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Dunbar Earthquake and Emergency Preparedness

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Earthquake

Hazard Identification
&
Risk Analysis

&

How to be Prepared

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In Vancouver

and more specifically

Dunbar

What sort of catastrophic emergency risks do we need to prepare for?

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What sort of catastrophic emergency risks do we need to prepare for?

- **Earthquakes** – probably the single most important catastrophic risk we face in Vancouver
  - **Tsunami** – for low-lying, delta and coastal regions (including estuaries and river valleys) – related to earthquake risk
- **Storm / flood** – less likely to be affected by a severe storm event in Vancouver (compared to east coast etc) – but not impossible
  - **Flooding** of low-lying and delta regions (including estuaries and river valleys) – related to excessive rain and run-off or snow melt in the hinterland – quite possible in Greater Vancouver
    - **Vancouver named one of top cities at risk of flooding from rising sea levels** (OECD 2013 Report)
- **Pandemic** – highly contagious diseases with high mortality rate
  - **Coronavirus** – e.g. SARS – currently originating in the Middle East
  - **Haemorrhagic Fever** – e.g. EBOLA – likely originating in Africa
  - **Avian-flu** – e.g. H7N9 – currently originating in Asia

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This Talk

For DEEP

Will Focus On

Earthquake & Tsunami Risk

(Although Storm-Related Flood Risk Areas are similar to those at risk of Tsunami Damage)

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Hazards, Unwanted Events & Risks

- A **Hazard** is:
  - A potential source of Harm – normally related to sources of Energy
- An **Unwanted Event** is:
  - A situation or condition where the Hazard (energy) is released with potentially negative Consequences
- **Risk** is:
  - A measure of how much we should worry

(**Risk** = Likelihood of an Event x Consequences of the Event (R=LxC))

Hazards:

- Are usually related to different forms of Energy:
  - Gravitational (e.g. objects falling)
  - Electrical
  - Thermal (heat, fire)
  - Explosion (combustion under pressure)
  - Machinery (often a mixture of energies)
  - Vibration (including sound and noise)
  - Chemical
  - Biological
  - People (!)
  - Geological
  - etc

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What is Risk?

- The "Worry Factor"
- It is better to be Proactive when managing risks, than Reactive
  - Or it simply may be too late
- It is important to think of abnormal situations, not just the "normal"
  - Nothing bad happened yet – so we must be OK. Right?

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The Earthquake Risk in Vancouver

- **BBC Documentary – Mega Quake Could Hit North America**

  http://www.youtube.com/watch?v=vEgLjgnv_3c&feature=player_detailpage

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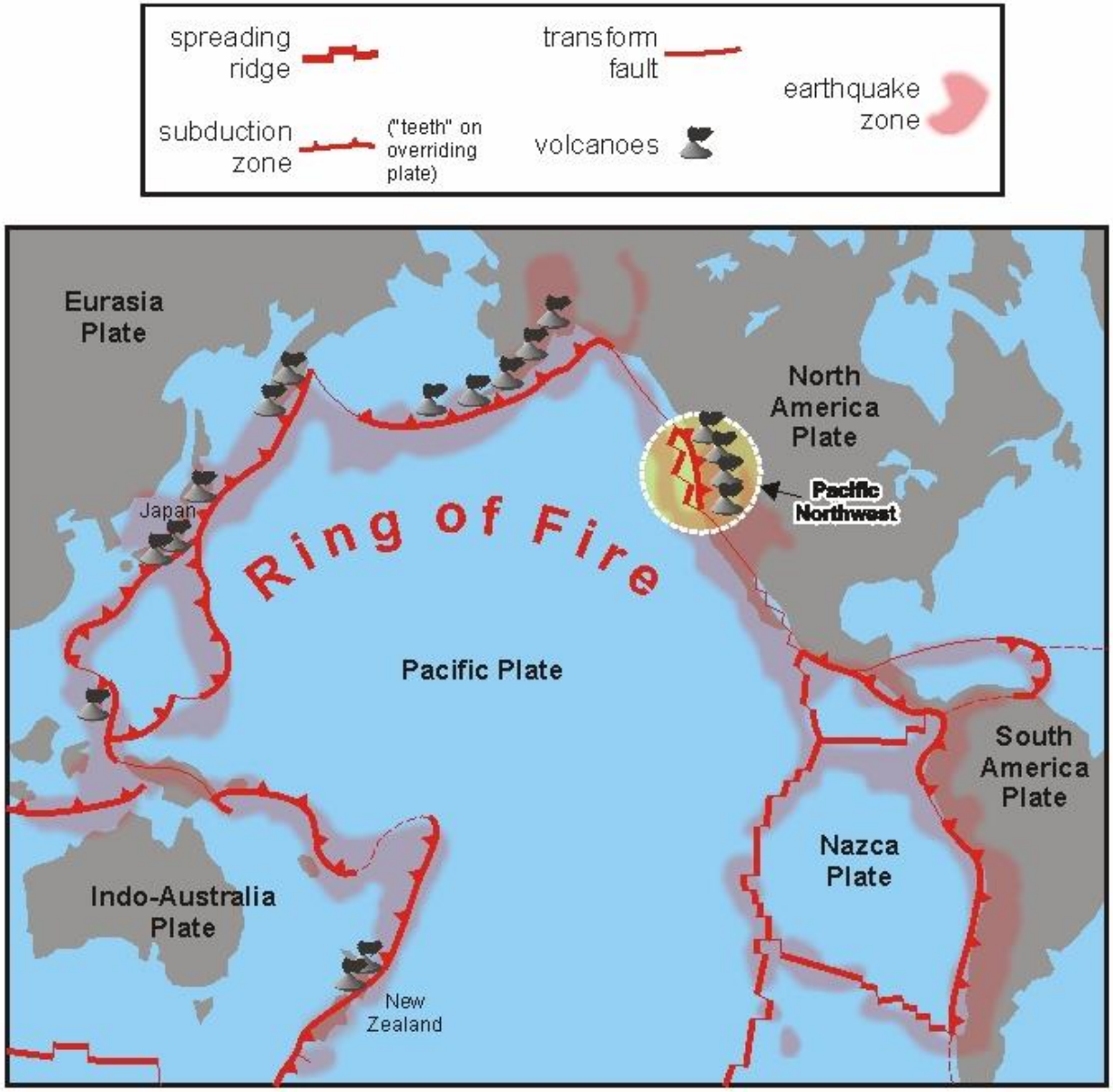
KABOOOOOM!!!!!

- Oh Dear!!
  - That's not good!!
- Did I prepare for this day?
  - Did I ever think this could happen?
  - To me, and my loved ones?
- Was I Proactive?

San Francisco 1981 – Magnitude 7.1

Geological Hazards (1):

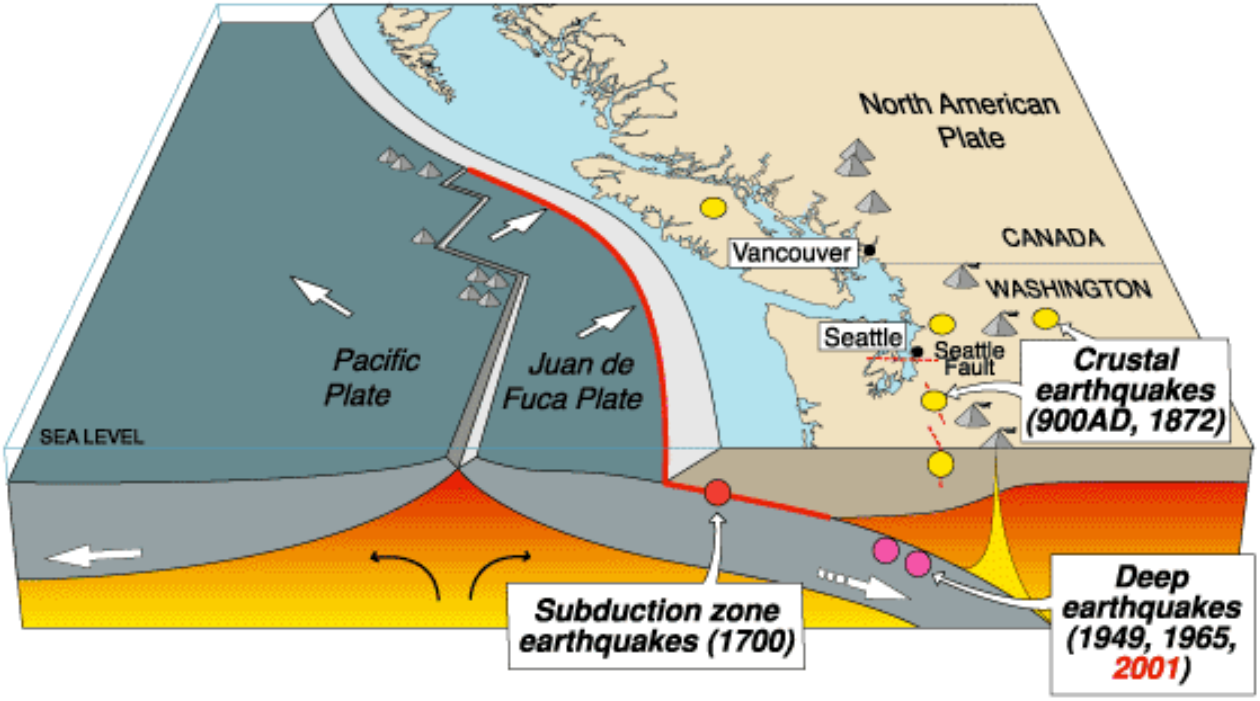
- Vancouver lies on the NW margin of the North American Continent tectonic plate, close to its contact with the Pacific Ocean tectonic plate **
  - This contact is called a subduction zone
  - The Pacific oceanic plate is being “subducted” beneath the North American continental plate along the NW Pacific Coast
- Movement between the two tectonic plates is restricted by very strong frictional forces
  - This results in very large deformational energies being stored up in the rock masses – This is the Hazard – Tectonic Energy
- ** In detail – the Juan de Fuca tectonic plate


spreading ridge
transform fault
earthquake zone
subduction zone
("teeth" on overriding plate)
volcanoes
Eurasia Plate
North America Plate
Pacific Northwest
Japan
Ring of Fire
Pacific Plate
South America Plate
Nazca Plate
Indo-Australia Plate
New Zealand

Geological Hazards (2):

- What is the Unwanted Event?
  - The Hazard – i.e. the Tectonic Energy – is released
- This results in an earthquake – very large release of energy
  - Rapid release of tectonic deformational energy results in crustal movements and extremely powerful vibrational energies propagating throughout the rock masses
  - Some energy is released as noise
- Earthquake energies are often measured by the Richter Scale (which has some limitations) or Moment Magnitude Scale (MMS)

Cascadia earthquake sources



Source	Affected area	Max. Size	Recurrence
Subduction Zone	W.WA, OR, CA	M 9	500-600 yr
Deep Juan de Fuca plate	W.WA, OR,	M 7+	30-50 yr
Crustal faults	WA, OR, CA	M 7+	Hundreds of yr?

