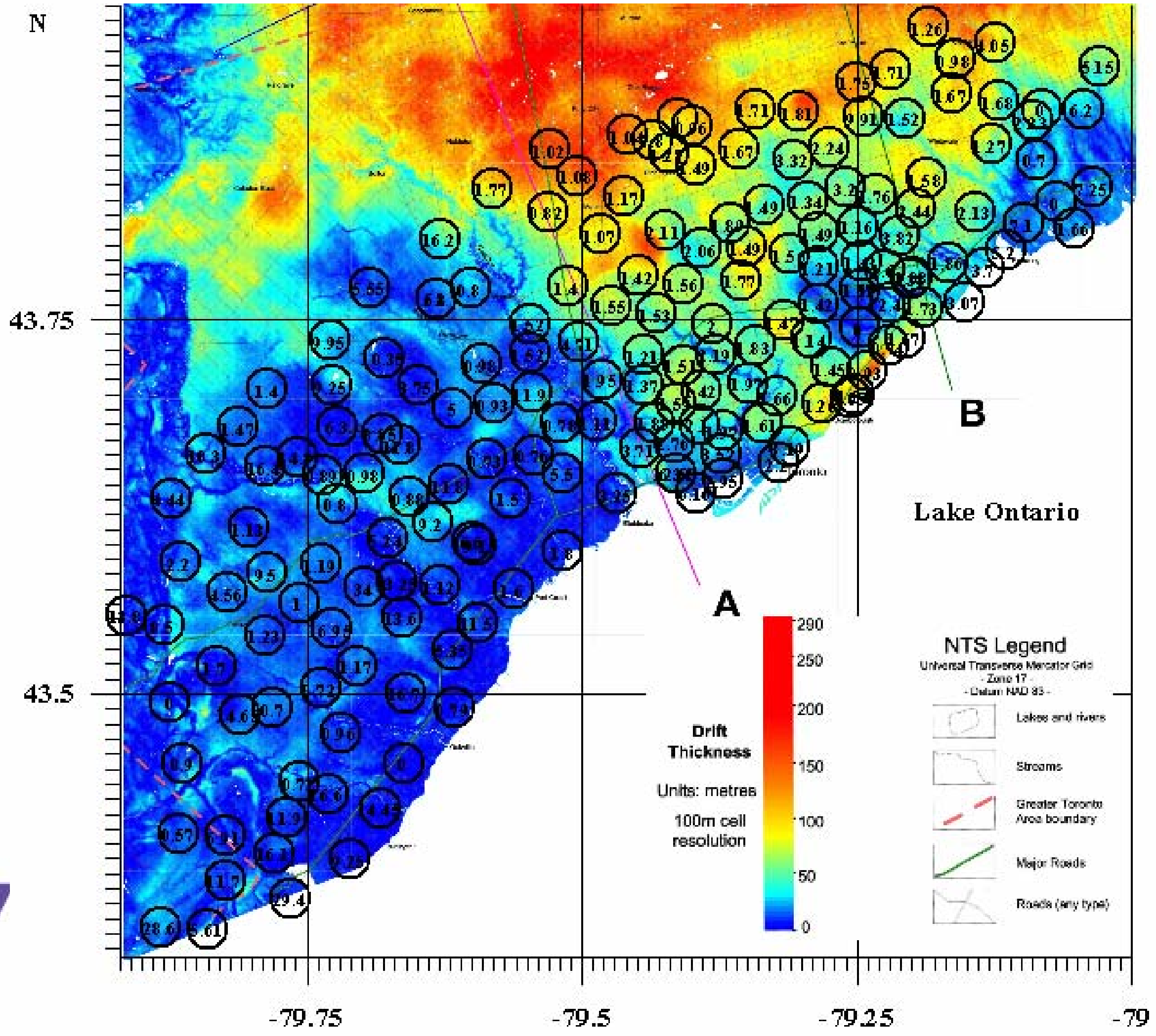
Predominant frequencies at each measured point (preliminary map)



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So, What does That Mean?

