GUY CARPENTER

PERILS ALL AROUND
AN OVERVIEW OF WC EARTHQUAKE AND HAZARDOUS FACILITY EXPOSURE

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Section #1

EARTHQUAKE

Earthquake
Topics

- ***The risk of a catastrophic workers' compensation loss arising from a large earthquake is not well understood, or even recognized. This session will provide an overview of the science, experience, and risk mitigation of these extreme events.***

- <u>Areas of focus:</u>
  - Earthquake hazard
  - Building vulnerability
  - State of modeling
  - Mitigating risk

- *As it pertains to workers' compensation insurance*

Earthquake Statistics

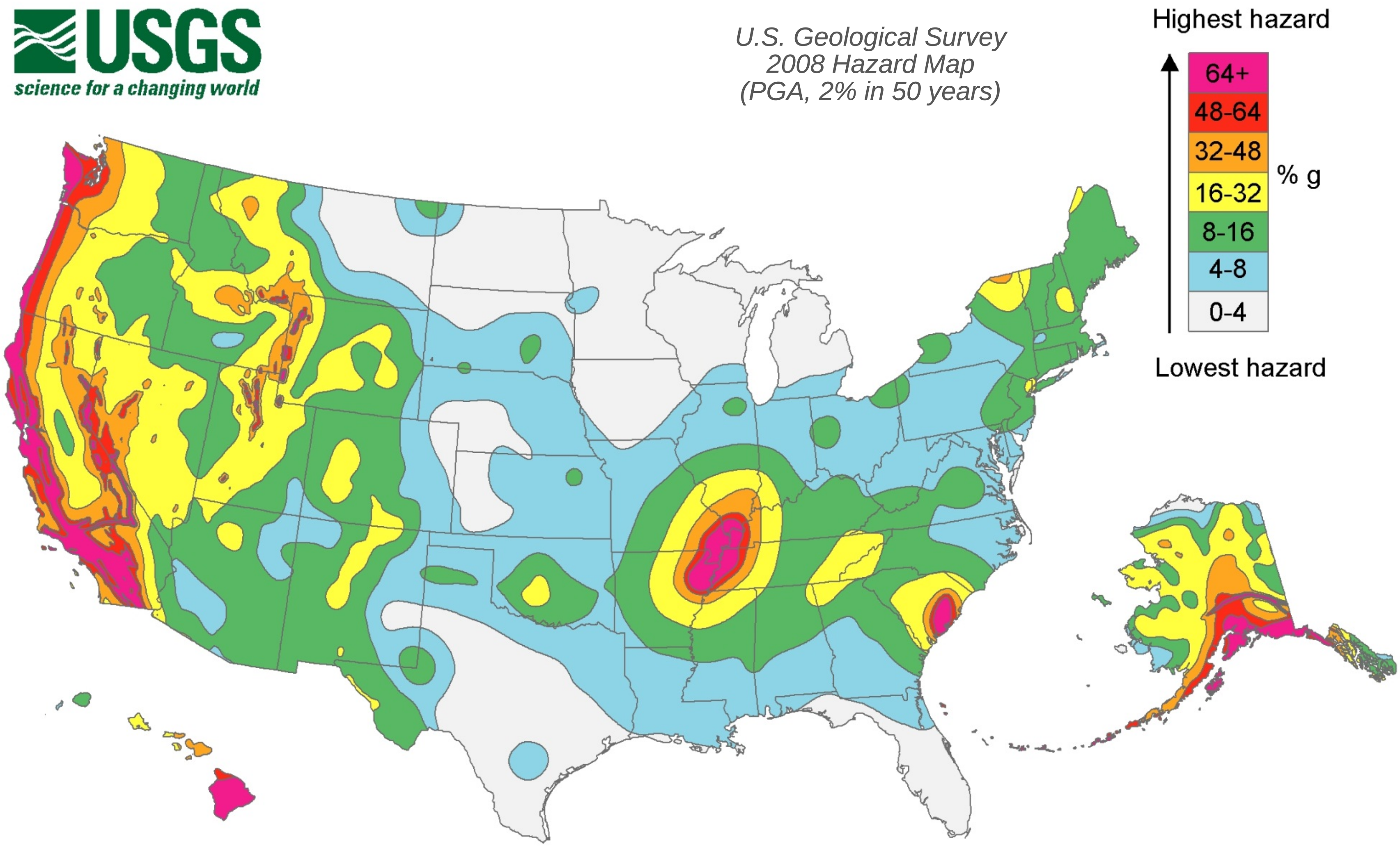
- **Number of Earthquakes in the United States for 2000 - 2012 Located by the US Geological Survey National Earthquake Information Center**

Magnitude	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
8.0 to 9.9	0	0	0	0	0	0	0	0	0	0	0	0	0
7.0 to 7.9	0	1	1	2	0	1	0	1	0	0	1	1	0
6.0 to 6.9	6	5	4	7	2	4	7	9	9	4	8	3	5
5.0 to 5.9	63	41	63	54	25	47	51	72	85	58	89	51	27