Vancouver Area - Earthquakes

Year	Magnitude	Location
1700	9.0	Vancouver Island
1872	7.4	Washington State
1909	6.0	Gulf Island Region
1918	7.0	Vancouver Island
1946	7.3	Vancouver Island
1949	7.1	Puget Sound
1965	6.5	Seattle
1976	5.3	Pender Island
1990	4.9	Northern Washington
1996	5.0	Seattle
1997	4.6	Strait of Georgia
2001	6.8	Olympia Washington

Source: Geological Survey of Canada

Geological Hazards (2):

- Earthquake energies are often measured by the Richter Scale (which has some limitations) or Moment Magnitude Scale (MMS)

http://www.livescience.com/20538-earthquake-magnitude-video.html

Geological Hazards (3):

- What is the **Risk**?
  - Great Subduction Zone earthquakes are the largest earthquakes in the world, and can exceed magnitude 9.0
    - The Cascadia subduction zone can produce magnitude 9.0 earthquakes or greater (if movement along entire length)
- The last known great earthquake in the northwest was the 1700 Cascadia earthquake
  - Geological evidence indicates that great earthquakes may have occurred at least seven times in the last 3,500 years, suggesting a return time of 300 to 600 years

Geological Hazards (4):

- **What is the Risk?**

- **The next rupture of the Cascadia Subduction Zone is anticipated to be capable of causing widespread destruction throughout the Pacific Northwest**

- **Geologists and engineers have broadly determined that the Pacific Northwest is not well prepared for such a colossal earthquake**

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What is Risk Associated with this Geological Hazard?

- Risk = Likelihood of an Event x Consequences of the Event

- Likelihood (L) = low (depends on the timescale you want to use)
- Consequences (C) = catastrophic (potentially)

- Risk (R) = low x catastrophic = high risk
  - i.e. We should worry and plan for this event and take precautions

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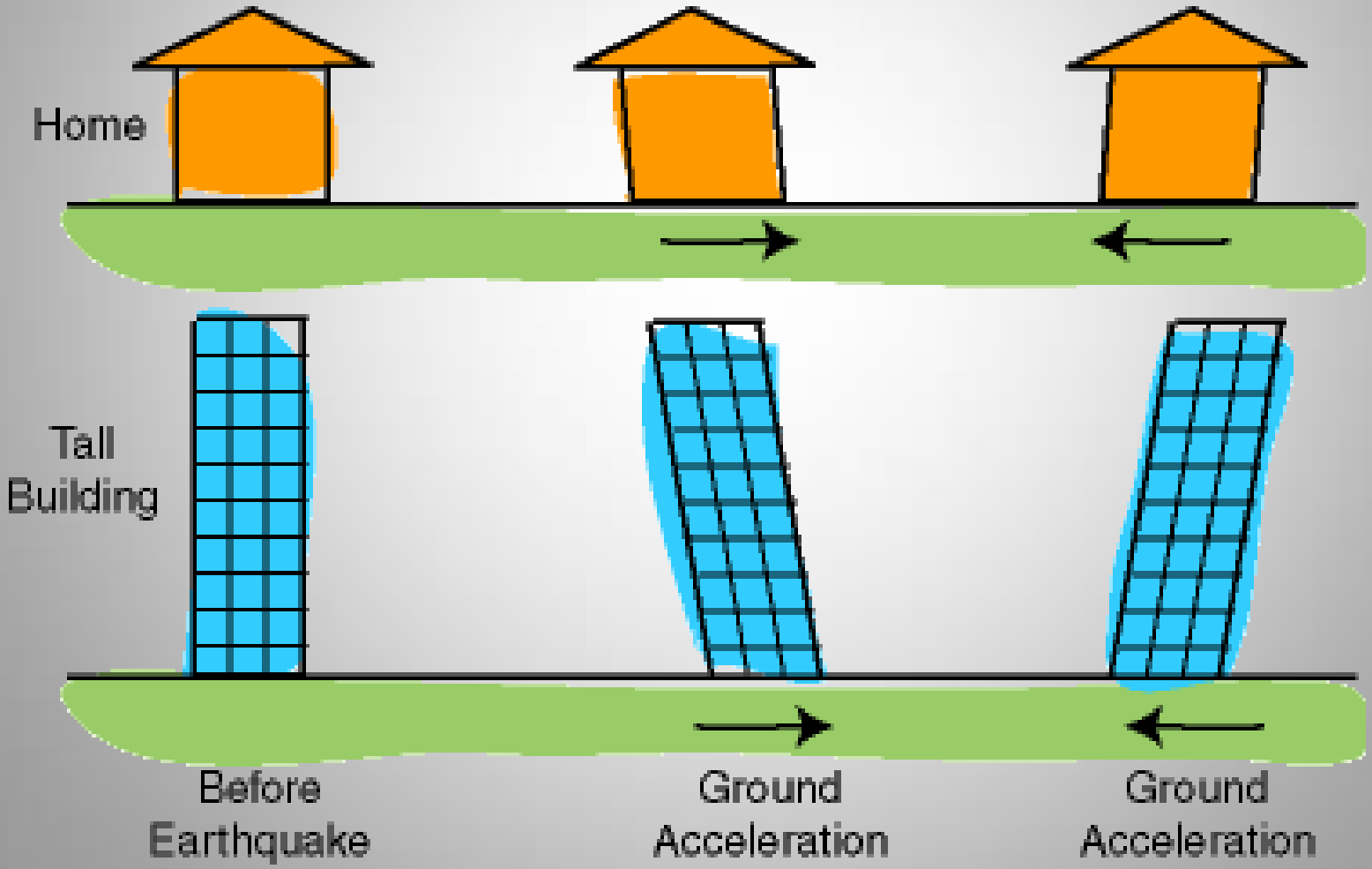
Geological Hazards (5):

- What is the **Risk**? (http://www.nature.com/news/2010/100531/full/news.2010.270.html)
- Geologists predict a 10% to 15% probability that the Cascadia Zone will produce a magnitude 9 event or higher in the next 50 years
  - However, the most recent studies suggest that this risk could be as high as 37% for earthquakes of magnitude 8 or higher
  - Ref: Goldfinger, C. et al. Turbidite Event History: Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone. USGS Prof. Pap. 1661-F
- Any tsunami produced may reach heights of approximately 30m
- Many man-made and natural structures are not built to withstand the vibrational shaking that accompanies such an earthquake
  - Nor are many structures suitably located for tsunami risk

Earthquakes – make things shake:



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Houses & Homes:

Prince William Sound, Alaska 1964 – Magnitude 8.5

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Westmorland, California 1981 – Magnitude 6.0

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Van, Turkey 2011 – Magnitude 7.2

Christchurch, New Zealand 2011 – Magnitude 6.3

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Christchurch, New Zealand 2011 – Magnitude 6.3

Larger Structures:

Niigata, Japan 1964 – Magnitude 7.4

Kobe, Japan 1995 – Magnitude 6.9

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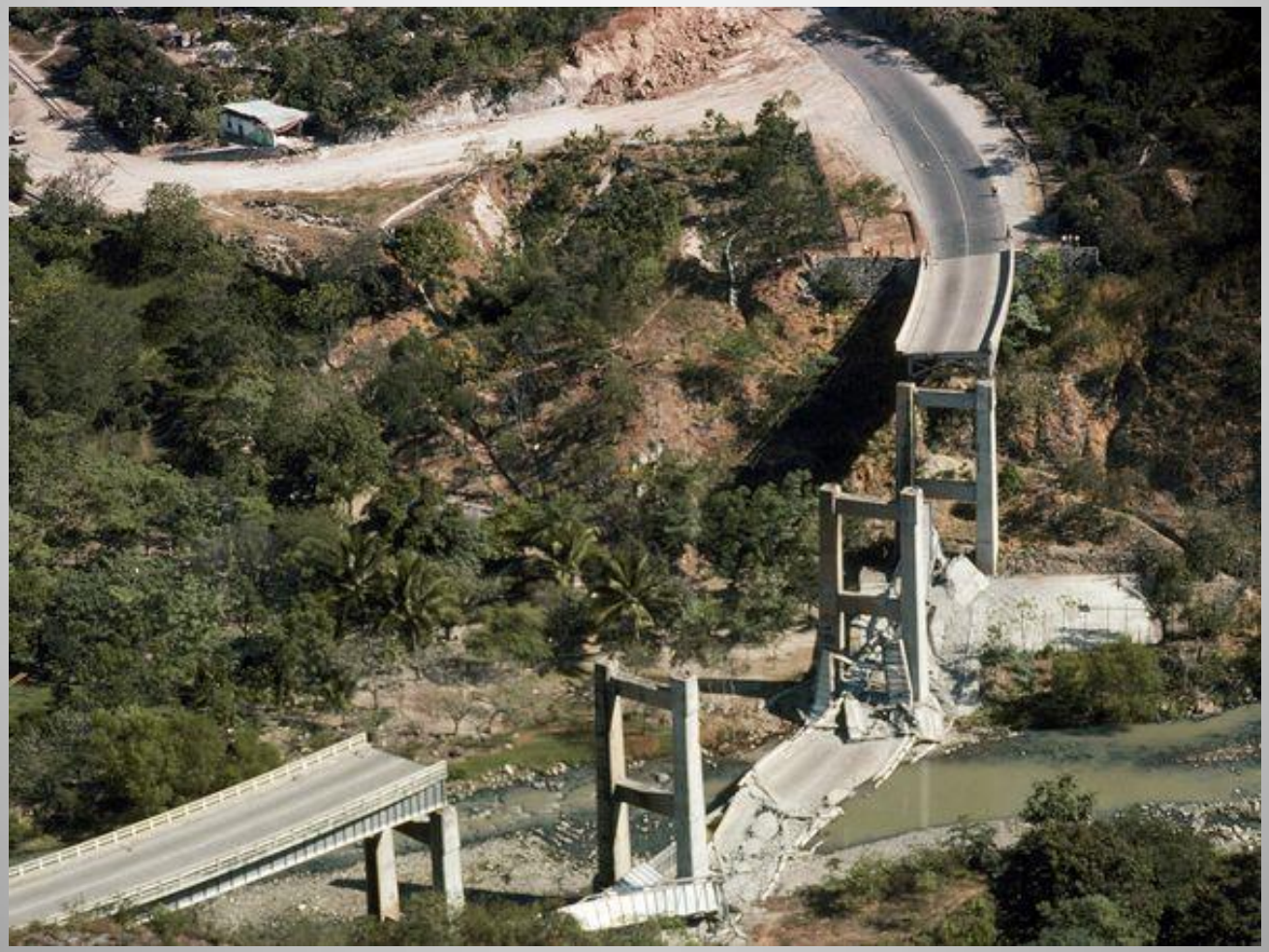
Infrastructure:



Guatemala City, Guatemala 1976 – Magnitude 7.5

A massive section collapsed from the four-lane 1-5 freeway after the 1994 Northridge, California earthquake. Though its magnitude was only 6.7, the Northridge earthquake was the costliest in U.S. history. Damages exceeded $20 billion. The earthquake destroyed 3,000 homes and killed 57 people. Image courtest of Robert A. Eplett/OES CA.