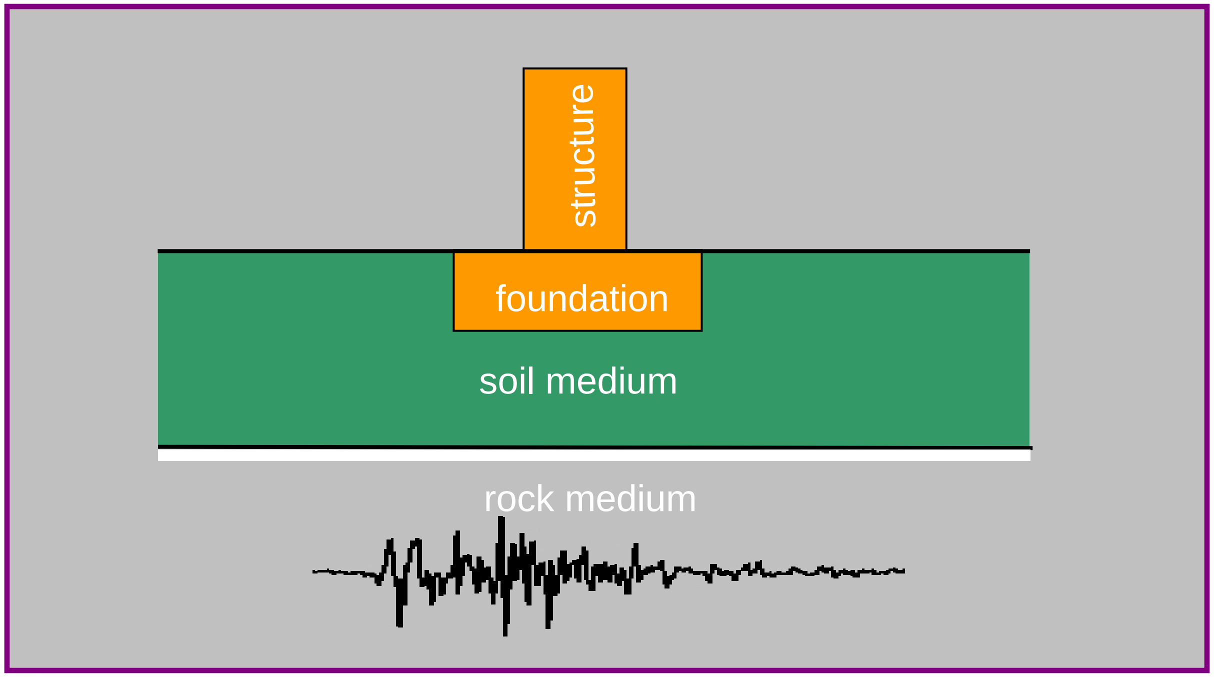
- Information about predominant frequencies and amplification factors can be helpful in assessing earthquake hazard and associated risk in different areas of the T/M region.
- Can be used to develop site specific seismic loading for safe and efficient design.
- Can be used by policy makers/planners for emergency preparedness, etc.
- In the final phase of the study, we can incorporate the field measurements, together with available geological information, into a GIS data base to apply HAZUS-like study for GTA conditions.

Well, How Does That Fit in The Picture?