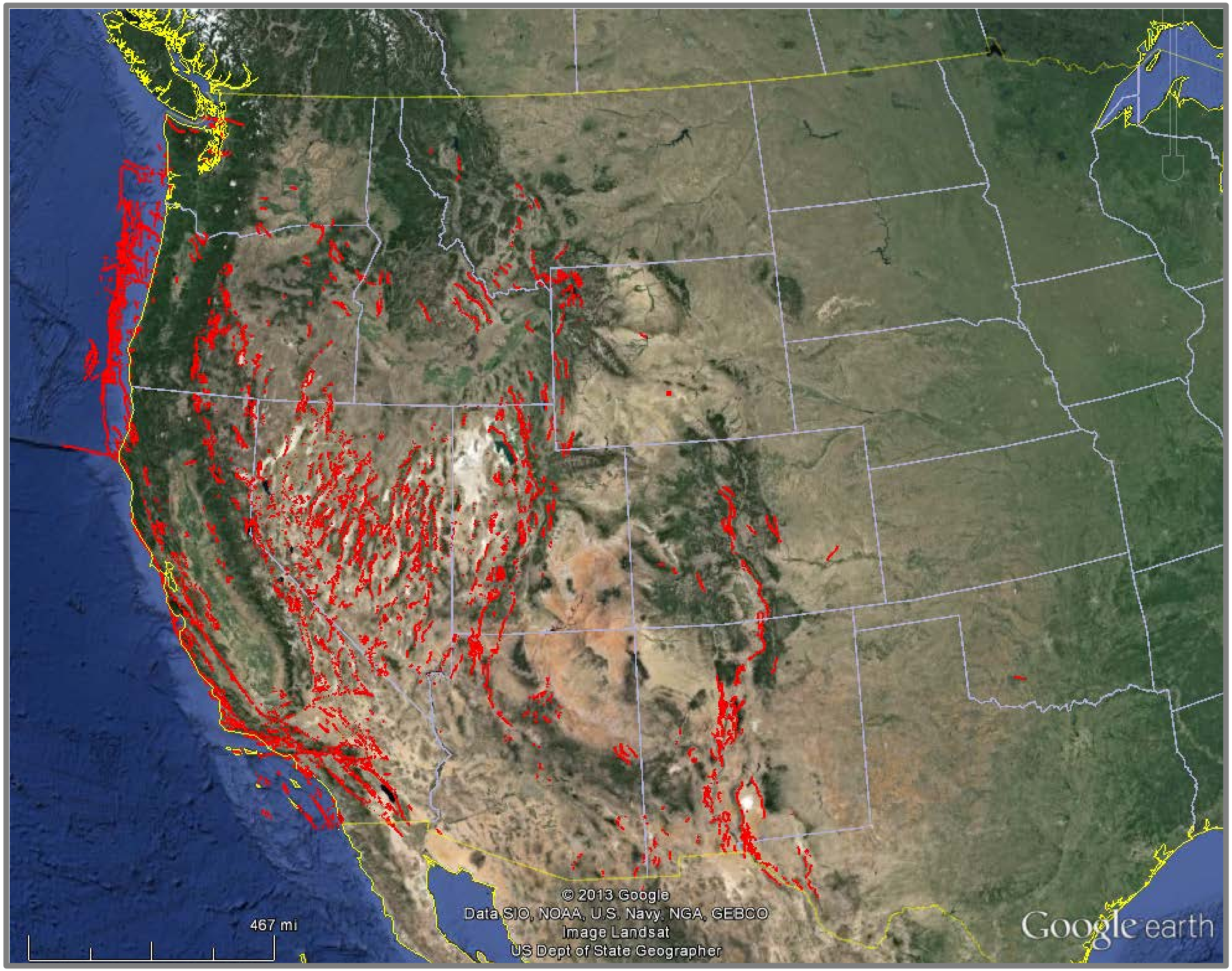
- Great San Francisco Earthquake of 1906
  - If the same event happened today during a workday
    - <u>Consensus is that this would cause a several-billion dollar WC loss</u>

Earthquake - *Hazard*
Seismic Hazard

U.S. Geological Survey
2008 Hazard Map
(PGA, 2% in 50 years)



Earthquake - *Hazard*
Faults



U.S. Geological Survey

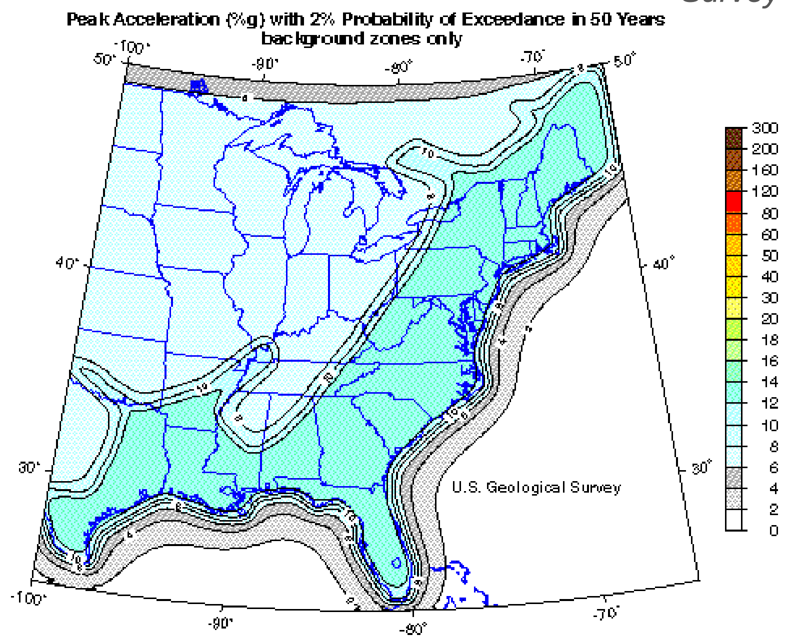
in Google Earth

(Historic, Holocene to Latest Pleistocene, Late Quaternary, Mid to Late Quaternary, Quaternary)

Earthquake - *Hazard*
Background Seismicity

- In addition to known faults, there is <u>background seismicity</u>
  - Unknown faults
  - Ancient faults
  - Uncertainty in location
  - Intraplate strain and stress
  - ?

