

EENS 204	Natural Disasters
Tulane University	Prof. Stephen A. Nelson
<b>Homework Assignment II. Seismological Exercises</b>	

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Answer the following questions. Typewritten answers should be turned in along with any maps required to answer the questions. **Note that it is recommended that you use the PDF version of this file and print the figures on a high quality ink jet printer using the black and white only setting, to see the highest resolution images.** This will enable you to be much more precise in locating the earthquake in problem 1.

1. Shown below in Figure 1 are three seismograms that show the records of a small earthquake somewhere in California. Time is marked on each seismogram by offsets in the records. Each offset corresponds to the passage of 1 minute. The records are read from left to right. Both P and S wave arrivals are recorded.

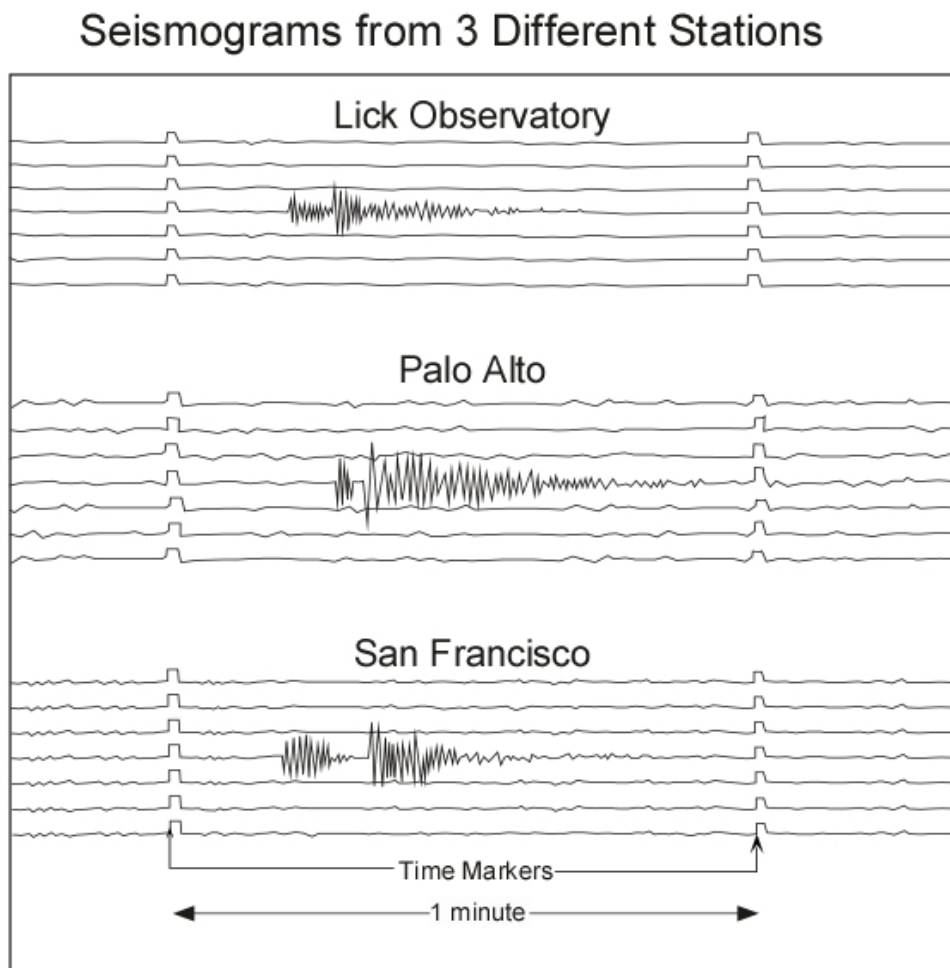


Figure 1

Shown below in Figure 2 are travel time curves for P and S waves determined from local earthquakes in California. Also shown is a curve (line) labeled S-P, which is travel time of the S wave minus the travel time of the P wave.