Washington Mutual/Seattle Art Museum

A: Soil-Structure Interaction

- Dynamic Soil-Structure Interaction (SSI) refers to the effect the interaction between the soil and structure has on the respective response of both components
- Dynamic SSI is a complex phenomenon consisting of many interacting variables

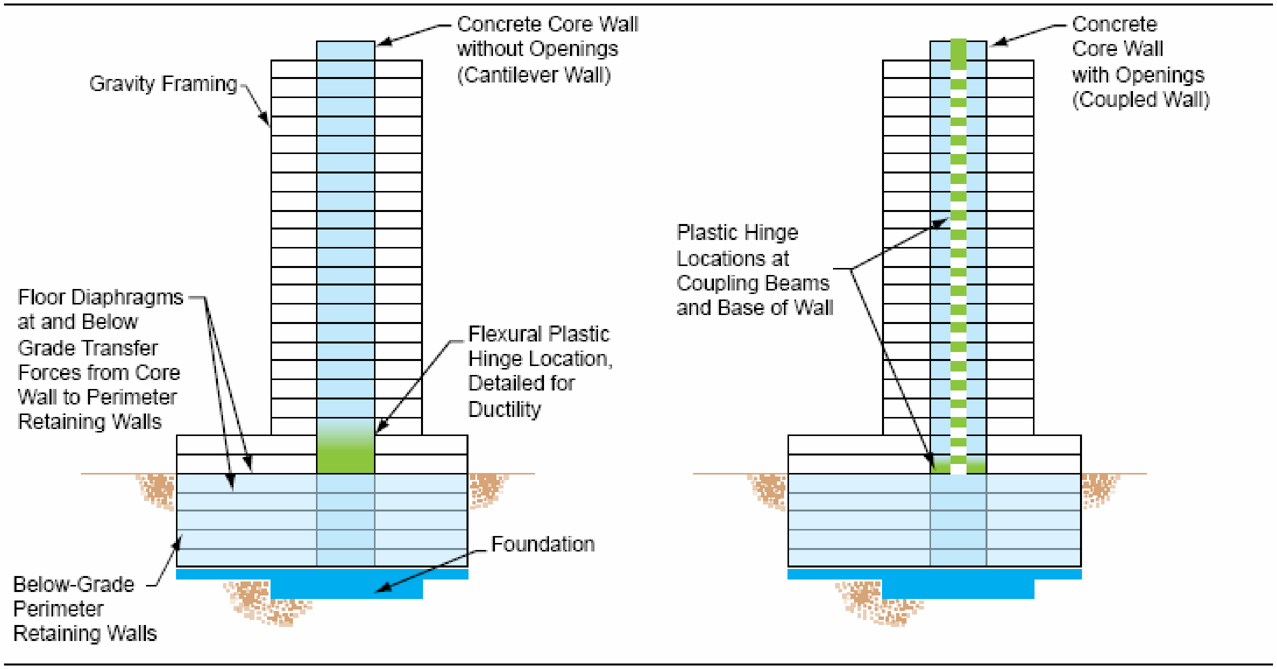


Soil-Structure Interaction

- Traditional seismic design is based on a force-based design (FBD) approach in which structures are designed for ***life safety.***
- SSI is often neglected in FBD since its effects are generally considered to be beneficial.

- Huge economic losses from recent natural disasters requires a change in design philosophy.
- Earthquake engineering researchers have responded to this request with the introduction of performance-based seismic design.