U.S. Geological Survey



- **Earthquakes can happen anywhere**

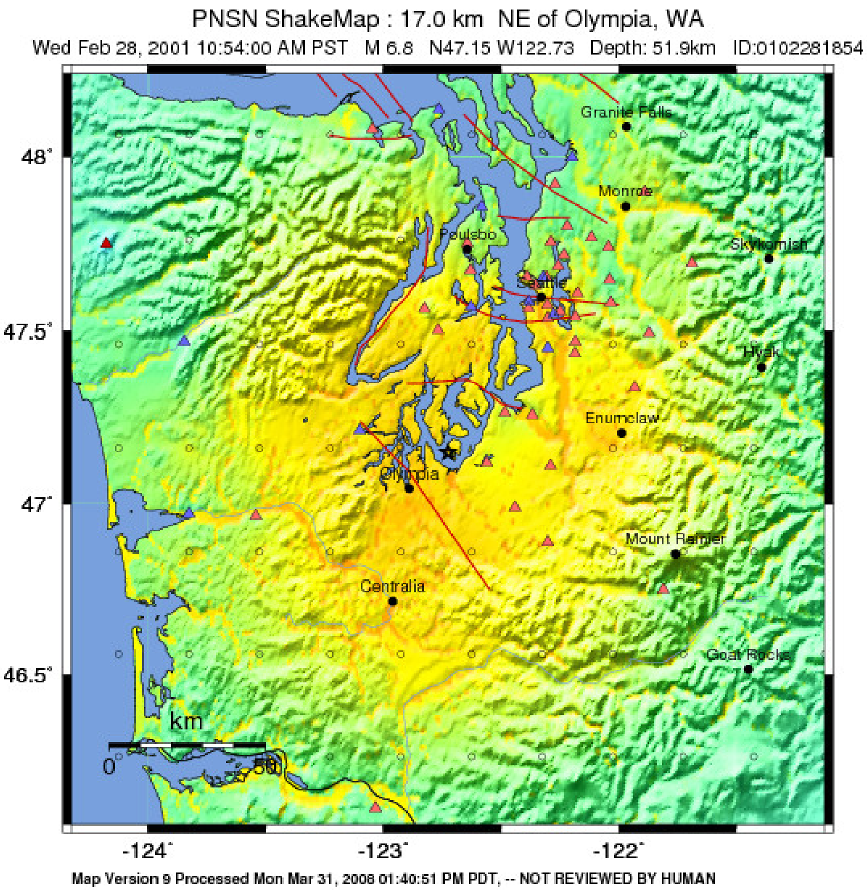
- *For many areas in the U.S., background sources are the only contributor to earthquake hazard*
  - Frequency of these earthquakes tends to be very low

Earthquakes induced by human activity are not considered here

Earthquake - *Hazard* Footprint

- Footprint Factors
  - Rupture type and length
  - Magnitude
  - Depth
  - Duration
  - Attenuation
    - Decrease in wave strength as it moves away from epicenter

- *Earthquakes in the Eastern part of the country tend to have larger footprints than earthquakes in California*

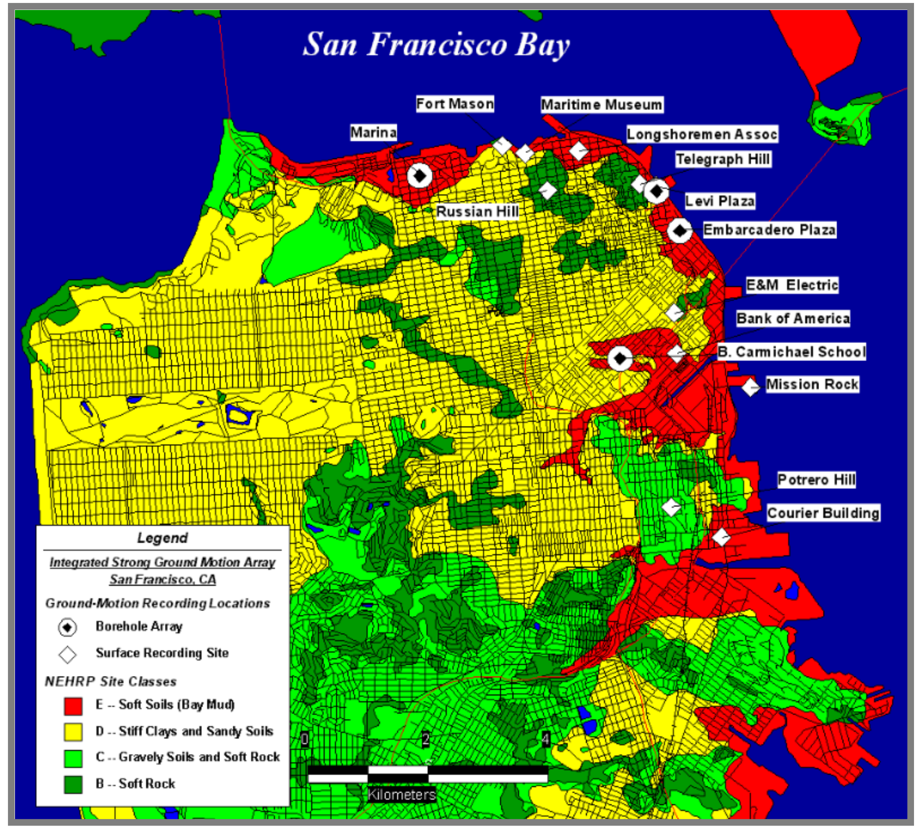


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

U.S. Geological Survey

Earthquake - *Hazard*
Local Conditions

- Local Factors
  - Soil amplification
    - Soft soils amplify ground shaking
  - Liquefaction potential
    - A process by which water-saturated sediment temporarily loses strength and acts as a fluid
  - Landslide potential
    - Movement of surface material down a slope
  - Slope
    - Damage potential for structure



U.S. Geological Survey

Earthquake - *Hazard*
Frequency

- Frequency is another component of the hazard
- What is the annual probability of a given earthquake event happening?