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Kobe, Japan 1995 – Magnitude 7.2

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Earthquake Risks:

- Risk to Buildings
  - Housing
  - Public Buildings and Offices
  - Schools and Hospitals

  } Unreinforced Masonry Buildings (URMs)

- Risk to Power and Gas Lines } Fire Becomes a Major Hazard
- Risk to Communications
- Risk to Transport Systems and Surface Infrastructure
- Risk to Water and Underground Infrastructure (sewers, drains etc)

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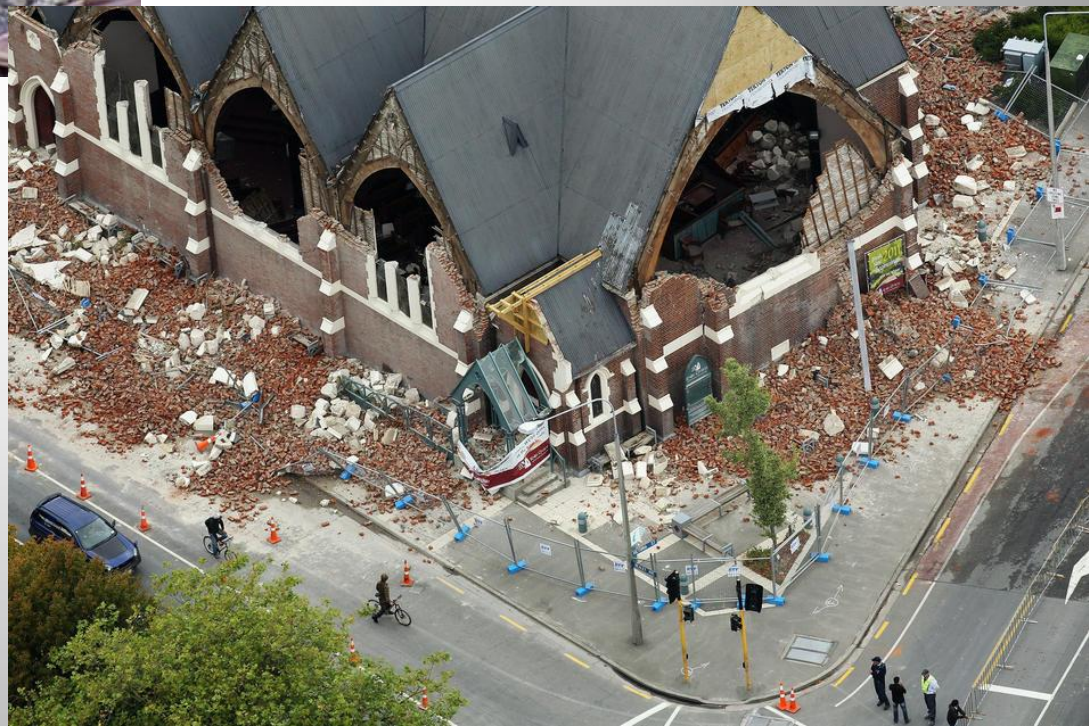
URMs:

Leninakan, Armenia - 1988

Christchurch, New Zealand - 2011



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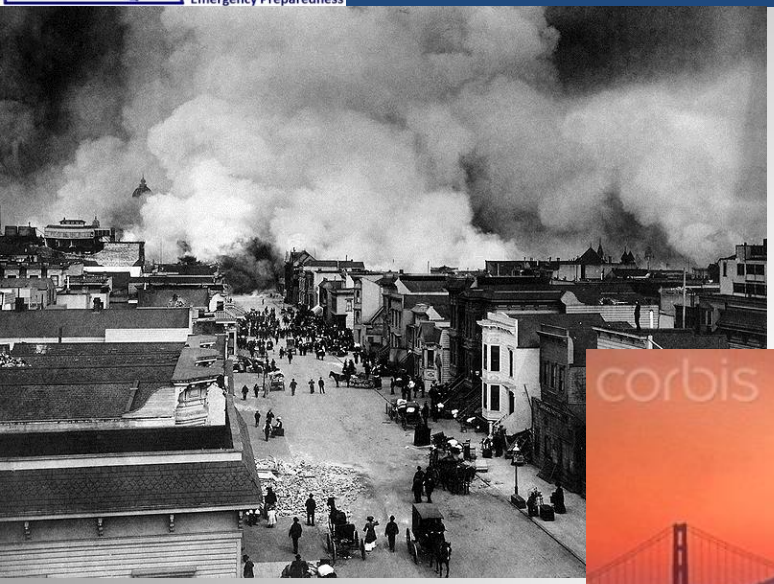
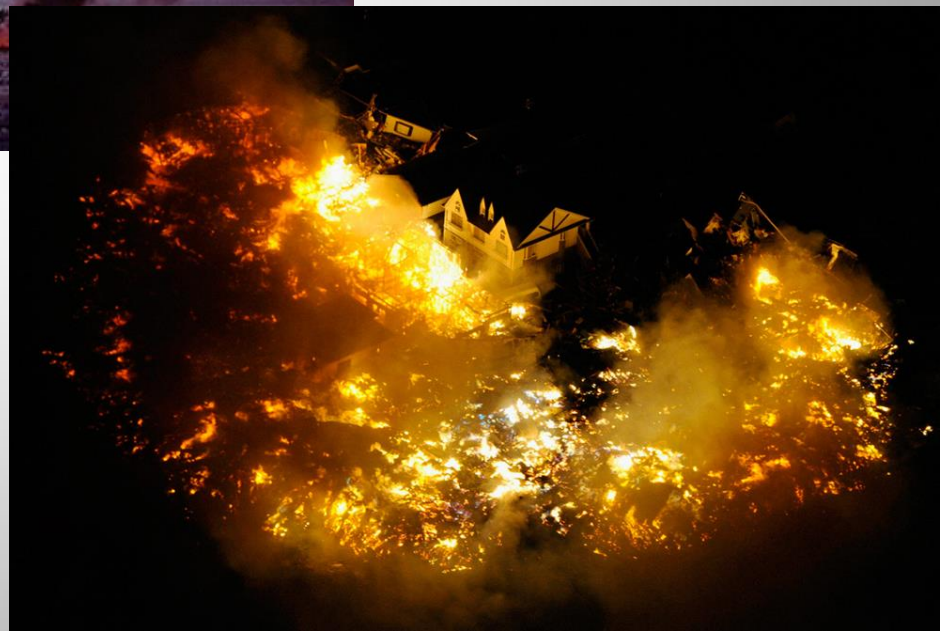
Fire:



San Francisco - 1906

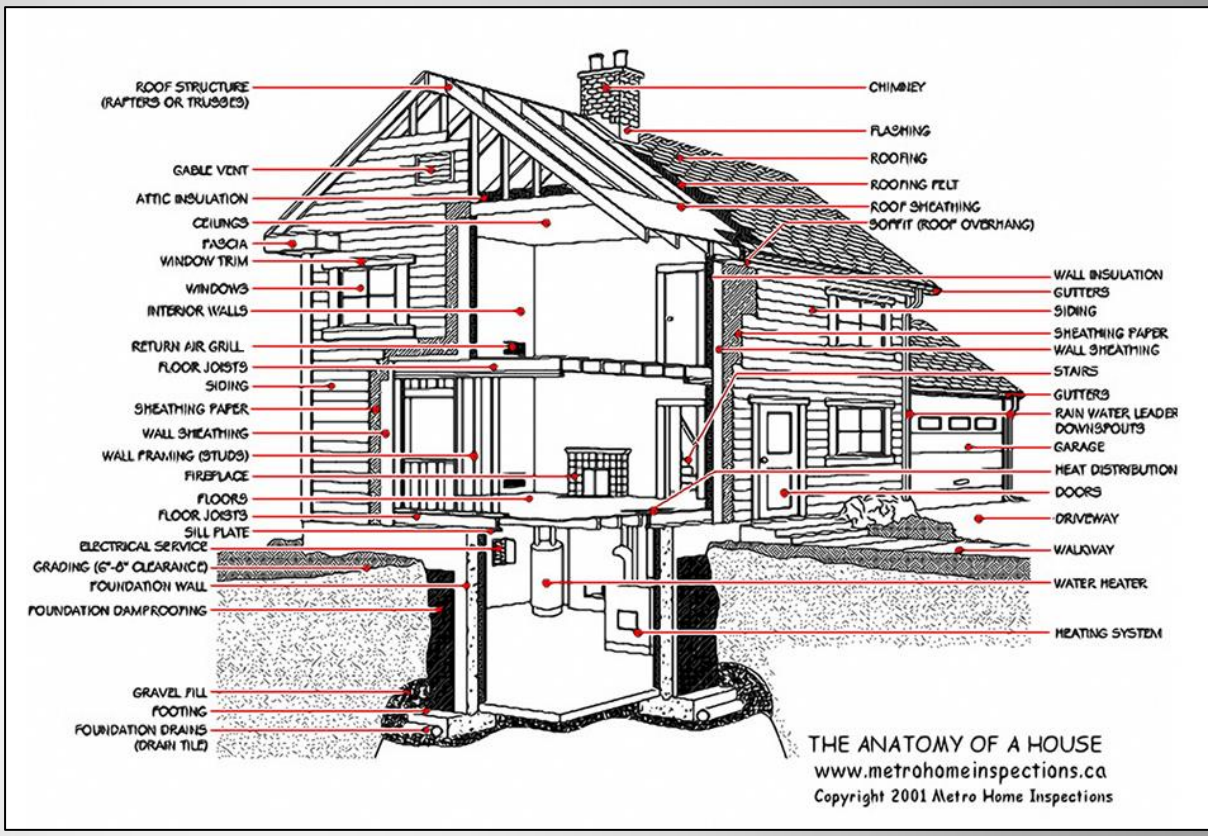
San Francisco - 1989



Japan - 2011

Housing (1):

(Note: Top-level observations – seek professional help)



- **In California (USGS 2008):**
  - **Wood buildings are light in weight and strong, and *modern* wood-framed buildings have performed well and have provided a high level of *life-safety* in earthquakes**

Housing (2):

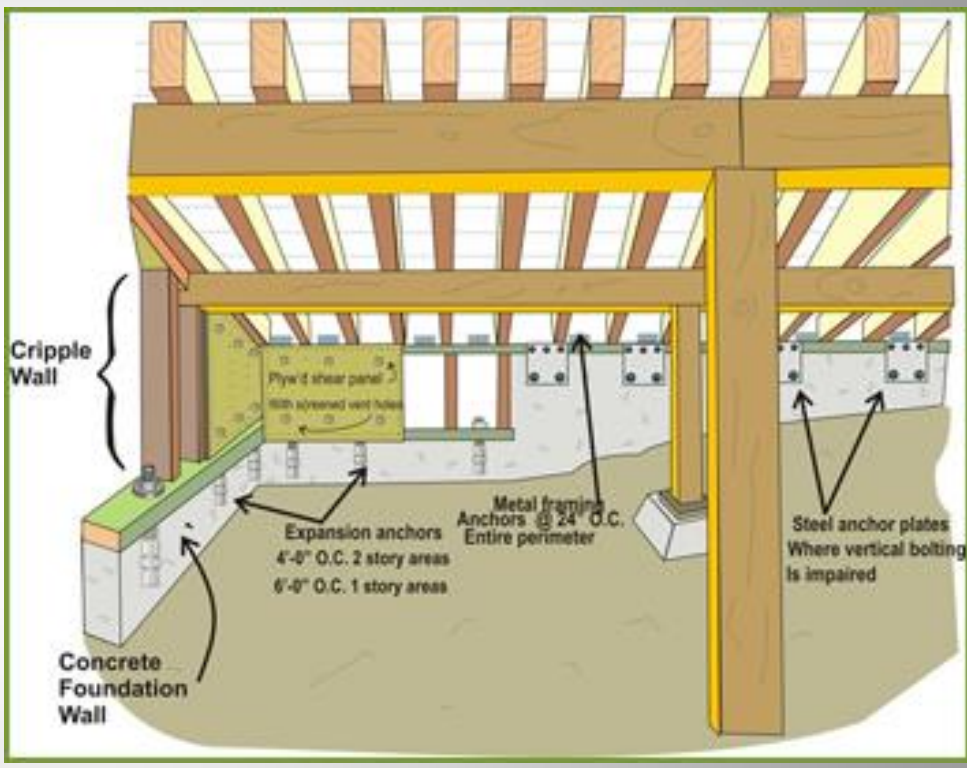
- In California (USGS 2008):
  - Seismic building codes require explicit design by a Professional Engineer (Civil or Structural) for the earthquake force-resisting system for any and all buildings
  - Regular wood dwellings up to 3 stories in height may be built using prescriptive conventional light-frame construction rules
    - These buildings are “deemed to comply” with earthquake provisions without formal design
  - Larger structures and buildings not meeting the restrictions for conventional light-frame construction must be engineered

Housing (3):

