Earthquake Threat Analysis of Seattle, WA

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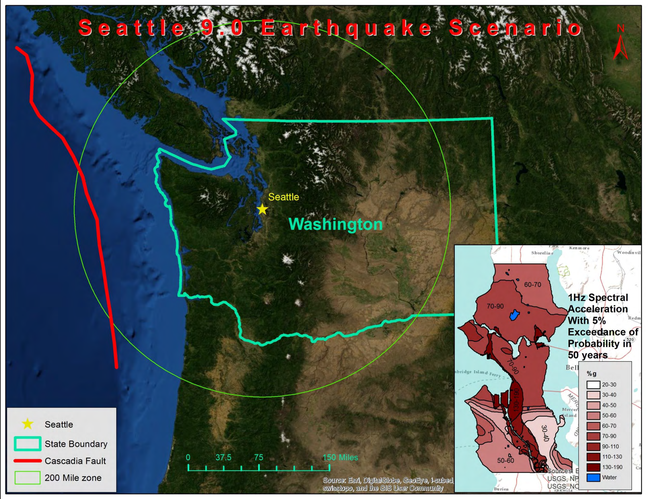
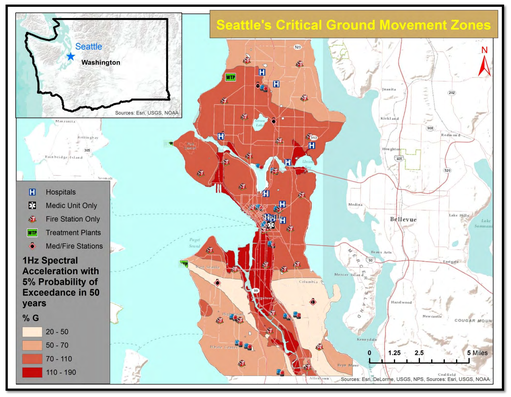
Study Area/Background



The map displayed to the left shows an overview of the Cascadian Subduction Zone Fault in relation to Seattle, WA, which will be the area of analysis for this project. A 200-mile buffer was placed around Seattle here to show that if an earthquake event occurs along the Cascadian fault line with a magnitude of 9.0 or higher, Seattle will indeed feel the effects. The 200-mile buffer was put in place based upon the 9.0 magnitude mega-quake scenario; earthquakes of this magnitude have been measured at distances greater than 500 miles away from the epicenter. With Seattle well within 500 miles of the Cascadian fault itself, this project aims to bring to light some of the possible threats to the city of Seattle from such a large seismic event.

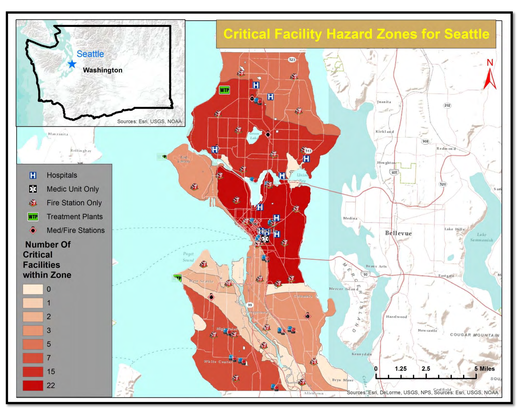
The inset map in the bottom right corner of the map displays a polygon layer derived from the study of Frankel, et. al., It's values of %g "depict the hazard for ground shaking at frequencies of about 1 cycle per second," or 1 Hz spectral acceleration due to seismic activity. Frankel, et. al. posit that a seismic event of such frequency is the most likely scenario in the Seattle area, which is why this project will utilize its zones of ground movement (as %g) to analyze the threat from a large earthquake to the overall and demographic population of Seattle, WA, using 2010 census data, as well as to the critical facilities within the city.

Analysis of Critical Facilities Distribution Within Seattle Shaking Zones*



The Seattle critical ground movement zones map shows four reclassified areas of ground shaking within Seattle, along with a visualization of critical facilities within the city. These zones are based upon the soil type in each zone; different types of soil have a higher susceptibility of movement while other soil is less susceptible (Frankel, et. al.). Facilities that would prove critical as assets following a large earthquake event are mapped on top of these shaking zones.