- Known faults
  - Do we know the general rate of recurrence?
  - Time-dependent
    - Tectonic loading - Faults more likely to rupture as time goes on, and less likely after an earthquake

- Background seismicity
  - Low frequency
  - Gutenberg–Richter law

Earthquake - *Hazard*
Associated Perils

- Fire
  - Conflagration
- Flood
- Landslide
  - Direct injuries
- Tsunami
  - In vulnerable regions
  - Tohoku Earthquake and Tsunami, March 2011
    - Magnitude 9 (thought impossible for that fault)
    - > 16K fatalities (the majority due to the Tsunami)
    - Fukushima nuclear power plant meltdown

Associated perils represent significant casualty risk, yet our current modeling capabilities are even less advanced than those for earthquake (or even non-existent)

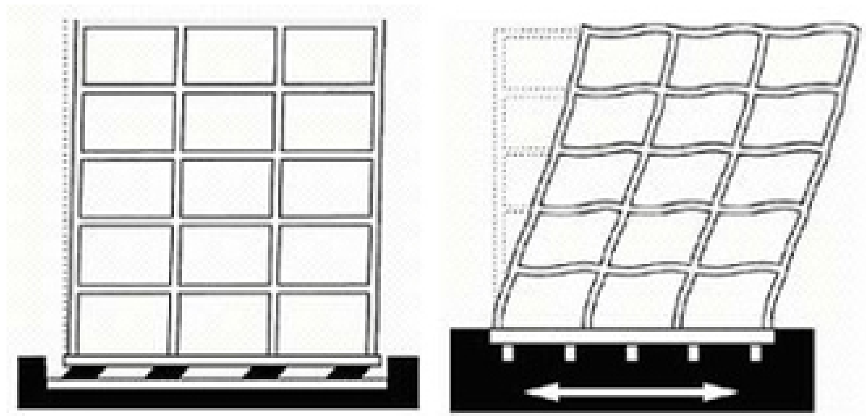
Earthquake - *Hazard*
Injuries from Shaking

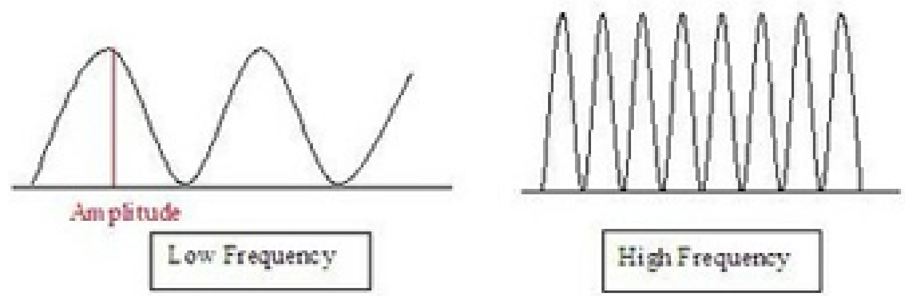
- How are people injured in an earthquake?
  - Falling items or debris
  - Rescue and recovery
  - Accidents
  - Exposure to hazardous substances
  - Infrastructure (gas explosions, falling power lines, bridge collapse, etc.)
  - **Full or partial building collapse**
    - <u>Potential for large number of casualties</u>

U.S. Geological Survey

Earthquake – *Building Vulnerability*
Building Characteristics

- Structural system
  - Seismic design characteristics
  - Example
    - Unreinforced masonry rare on the West Coast
- Year of construction
  - Building codes have become stricter over the years (and after events)
  - Retrofitting of older buildings
- Building height
  - Figures into the buildings natural period
    - Resonance with ground motion frequency

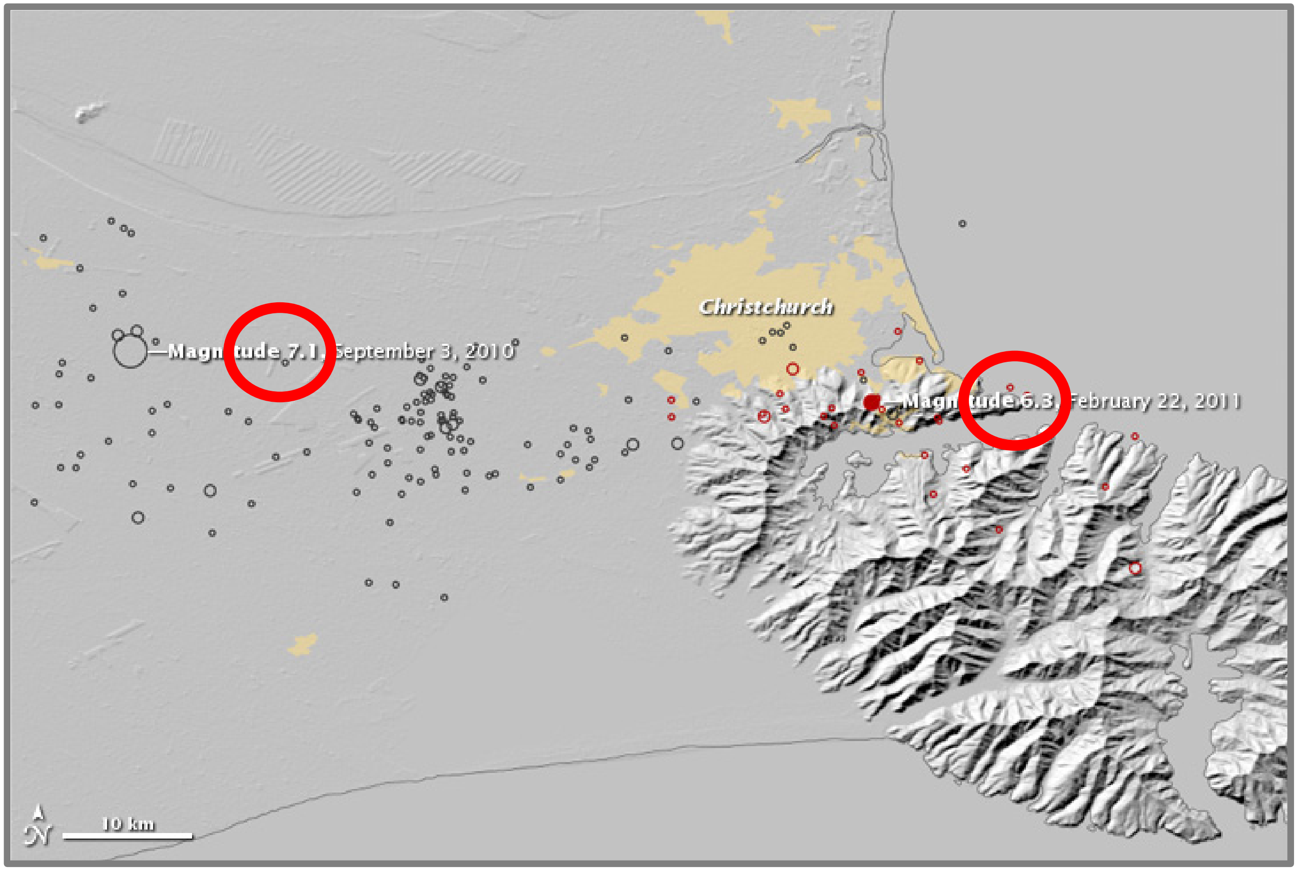




www.nature.com

Earthquake – *Building Vulnerability*
Earthquake Clustering

- Multiple earthquakes can strike that same region
- Buildings could be weakened in a foreshock
  - More susceptible to mainshock (or aftershock)