- In California (USGS 2008): – Key weaknesses in wood frames:
  - Materials like stucco and gypsum wall-board provide poor resistance to cyclical earthquake motions
  - Heavy, rigid elements such as masonry fireplaces and chimneys, or masonry veneers, require careful reinforcement and good connections to prevent damage to the wood-framed structure under strong ground shaking
  - Many wooden homes that survive the initial earthquake can then be destroyed by fire (often due to ruptured gas mains)

Housing (4):

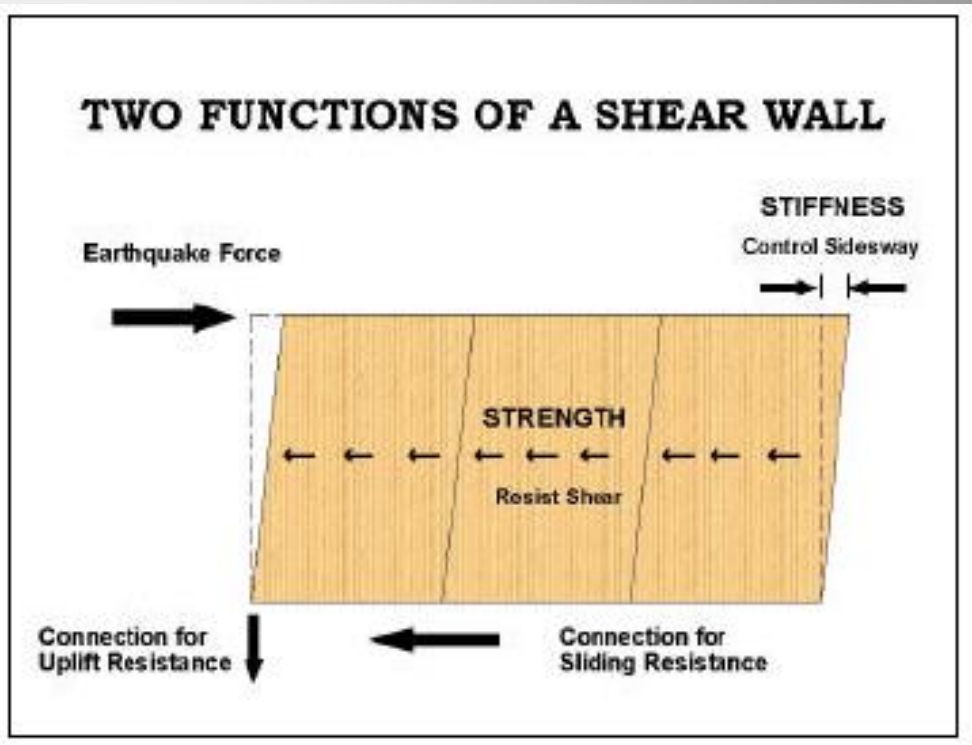
- **Older Buildings – Weaknesses:**
  - **Are often not bolted to reinforced concrete or masonry foundations and can be shaken off the foundation or topple over**
    - **Un-braced cripple walls**



Dwelling in Oakland with Failed Cripple Wall, 1989 Loma Prieta Earthquake

Housing (5):

- **Older Buildings – Weaknesses:**
  - **Weak and brittle shear wall sheathing materials permitted under previous codes (e.g. gypsum wall board and stucco)**



Dwelling in California with Failed Wall Sheathing

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Housing (6):

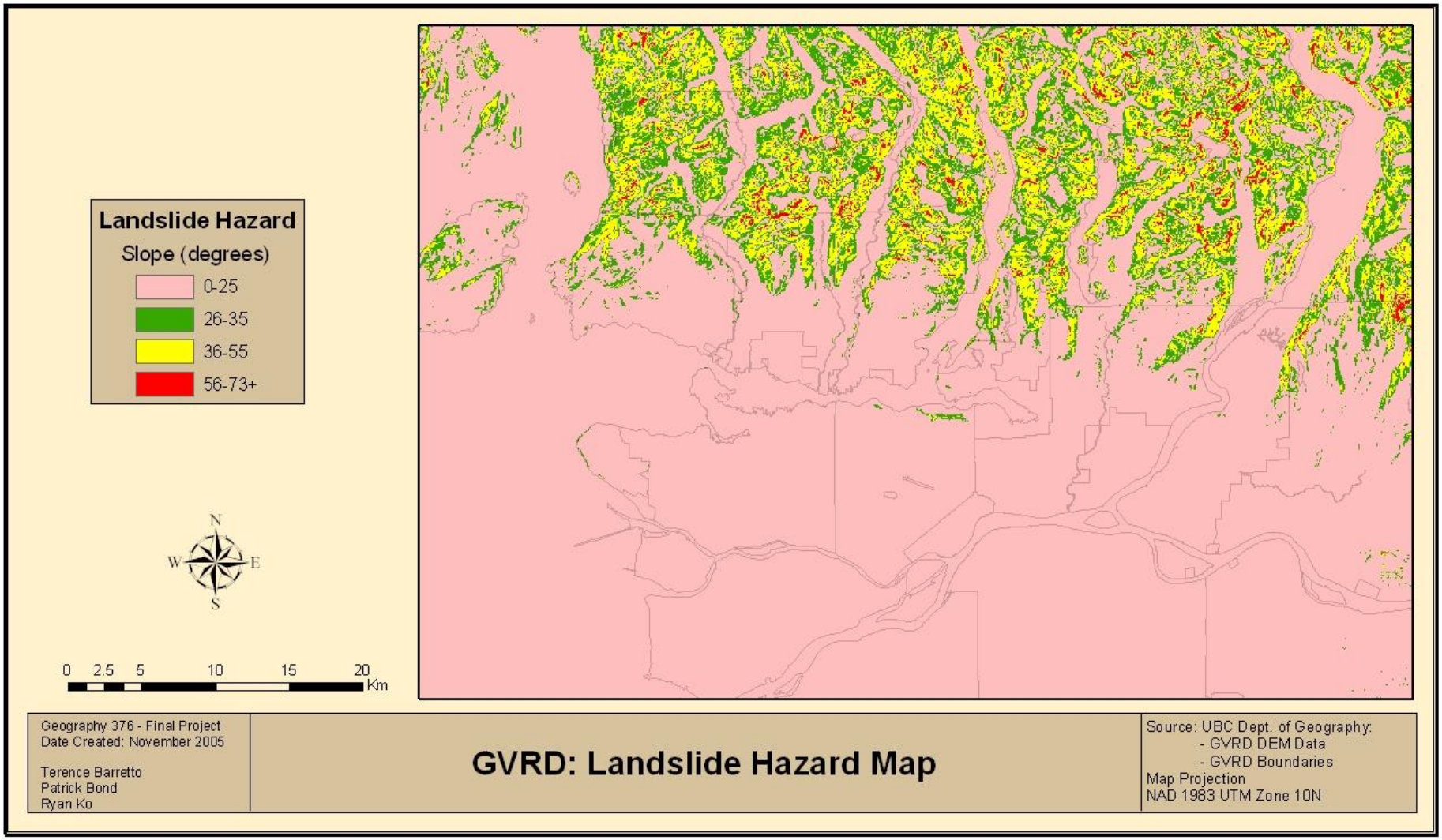
- **Older Buildings – Weaknesses:**
  - **Un-reinforced brick and stone masonry chimneys**
  - **Fragile or poorly attached masonry veneers**

Housing (7):

- **Multi-story Construction – Weaknesses:**
  - **Tuck-under parking designs – frequently weak unless specifically strengthened (also store frontages)**
  - **Newer 4- and 5-story wood-framed apartment construction (taller than historic buildings)**

Housing (8):

- Foundation Damage – Problems:
  - Hillside homes – these are susceptible to landslide, and are subject to torsion when not properly braced
  - Foundation problems from
    - Cut-and-fill lots
    - Sloped or stepped foundations
    - Liquefaction, landslide, lateral spreading


Landslide Hazard
Slope (degrees)
0-25
26-35
36-55
56-73+
N
W
E
S
0 2.5 5 10 15 20
Km
Geography 376 - Final Project
Date Created: November 2005
Terence Barretto
Patrick Bond
Ryan Ko
GVRD: Landslide Hazard Map
Source: UBC Dept. of Geography:
- GVRD DEM Data
- GVRD Boundaries
Map Projection
NAD 1983 UTM Zone 10N

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Landslide:

New Zealand

California

Housing (9):

- References:
  - The Shake-Out Scenario: Wood-Frame Buildings
    - William Graf – May 2008 (USGS & California Geological Survey)
  - Wood-Frame Construction: Meeting the Challenge of Earthquakes
    - Building Performance Series #5 (Canadian Wood Council)
  - Ensuring Good Seismic Performance with Platform Frame Wood Housing
    - J.H. Rainer and E. Karacabeyli – 2000 (Institute for Research in Construction – IRC)

Inside Your House (1):

- **Your house survives – but is that the only risk?**

Inside Your House (2):

- It is recommended that:
  - You check for Hazards
    - Assess Unwanted Events
      - And evaluate Risks
  - E.g. Tall furniture is fixed to the wall or braced
  - E.g. Heavy items are placed low down on shelves
    - Lighter items above
  - E.g. Your emergency / survival kit is located in a low risk place
    - Garage or garden shed?

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City of Vancouver
NEIGHBOURHOOD EMERGENCY PREPAREDNESS PROGRAM

Home Hazard Hunt

LOOKING OUT FOR HOME HAZARDS

Water Heater†	• Secure your water heater to the wall. • Contact BC Hydro or a professional for more information.
Gas Appliances‡	• Secure any gas appliances such as your stove or clothes dryer to a wall stud. If these objects move or topple, the resulting gas leak could destroy your home. • Longer, flexible gas connectors and electrical cords long enough to allow for movement should be installed, but only by qualified personnel.
Major Appliances†	• Secure the top and bottom of your refrigerator with plumber's tape or perforated metal strapping. • Contact the manufacturer regarding bolting free-standing, wood-burning stoves to the floor.
Furniture on Wheels	• Items such as stereo stands and portable dishwashers can become large moving projectiles which could cause serious damage. If you must use castors or glides on appliances, lock the wheels or place a wedge under the front wheels to keep them from sliding or overturning.
Tall Furniture	• Secure top-heavy, free-standing furniture (like bookcases or china cabinets) using commercially available devices. Anything over a metre high could be a problem.
Heavy Objects	• Move heavy, breakable or valuable objects from high shelves or cabinets to lower locations, or attach a wooden or metal guardrail to open shelves to keep items from sliding off.
Electronic Appliances†	• Secure electronic equipment like stereos, televisions, computers or microwave ovens, which may slide off shelves. • Use double-sided tape or velcro fasteners, or put restraining edges on the cabinets or shelves.
Mirrors & Pictures	• Move mirrors and heavily-framed pictures which are placed over beds, couches or exits.