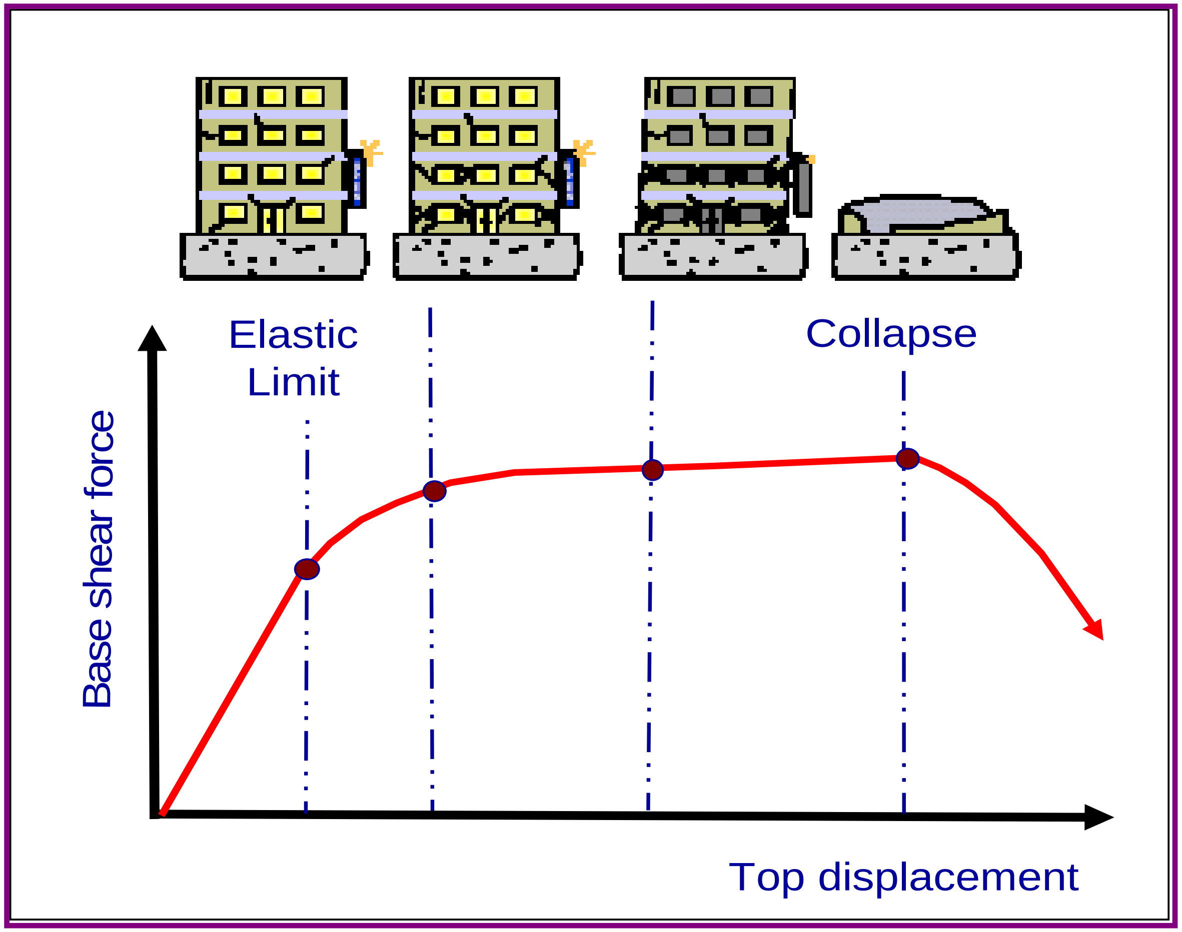
Failure Patterns for Core-Wall Buildings



B: Performance-Based Design (PBD)

- PBD can be defined as the design of structures to meet a specified performance goal based on a ***realistic*** and ***reliable*** understanding of their probable performance

- The performance goals are expressed in quantitative terms and the response of the structure at every stage must be accurately predicted



Each target point on the capacity curve is linked to quantitative measures such as economic loss, casualty rate, etc.

- PBD can be formalized probabilistically as:

$$\upsilon(DV)=\iiint G(DV/DM)\,dG(DM/EDP)\,dG(EDP/IM)\,d\upsilon(IM)$$

- ***Intensity measure*** (IM) defines the expected ground motion hazard
- ***Engineering demand parameter*** (EDP) describes structural response in deformation terms
- ***Damage measure*** (DM) describes the condition of the structure and its components
- ***Decision variable*** (DV) are the final quantitative estimates used in risk management

$$dG(EDP/IM)=\iint \underbrace{dG(EDP/FIM)}_{\textbf{Structural analysis}}\,\underbrace{dG(FIM/FF)}_{\textbf{Soil-Structure Interaction analysis}}\,\underbrace{dG(FF/IM)}_{\textbf{Free-field analysis}}$$

Did you get my point?

Many **THANKS** for your support