Christchurch, New Zealand Earthquake, Feb. 2011

Nearby earthquake in Sep. 2010 damaged buildings prior to Feb. 2011 quake

NASA Earth Observatory

Earthquake – *State of Modeling*
Exposure Data Availability and Quality

- **Generally, workers' compensation exposure data quality is behind that of property**
  - Property exposure was the focus of modeling originally
    - Especially after Hurricane Andrew
  - More difficult to capture modeling data for WC
    - Many applications forms do not capture the data necessary for modeling
- <u>Garbage in; garbage out</u>
- ***Progress is being made***

Earthquake – *State of Modeling*
Exposure Data - Minimum

- By location:
  - Employee count
    - Or payroll
  - High-resolution geocoding information
    - Street address
    - Latitude/longitude coordinates
  - Occupancy/occupation information
    - Class codes, SIC codes, NAICS codes, etc.
  - Shift information
    - Or other indication of employee presence
  - Building construction
  - Year of construction
  - Building height
  - If excess policies: policy terms

Earthquake – *State of Modeling*
Importance of By-Location Exposure Data

- **By-location data is not always available:**
  - Policy-level or headquarters
  - Industries where employees are generally off-site
    - Staffing agencies
    - Construction
  - Campus locations
    - Where multiple buildings are assigned one address
      - University campuses
      - Hospital campuses
- **By-location data is important**:
  - Proximity to the earthquake event
  - Diversification credit for having employees spread amongst locations

Earthquake – *State of Modeling*
Importance of Employee Presence / Shift Data

- **In the absence of shift data, or maximum employee presence, models tend to weight the weekday shifts heavily**
  – Resulting in higher tail-end loss estimates
    - Weekday earthquakes

  – Some risk types tend toward more evenly-distributed shifts
    - Examples:
      - Universities
      - Hospitals
    - Capturing or estimating shifts may:
      - Increase loss estimates for night/weekend earthquake events
      - Decrease loss estimates for tail-end events
        - (Weekday events tend to drive the tail)

Earthquake – *State of Modeling*
Other exposure Data

- Structural type and year of construction
  – Can reflect strong underwriting standards
- User-defined injury cost estimates
  – Direct effect on overall loss estimates
  – Confidence in these estimates?
- Premium
  – Useful after modeling
    - Evaluate policies
    - Portfolio management

Earthquake – *State of Modeling*
Uncertainty in Workers' Compensation Modeling

- **Workers' compensation earthquake modeling is subject to the same uncertainties as property modeling**
  - Hazard
    - Magnitude, attenuation, soil conditions, liquefaction and landslide
    - Example:
      - Tohoku magnitude 9 earthquake
      - Maximum magnitude of 8?
  - Vulnerability
    - New designs
    - Substandard construction quality
  - Accuracy of exposure data

But WC modeling is also subject to additional uncertainties not seen in property modeling…

Earthquake – *State of Modeling*
Uncertainty in Translating Building Damage into Injuries

- **Many workers compensation earthquake models are extensions of property models**
  - Design codes save lives by resisting collapse
    - In a property model, a building may be a total loss and:
      1. Collapse (partial or full)

         Resulting in large number of casualties
      2. Remain standing

         Condemned and demolished

         But few casualties

  - <u>This adds another layer of uncertainty when modeling workers' compensation risk</u>

Earthquake – *State of Modeling*
Uncertainty in Employee Presence

- **How many employees are present during the event?**
  - During workday
  - At night
  - During the weekend

- <u>Buildings don’t move; people do!</u>

- The time of earthquake occurrence, and presence of insured employees, is a major factor in estimating losses
  - <u>This is yet another layer of uncertainty in WC modeling</u>
  - Tends to be highly correlated across a portfolio

Earthquake – *State of Modeling*
Uncertainty in Injury Costs

- **How much will injuries cost?**

- Very little historical precedents
- Not enough information on insureds
- Post-event trends and political environment

Earthquake – *State of Modeling*
Implicitly Modeled Sources of Loss

- **Models tend to model only certain factors explicitly**
  – Earthquake shaking
- <u>But other hazards and sources of loss exist</u>
  – Falling items or debris
  – Rescue and recovery
  – Accidents
  – Exposure to hazardous substances
  – Infrastructure (gas explosions, falling power lines, bridge collapse, etc.)
- **These may be *implicitly* included**
  – By calibration using claims data
  – *However, there are less historical precedents for WC earthquake losses than for property, and claims data may be difficult to collect*

Earthquake – *State of Modeling*
Model Uncertainty is a Challenge

- **Greater uncertainty than property modeling**
  - Model output has less explanatory power
- BUT, uncertainty is a valid concern
- Example:
  - Christchurch, New Zealand earthquake of 2011
    - Half of fatalities from one building collapse
      - If it had not collapsed, much lower casualties
      - If another had collapsed, much higher casualties
    - Shallow earthquake; higher damage
    - Previous damage from earlier earthquake; higher damage
    - Questionable structural integrity; higher damage
    - Occurred during a workday; higher casualties