† Home safety tips involving appliances, water and electricity found at: www.bcydro.com/safety

‡ Home safety tips involving gas found at: www.fortisbc.com

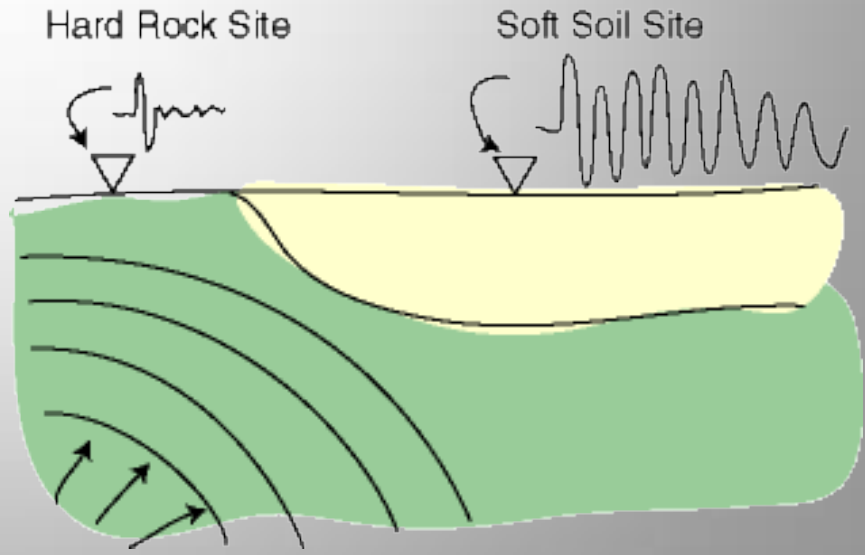
CITY OF VANCOUVER

NEPP Neighbourhood Emergency Preparedness Program

vancouver.ca/nepp
nepp@vancouver.ca or call 3 1 1

Liquefaction Hazards (1):

- In geology, soil liquefaction refers to the process by which water-saturated, unconsolidated sediments are transformed into a substance that acts like a liquid, often in an earthquake
  - By undermining the foundations and base courses of infrastructure, liquefaction can cause serious damage



Liquefaction Hazards (2):

- The 1985 Mexico City earthquake was a magnitude 8.1 earthquake
- 10,000 people were killed and serious damage caused to the Greater Mexico City area
- A series of 4 earthquakes were located off the Mexican Pacific coast, more than 350 km away
    - But due to the fact that Mexico City sits on an old lakebed, Mexico City suffered major damage due to liquefaction
- 412 buildings collapsed and another 3,124 were seriously damaged

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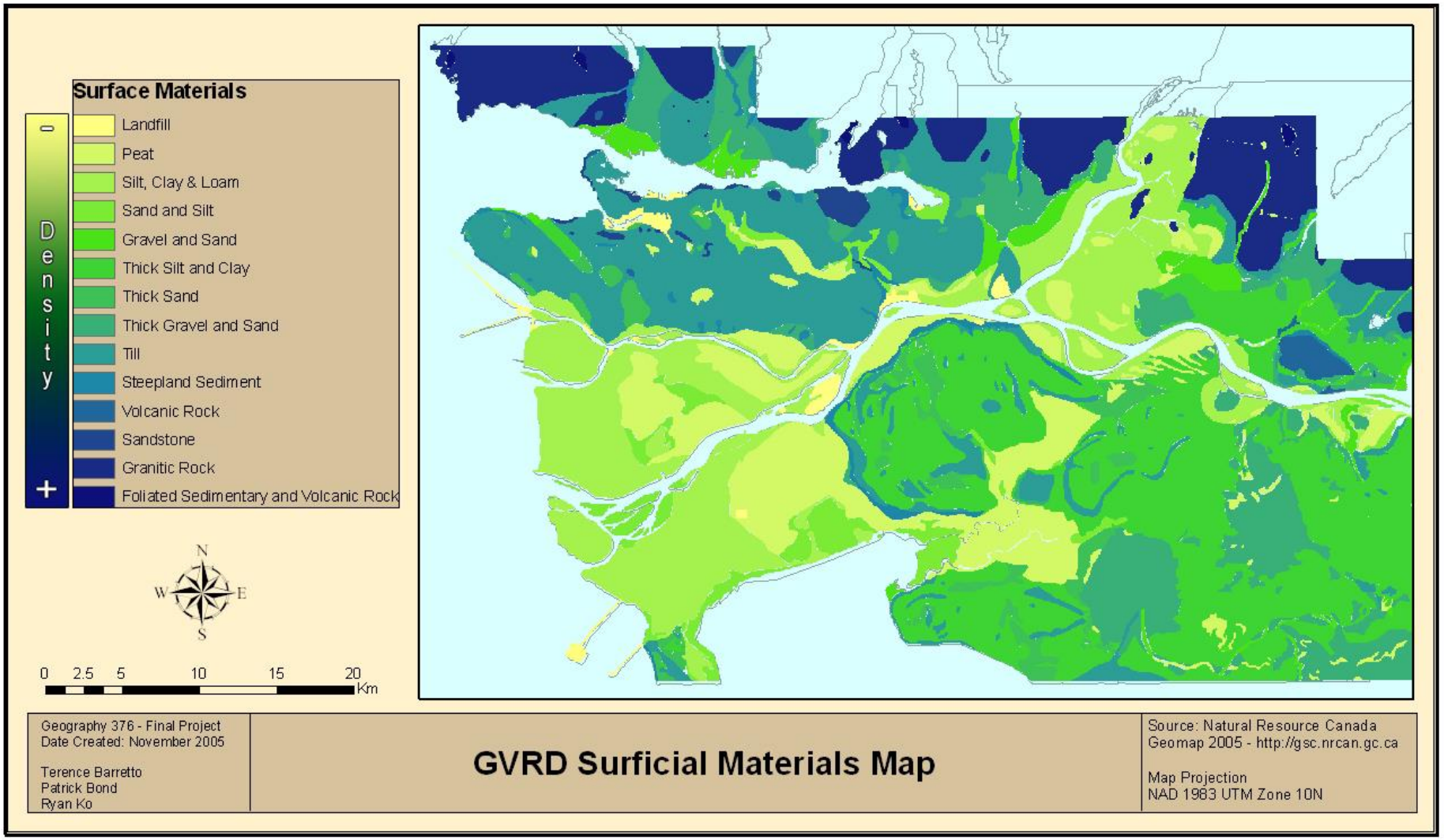
Mexico City, Mexico 1985 – Magnitude 8.1

Liquefaction Hazards (3):

- Liquefaction is considered an important seismic hazard for integrated land use planning in British Columbia (Resources Inventory Committee, Province of BC, 1998):
  - Liquefaction has caused severe damage to structures in historic earthquakes
  - Many communities in British Columbia are located near rivers and lakes where liquefaction-susceptible soils such as loose, saturated sands are commonly found
    - Previous studies of the Lower Mainland indicate that much of Richmond and Delta, and parts of other Greater Vancouver communities, are underlain by liquefaction-susceptible soils



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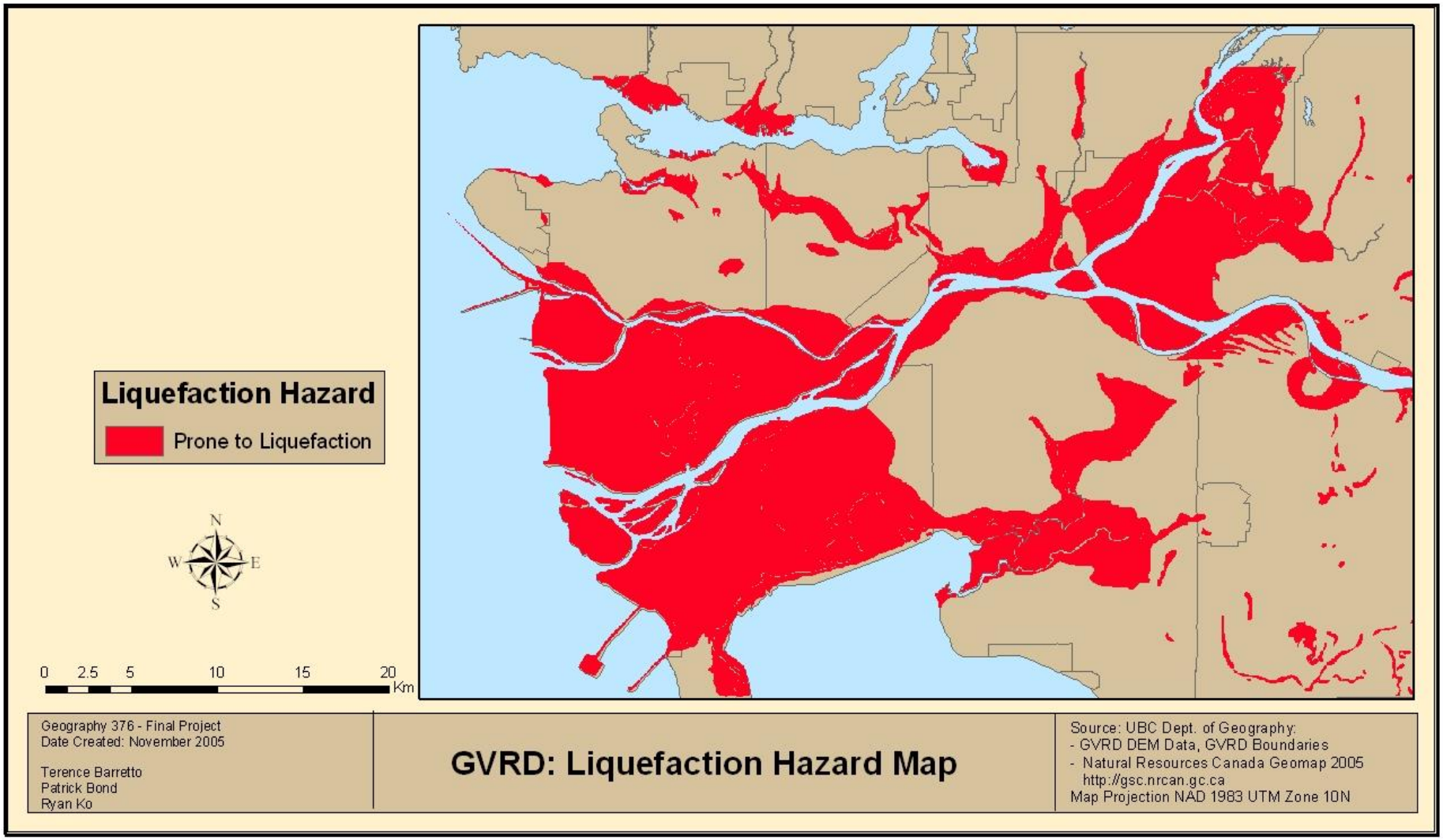
Terence Barretto
Patrick Bond
Ryan Ko