The critical facility hazard zones for Seattle map displays choropleth symbology of the number critical facilities within the polygons of the reclassified shaking zones polygons from the Seattle critical ground movement zones map (above left).



Data Sources

1 Hz Spectral Acceleration in %g: Layer discussed in Study Area/Background section of poster. The zones of this dataset show the levels of horizontal shaking that have a 5 in 100 chance of being exceeded in a 50-year period. Shaking is expressed as a percentage of g (g is the acceleration of a falling object due to gravity).

2010 King County Census Blocks with Demographic Population: Dataset used for deriving total and demographic population values for analysis. Block level data allows for more detailed visualization of population distribution in Seattle than block groups or tracts.

Potential Slide Locations: This polygon vector layer was produced by Seattle Public Utilities and represents areas within Seattle that have the potential for landslide activity, based upon the slope, soil, and previous landslide records.

Critical Facilities: All critical facilities point data (hospitals, medic units, fire and police stations, water treatment plants) was produced by the King County GIS Center and derived from their website.

Results & Conclusions

Multi-criteria earthquake threat analysis:

- The analysis for potential earthquake threat to the population of Seattle could be analyzed in even greater detail than our three threat factors; age of buildings, height of buildings, building density, daytime and nighttime population density, and property values could all be added to an analysis of earthquake threat. Due to the constraints of available data we were not able to include such factors.
- Because landslides are a major risk factor during strong ground shaking events this threat can be seen in quite well in all of the earthquake threat analysis outputs; seen in the ringed areas of steep elevation change north and east of downtown especially.
- According to our multi-criteria threat outputs, the areas of Seattle with the greatest threat to total population are on hillsides (especially around downtown) and on and nearby the University of Washington Campus.
- Some areas of great threat to particular demographic population groups within Seattle include:
  - White: the white population is at greatest threat on the hillsides directly north of downtown, as well as on hillsides along the southwest coastline.
  - Black: the black population is at greatest threat on hillsides directly east of downtown, as well as on hillsides along the southeast coastline.
  - Hispanic & Latino: the Hispanic and Latino population is at greatest threat on hillsides directly north, south, and east of downtown.
  - Asian: the Asian population is at greatest threat in a few blocks at the southern end of downtown, the area directly west of the University of Washington, and on hillsides along the coastline just north of downtown.

Critical Facilities:

- The downtown area of Seattle, represented with a %g value of 70-110, has the most critical facilities as well as population density in the city. Included in this downtown zone are 6 of the 9 hospitals in Seattle.
- Two hospitals, the University of Washington Medical Center and the Seattle Children's Hospital, located on opposites sides of the University of Washington Campus, are in very close proximity to the most violent shaking zone (110-190 %g). More detailed analysis on these two facilities would be useful to establish a better understanding of their risk from earthquake ground shaking.
- The University of Washington Campus is located directly on top of the most violent shaking hazard zone (130-190 %g), thus indicating, via Frankel, et. al., it is also an area of "artificial fill and young alluvium (soft soils)." This is a serious concern for any large magnitude earthquake scenario, because of the dense student population and many historic building found on the site.

Multi-Criteria Population & Demographic Analysis of Threat From A 1Hz Spectral Acceleration Earthquake in Seattle, WA*

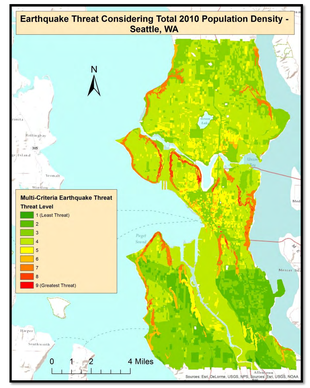
Methodology

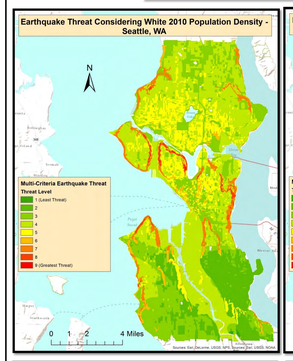
In order to gauge the level of threat to overall and key demographic populations of Seattle, we have created a raster based multi-criteria model to assess the level of threat from three factors during a large earthquake event. These rules were assessed on a nominal scale threat index between 1 (least threat) and 10 (greatest threat). The three rules for our threat analysis are:

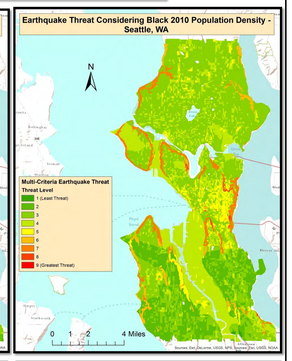
- Areas with higher population density pose a greater threat to the population (1-10)
- Areas of high ground shaking movement (%g) pose a greater threat to the population (1-10)
- Areas within demarcated "potential landslide zones" pose a great risk to the population (10)

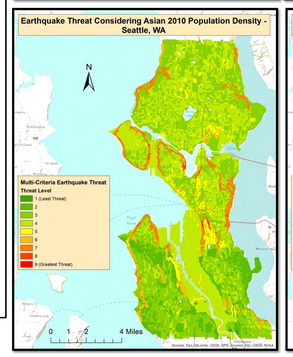
We began our analysis by converting the 1 Hz spectral acceleration in %g, potential landslide zones, and 2010 census blocks (symbolized into population density for: total population density, and white, black, Hispanic and Latino, and Asian population densities) polygon layers into raster layers, using the Feature to Raster and Euclidean Distance tools. Once rasterized, the nominal and ratio data of our datasets were converted to ordinal data that would rank threat level from a large earthquake event using the Reclassify tool. During this process the ground shaking %g and population density by census block data was first classified into ten classes using natural breaks; the areas of the lowest shaking and population density were assigned a threat level of one and each of the subsequent classes up the greatest values were raised by one, going up to ten. The potential landslide zones raster was classified into two classes, the area inside and area outside the potential landslide zones; the areas within potential landslide zones were assigned a threat level of ten and areas outside a threat level of zero. The final step in our multi-criteria analysis was to combine the three classified rasters to achieve our final results: threat index layers. Using the Raster Calculator tool the three classifed rasters were combined using the following formula:

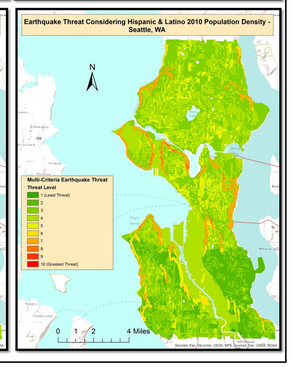
- ("potential slides" + "shaking zones" + "population density")/3











Literature & Data Sources Cited

Cascadian Subduction Zone Dataset & Study:
Blair, J.L., McCrory, P.A., Oppenheimer, D.H., and Waldhauser, F., 2011, revised 2013, A Geo-referenced 3D model of the Juan de Fuca Slab and associated seismicity: U.S. Geological Survey Data Series 633, v.1.2, http://pubs.usgs.gov/ds/633/.

2010 Census Blocks Dataset:
"Census Blocks." State of Washington Office of Financial Management. 2012. http://www.ofm.wa.gov/POP/geographic/tiger.asp

Potential Slide Locations Dataset:
"City Of Seattle Environmentally Critical Areas." The City of Seattle. data.seattle.gov. 2014. https://data.seattle.gov/dataset/City-Of-Seattle-Environmentally-Critical-Areas/zwze-9nv3

Seattle Spectral Acceleration Dataset & Study:
Frankel, A.D., Stephenson, W.J., Carver, D.L., Williams, R.A., Odum, J.K, and Rhea, S., 2007, Seismic hazard maps for Seattle, Washington, incorporating 3D sedimentary basin effects, nonlinear site response, and rupture directivity: U.S. Geological Survey Open-File Report 2007-1175, 77 p., 3 pls. http://pubs.usgs.gov/of/2007/1175/

Critical Facilities Datasets:
"Public Saftey (pubsafe)" & "Wastewater Treatment Facilities of King County." King County GIS Center–Data Portal. 2010. http://www5.kingcounty.gov/gisdataportal/Default.aspx

* **All maps on this poster:**

- Projection = Lambert Conformal Conic
- Geographic Coordinate System = NAD_1983_HARN_StatePlane_Washington_South_FIP
- Datum = GCS_North_America_1983_ HARN