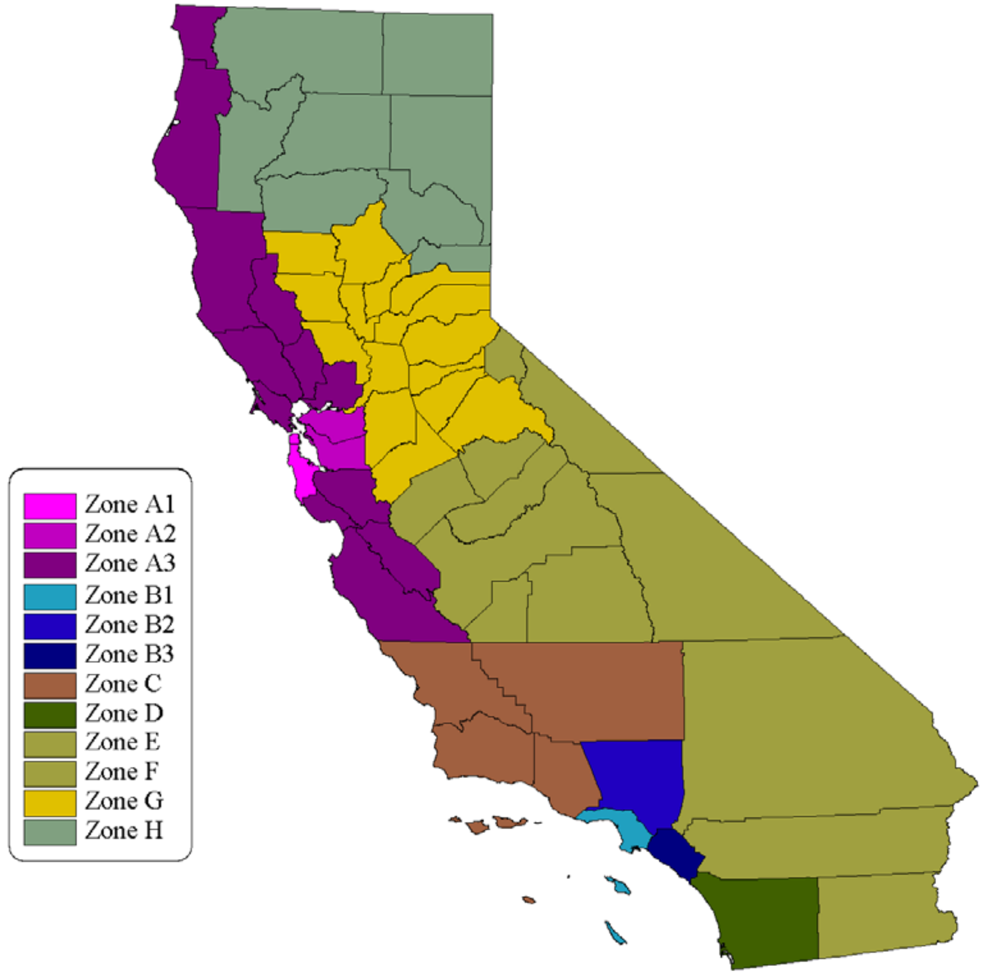
Earthquake – *Risk Mitigation*
Challenges in Risk Mitigation

- Generally compulsory earthquake coverage
  - As opposed to property earthquake policies
- Claims are not limited in the way that property policies are
- Hazard group information is not necessarily indicative of earthquake catastrophe risk
- Catastrophe reinsurance
  - Maximum Any One Life
- Portfolio management
  - Managing aggregations
    - Localized
    - Area
  - Policy underwriting risk

Earthquake – *Risk Mitigation*
Managing Aggregations

- Drivers of tail earthquake loss
  - West: Exposure aggregations around faults
    - Because of high frequency of known fault events
  - East: Exposure aggregations
    - Because of background seismicity possibilities everywhere

- Managing fault exposure not practical
  - Geographic areas
    - CRESTA zones
    - State
    - County



Earthquake – *Risk Mitigation*
Underwriting

- Examine:
  - Construction / structural system
  - Year of construction
  - Building height

- Detailed information on:
  - Number of employees
  - <u>By location</u>
    - High-resolution geocoding data
    - Placing of employees
  - Employee presence / shift information

- *Faults and seismicity of the area*

Earthquake – *Risk Mitigation*
Other Measures

- Catastrophe reinsurance
  - May have Maximum Any One Life Clause
  - Consider Per-Person Excess cover
- Remember
  - Some rating agencies may look at earthquake loss potential
- Model your portfolio
  - Understand the results
  - Gain insights into managing catastrophic risk potential

Section #2

HAZARDOUS FACILITY RISK
THE ELUSIVE SIDE OF INDUSTRIAL ACCIDENT

Hazardous Facility Risk
Industrial Accident

- Industrial accident catastrophes are a well-known risk
  - Information about insured facilities is readily available
  - Critical information gathered in the underwriting process
  - Premium can be gauged against this risk

U.S. Coast Guard, April 21, 2010

Hazardous Facility Risk
Catastrophe Types

- Explosion / Fire
  - Central explosion
    - Blast strongest in epicenter, dissipates as it moves outward
  - Chain reaction
    - Gas or liquid build-up in surrounding area
    - Nearby facilities
- Chemical release
  - Gas clouds
  - Liquids
- Collapse
  - Buildings or mines

Hazardous Facility Risk
Injuries from Large Industrial Accidents

- Injuries from large industrial accidents may potentially be larger claims than typical WC claims
  - Burns
  - Chemical burns
  - Other trauma

- New and costly treatments are available
  - High tech skin grafts

- Moreover, likely correlation of injury types and claims costs across a large number of injured employees

Hazardous Facility Risk
Texas City Explosion, 1947

- Worst industrial accident in U.S.
- Fertilizer cargo ship
- In port
  - Other industrial facilities nearby
  - Caused chain reaction
    - Oil refineries and storage tanks
    - Chemical plants
    - Subsequent fires and explosions
  - > 4,000 injuries (with > 500 fatalities)

NBC News, April 18, 2013

Hazardous Facility Risk
Injuries from Large Industrial Accidents

- Insurers of industrial facilities are aware of the type of its risk
  - Through underwriting process

- **But what about insurers of nearby locations?**
  - Are they aware of the potential risk posed by adjacent facilities?