GVRD Surficial Materials Map

Source: Natural Resource Canada
Geomap 2005 - http://gsc.nrcan.gc.ca

Map Projection
NAD 1983 UTM Zone 10N



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http://gsc.nrcan.gc.ca
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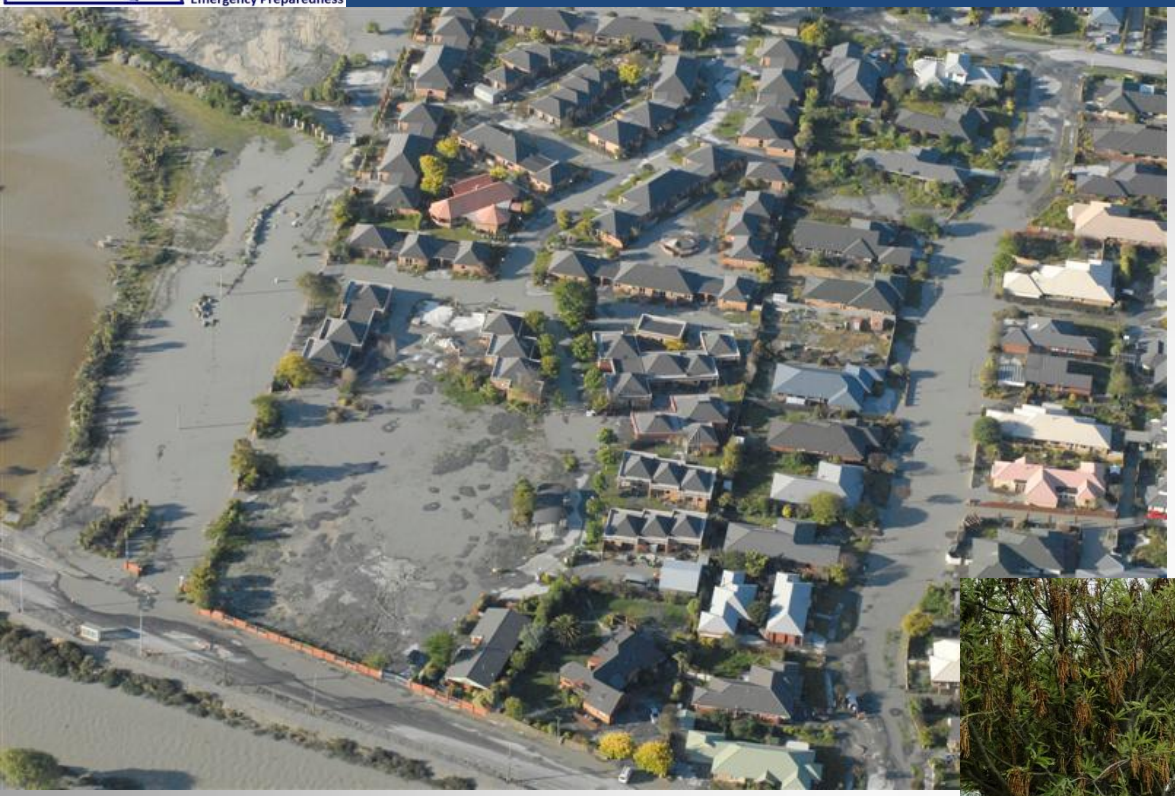
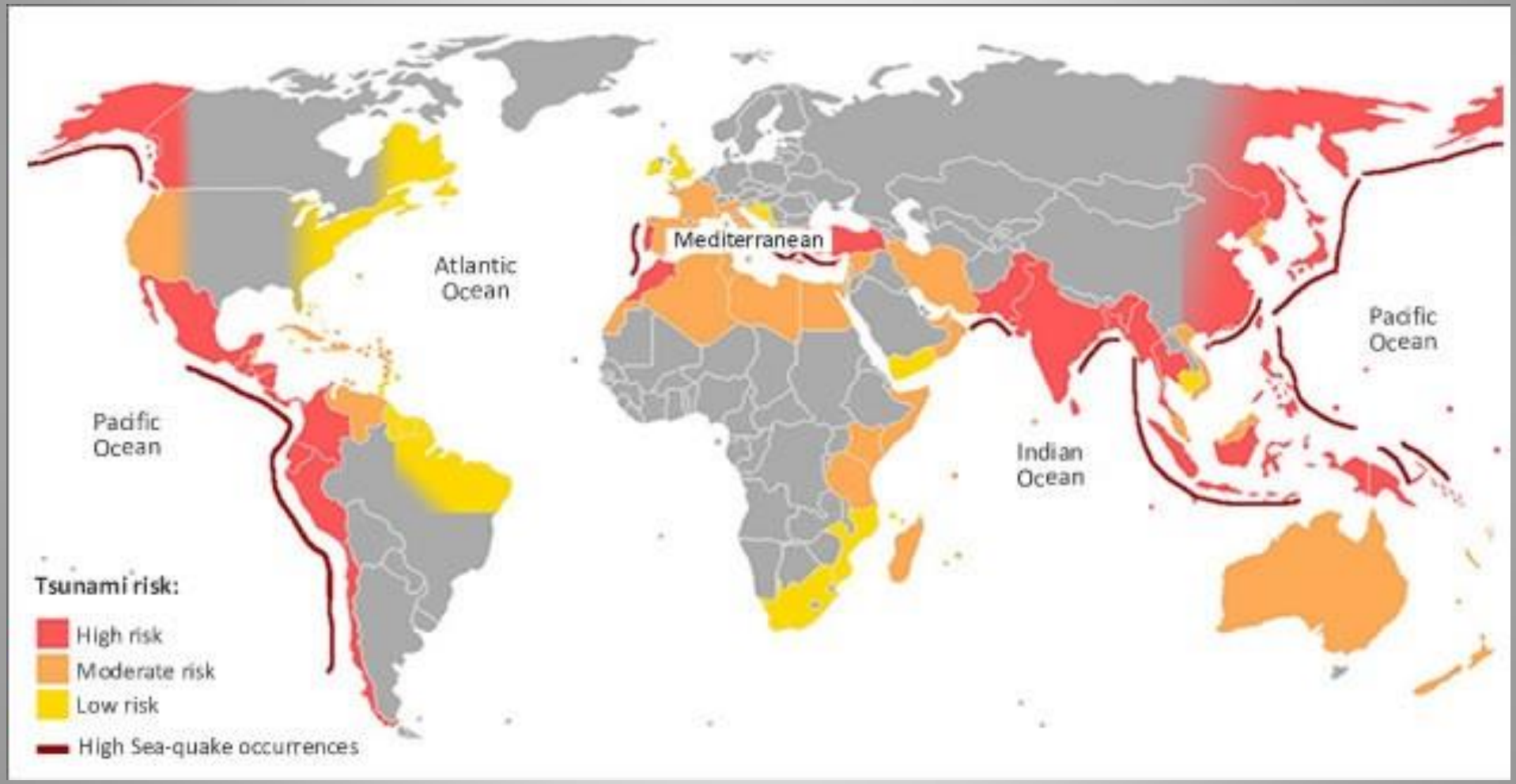
Liquefaction:

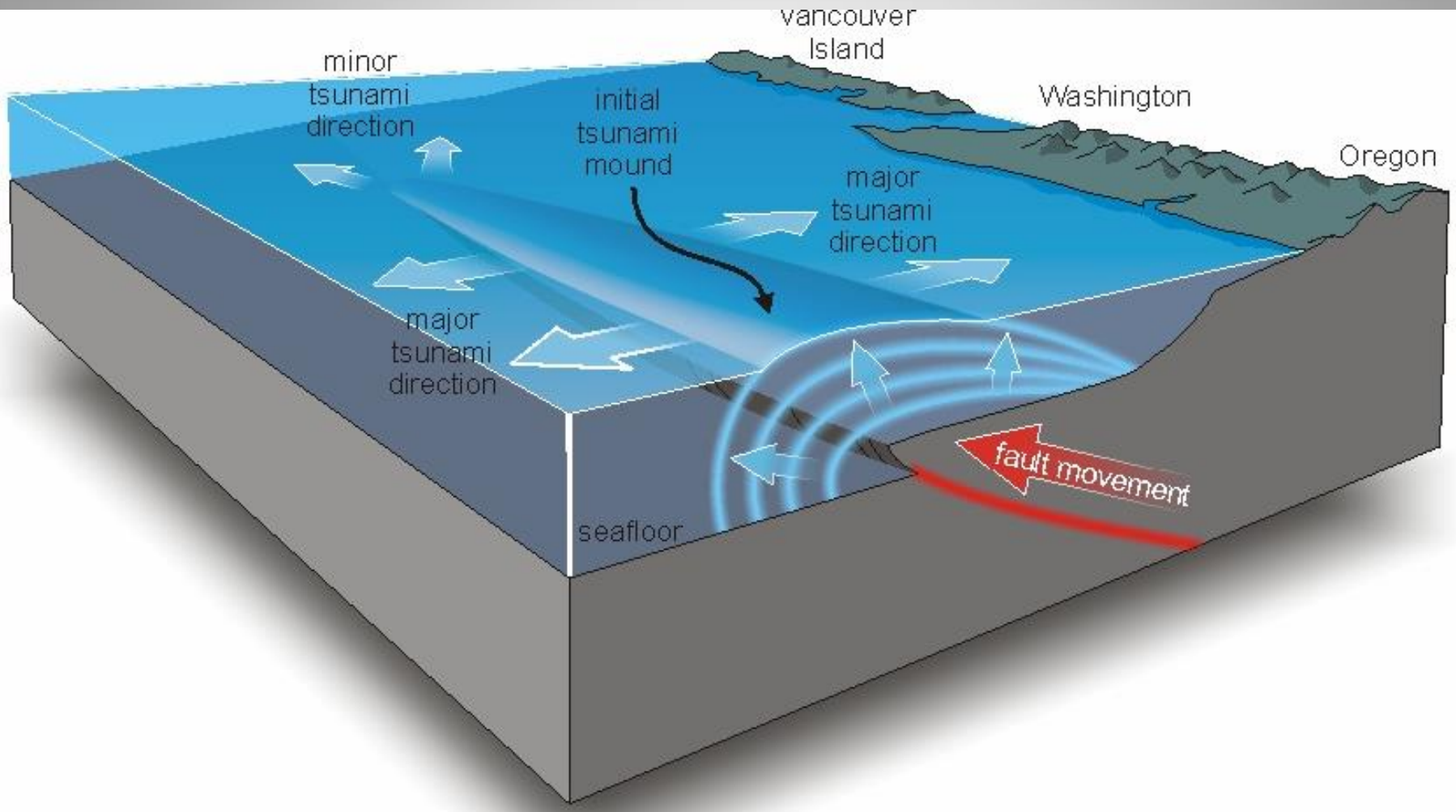


Christchurch, New Zealand - 2011

Tsunami Hazards (1):

- Tsunami, also known as seismic sea waves, are caused by sudden movements in the seafloor
    - Generally caused by earthquakes and more rarely large landslides
- To generate a tsunami, the earthquake must occur under the ocean, be large, and create vertical movements of the seafloor
- Much of the earthquake's energy is transferred to the water column above it, producing a tsunami
- All oceanic regions of the world can experience tsunami, but the Pacific Ocean is especially vulnerable because of "Ring of Fire"


Atlantic
Ocean
Mediterranean
Pacific
Ocean
Pacific
Ocean
Indian
Ocean
Tsunami risk:
High risk
Moderate risk
Low risk
High Sea-quake occurrences


Vancouver Island
Washington
Oregon
minor tsunami direction
initial tsunami mound
major tsunami direction
major tsunami direction
fault movement
seafloor