Hazardous Facility Risk
Fertilizer Storage Facility Explosion, West, Texas, April 2013

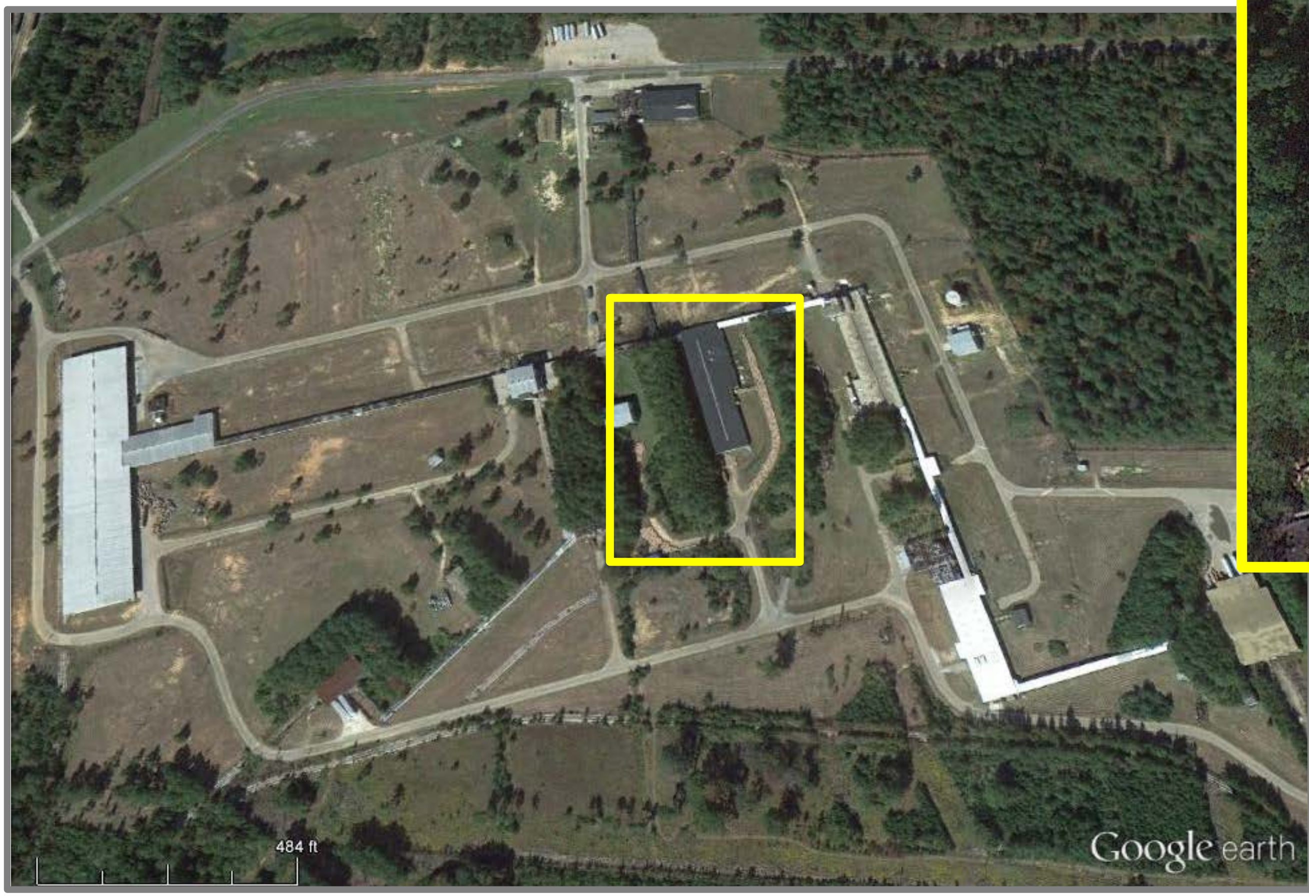
- 15 fatalities, > 200 injuries
- School, apartment building, hundreds of houses damaged or destroyed

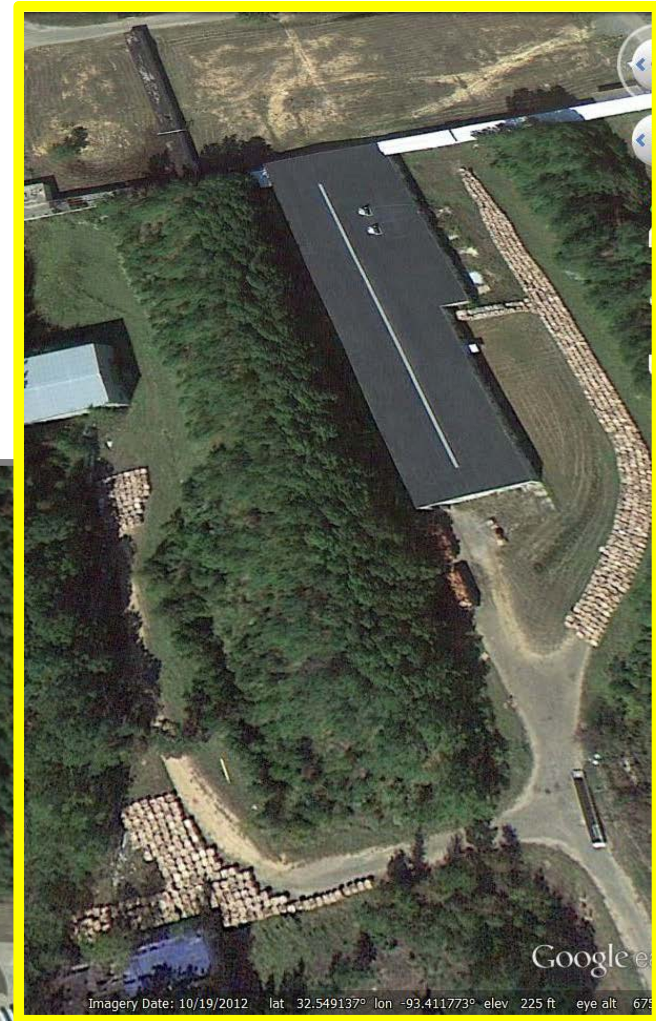
Washington Post, April 18, 2013

ABC News, April 18, 2013

Hazardous Facility Risk
Historical Examples - #1

- **Explo Systems, Inc. - Camp Minden, LA**
  - *6 million pounds of explosives*
  - *Improperly stored*





Hazardous Facility Risk
Historical Examples - #2

- Oil train explosion – Lac-Megantic, Quebec – July 2013
  - 47 Fatalities
  - Destroyed half of the town
- In the U.S., train lines like this are running more frequently

www.cnn.com, July 11, 2013

Hazardous Facility Risk

Recognition of Hazardous Facility Risk

- **The West, Texas fertilizer explosion highlighted the importance of managing this type of risk**

- <u>Subrogation potential is an important mitigating factor</u>
  - *But, the owners of the fertilizer storage facility only had $1 million in liability coverage*
  - *Whereas insured losses were probably in the hundreds of millions*

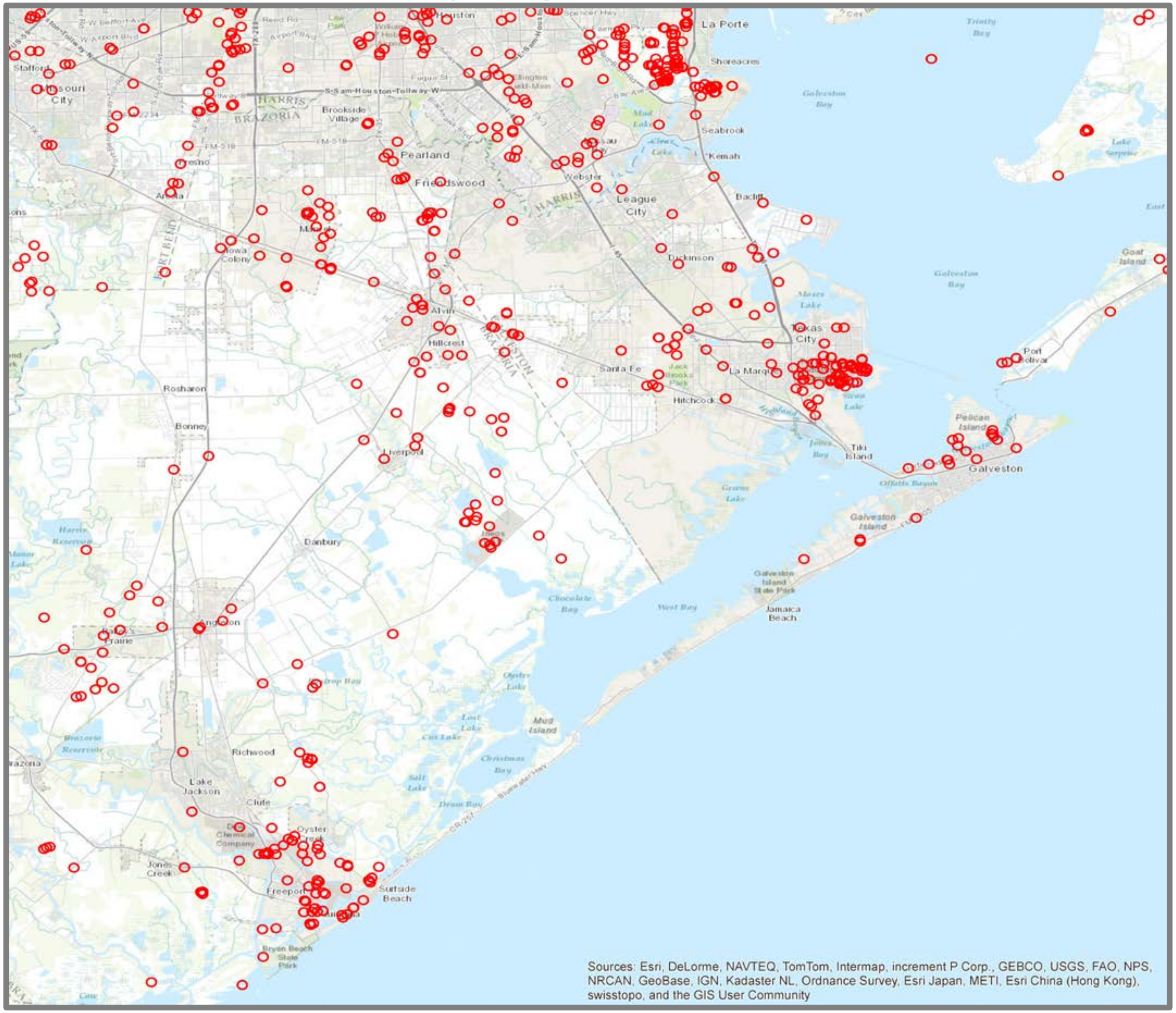
- ***The challenge is how to quantify this type risk***

Hazardous Facility Risk
Quantification of Hazardous Facility Risk

- Three *tiers* of catastrophe risk quantification
  1) **<u>Identification of exposure accumulations near hazard</u>**
     - Using GIS tools
     - Requires latitude/longitude coordinates of potentially hazardous facilities
       - This information may be difficult to obtain
  2) **<u>Deterministic loss estimation</u>**
     - “What-if?” scenario losses
     - Requires the above, and also knowledge of the facilities and perils, and likely losses
  3) **<u>Probabilistic loss estimation</u>**
     - Likelihood of achieving loss thresholds
     - Requires the above, and also an idea of frequency
       - Both for the industries in general, and the specific facilities

Hazardous Facility Risk

Using GIS Software to Identify Exposure Accumulations



Hazardous Facility Risk

Gauging a Prospective Risk for Exposure to a Hazardous Facility

Hazardous Facility Risk
Key Take-Away

- **Basic knowledge of where your portfolio is exposed is the first step to managing this risk!**

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