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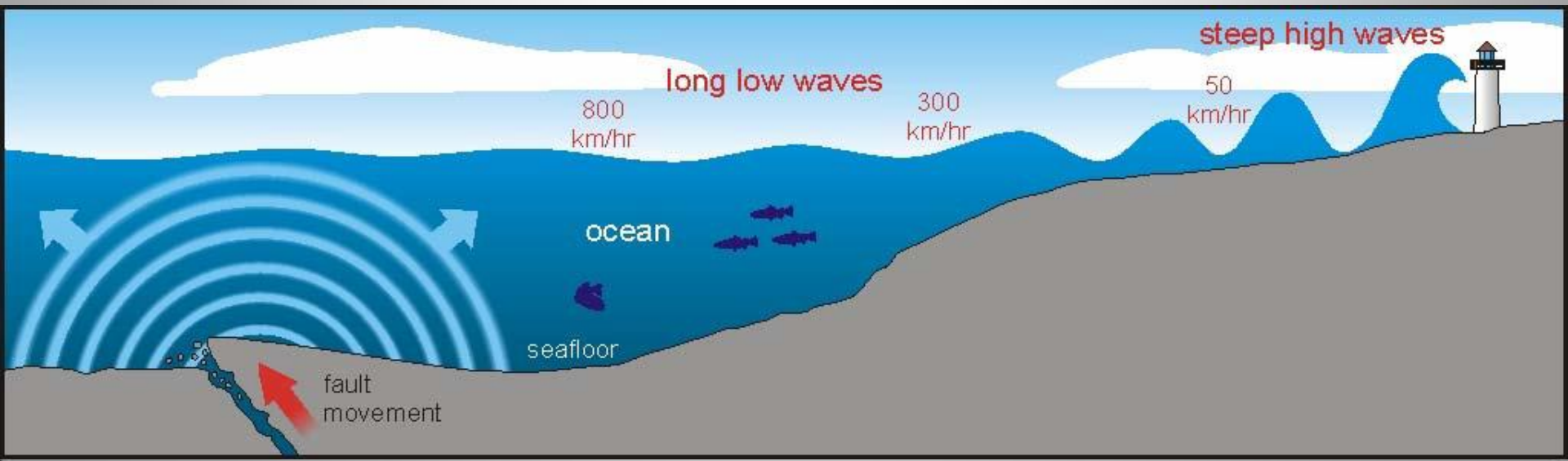
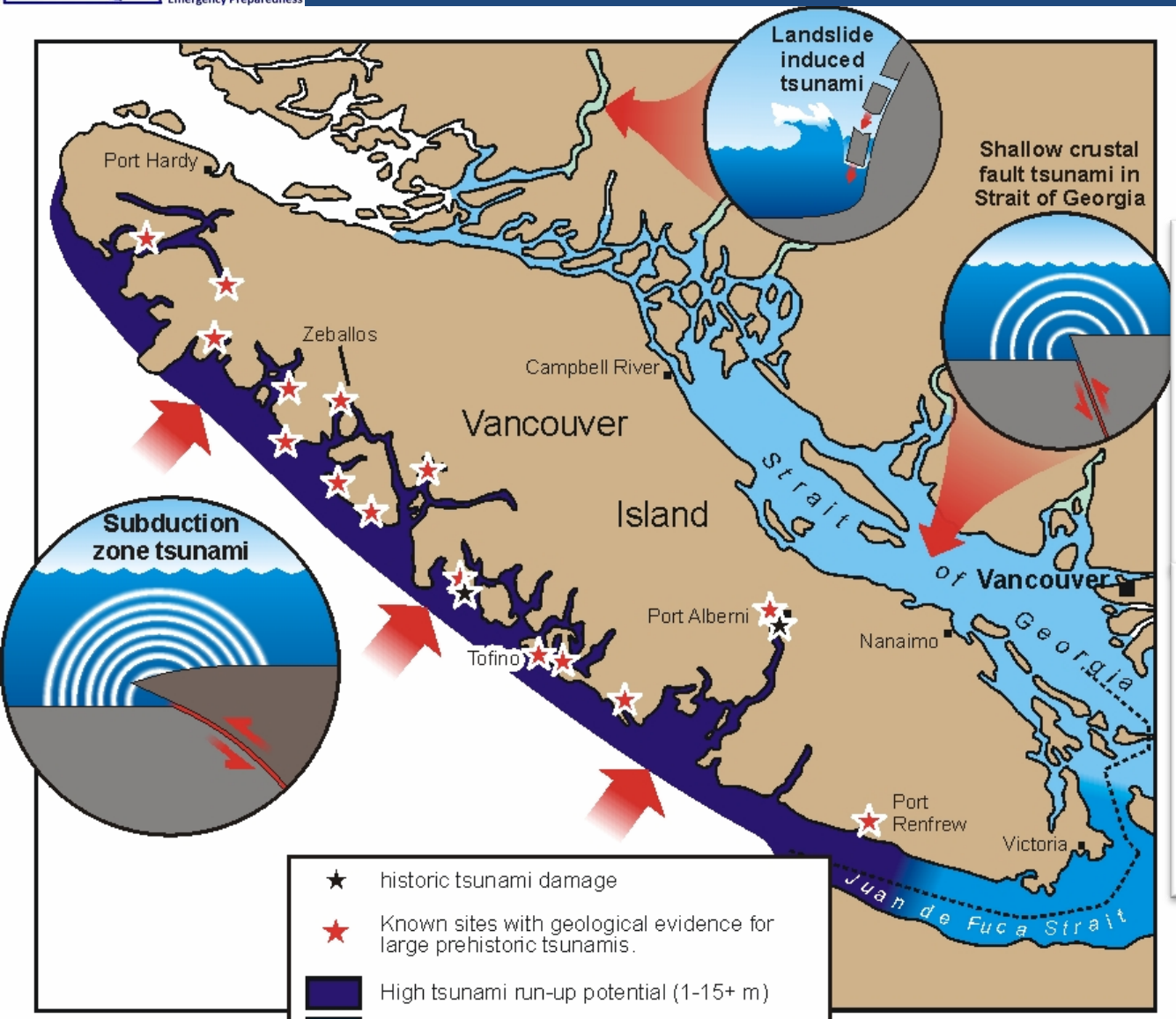
Tsunami Hazards (2):

- **In the deep ocean, tsunami have very small amplitudes (wave heights are only a few cms), wavelengths of up to 1000 Km, and speeds of more than 800 Km / hour**

- **When a tsunami reaches shallow water, such as a coastline, the energy is concentrated into a smaller volume and its speed decreases and its amplitude increases to dangerous heights**





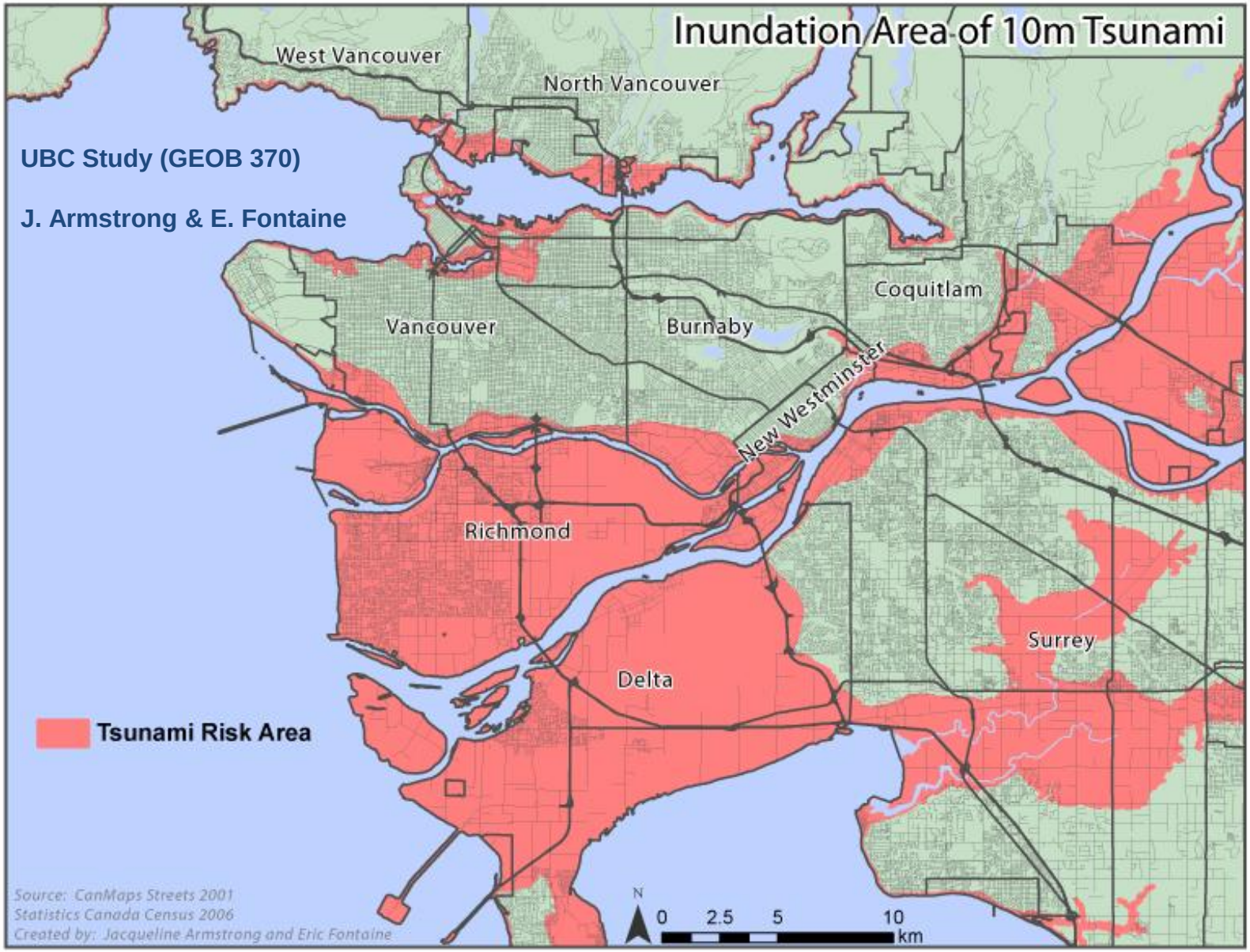
Simon Frazer University Study – 2005

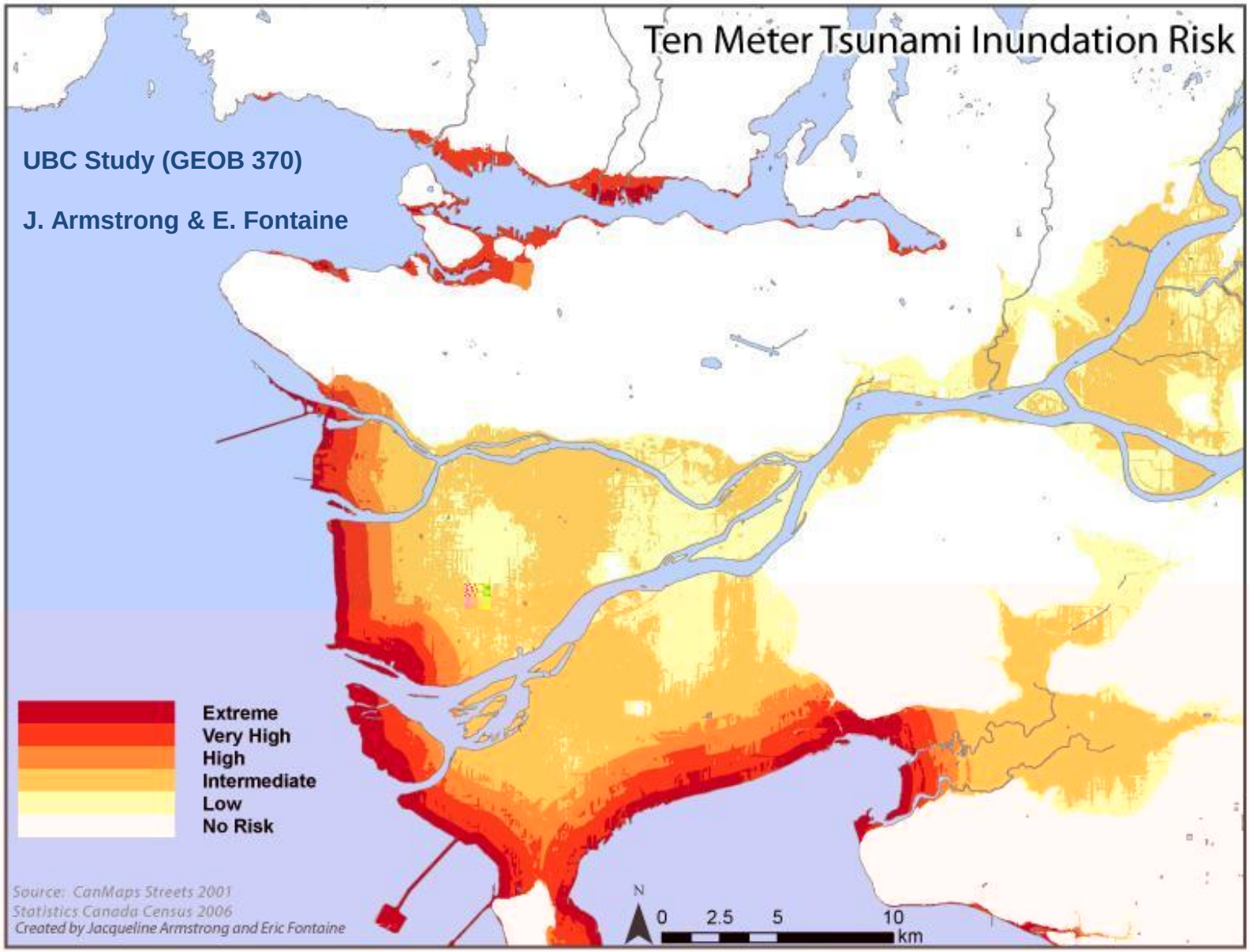
J. Clague & J. Orwin

Port Alberni - 1964

Estuary & River Valley Risk of Tsunami

http://blogs.agu.org/tremblingearth/2013/08/13/another-heart-stopping-tsunami-video-from-japan/


Inundation Area of 10m Tsunami
West Vancouver
North Vancouver
UBC Study (GEOB 370)
J. Armstrong & E. Fontaine
Coquitlam
Vancouver
Burnaby
New Westminster
Richmond
Surrey
Delta
Tsunami Risk Area
Source: CanMaps Streets 2001
Statistics Canada Census 2006
Created by: Jacqueline Armstrong and Eric Fontaine
N
0 2.5 5 10
km


Ten Meter Tsunami Inundation Risk
UBC Study (GEOB 370)
J. Armstrong & E. Fontaine
Extreme
Very High
High
Intermediate
Low
No Risk
Source: CanMaps Streets 2001
Statistics Canada Census 2006
Created by Jacqueline Armstrong and Eric Fontaine
N
0
2.5
5
10
km

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- **Great East Japan Earthquake of March 2011 – Magnitude 9**
  - **Caused measured tsunami heights up to 15m, but calculated maximums of up to 40m**

- Aleutian Islands earthquake of April 1946 – Magnitude 7.8
  - Scotch Cap lighthouse in Alaska destroyed by 30m tsunami

Insurance Risk:

- Institute for Catastrophic Loss Reduction
  - Earthquake Hazard Zones: The Relative Risk of Damage to Canadian Buildings (P Kovacs & R Sweeting – June 2004)

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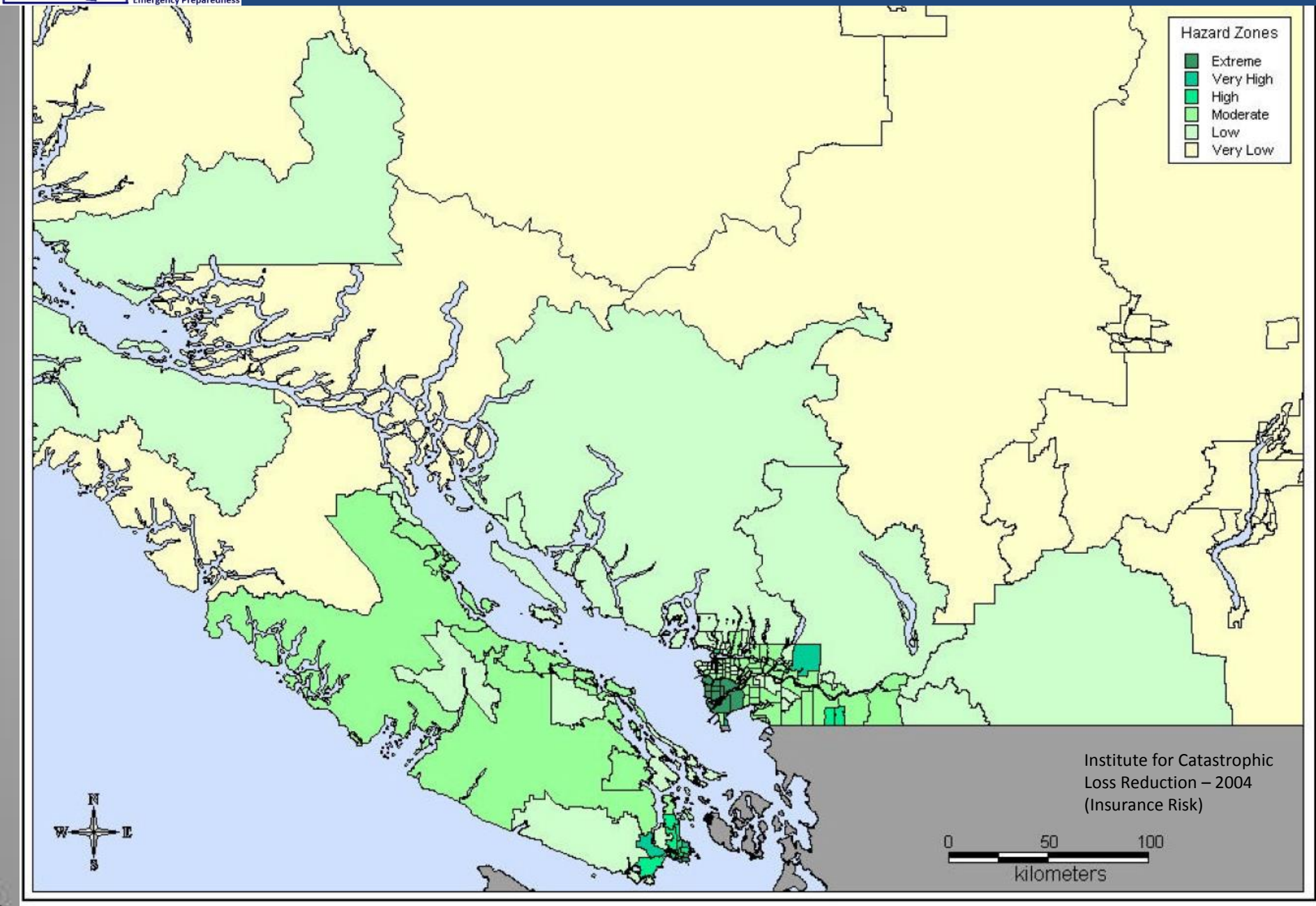

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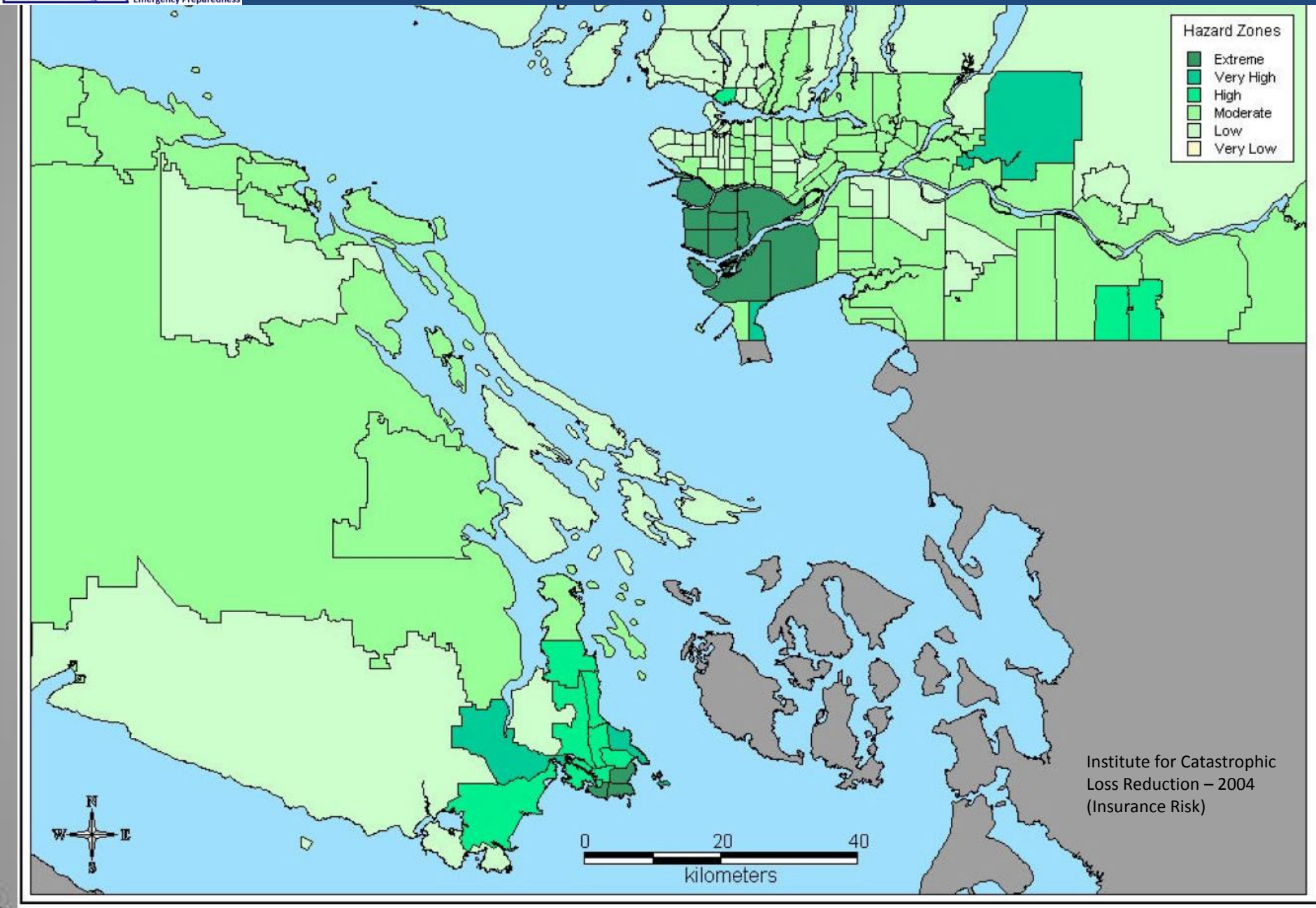

Institute for Catastrophic Loss Reduction – 2004 (Insurance Risk)

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Be Prepared (1):

- Where is your house?
  - Is it located on a site at risk of liquefaction?
  - Is it located on a site at risk of tsunami (or flood) inundation?
- How old is your house?
  - How is it constructed?
  - Is it secured to solid foundations?
  - Does it have unsecured masonry features?
- What do you have inside your house?
  - Is tall heavy furniture, and are heavy objects, secured and/or stored low down?

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Be Prepared (2):

- Where do you keep valuable items?
- Will they be accessible after even a major earthquake?
    - Money
    - Important documents and records
- Have you copied key documents and stored them in a separate location (e.g. bank box or out-of-town relative's house)?
- Have you established meeting points (primary, secondary, tertiary) for your family?
- Have you established an out-of-town contact (e.g. relative) in case of in-town communication problems?

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Be Prepared (3):

- Have you carried out a simple risk analysis of the outside and inside of your home?
- Will your emergency kit be accessible even after a major earthquake?
  - Does it include:
    - Clothing (for wet and cold too)
    - Dry rations and other long-life basic food stuffs
    - Potable water
    - Shelter (e.g. a tent)
    - Bedding (e.g. sleeping bag)
    - Cooking facilities (e.g. camp stove and fuel)
    - Lighting (e.g. torches and lanterns)
    - Radio for information (e.g. wind-up or re-chargeable type)

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- City of Vancouver – Useful Websites:
  - Understand your risks, and be prepared for any emergency
    - http://vancouver.ca/home-property-development/understand-your-risks.aspx
  - During and after an earthquake
    - http://vancouver.ca/home-property-development/during-and-after-an-earthquake.aspx
- Cascadia Region Earthquake Workgroup
  - http://crew.org/

Thank You !!

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Cascadia Fault (Subduction Zone)