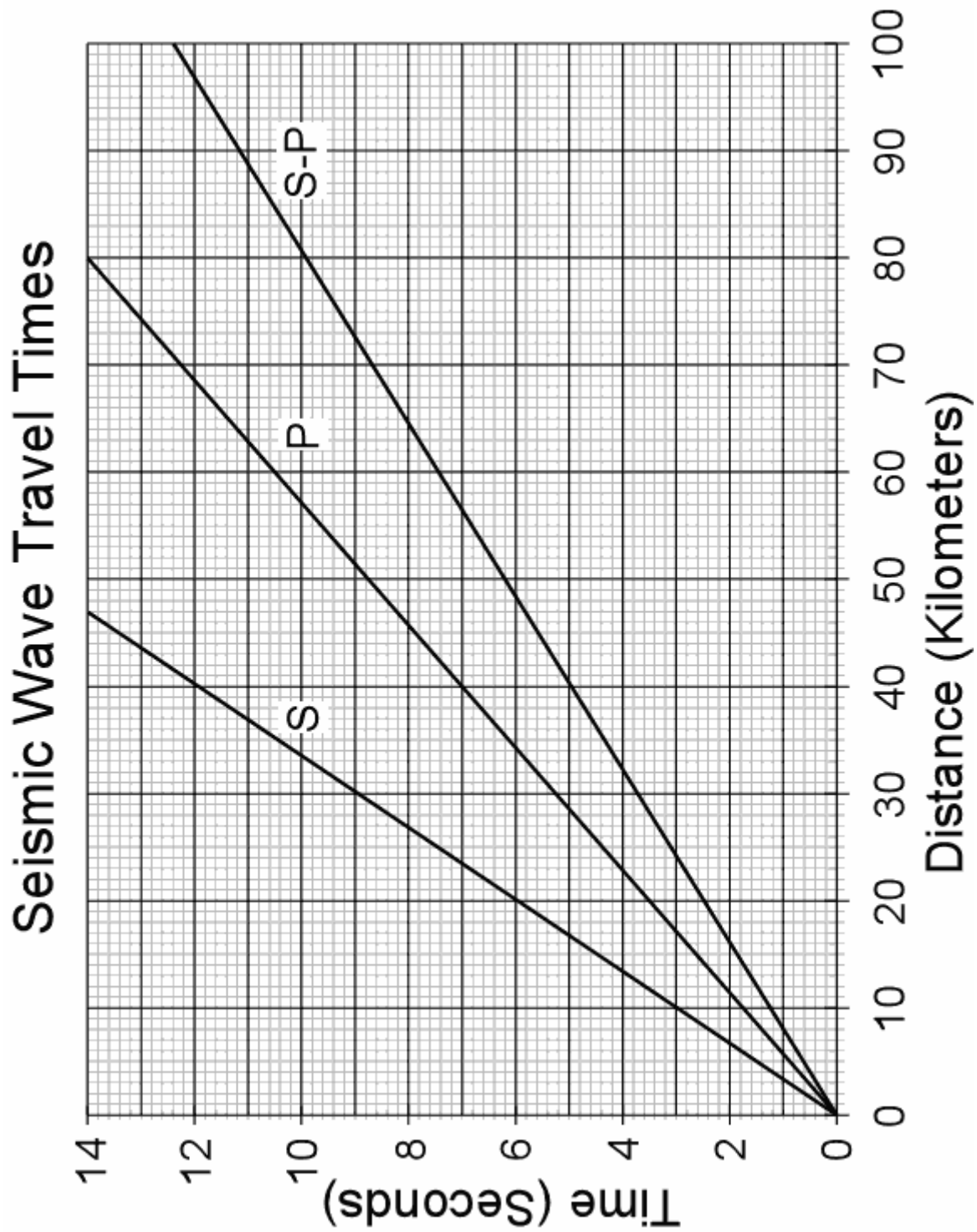


Figure 2

- a. From Figure 1, first **carefully** determine the time interval between the arrival of the first S wave and the arrival of the first P wave at each seismographic station. It is important that you **determine these S-P intervals as precisely as possible. (2 points)**
- b. From Figure 2, determine the distance of each seismographic station from the earthquake, **again, it is important that you be as precise as possible. (2 points)**
- c. Then, using the map below in Figure 3, and a drawing compass, locate the epicenter of this earthquake. **(2 points)**
- d. On which fault did the earthquake most likely occur? **(1 point)**

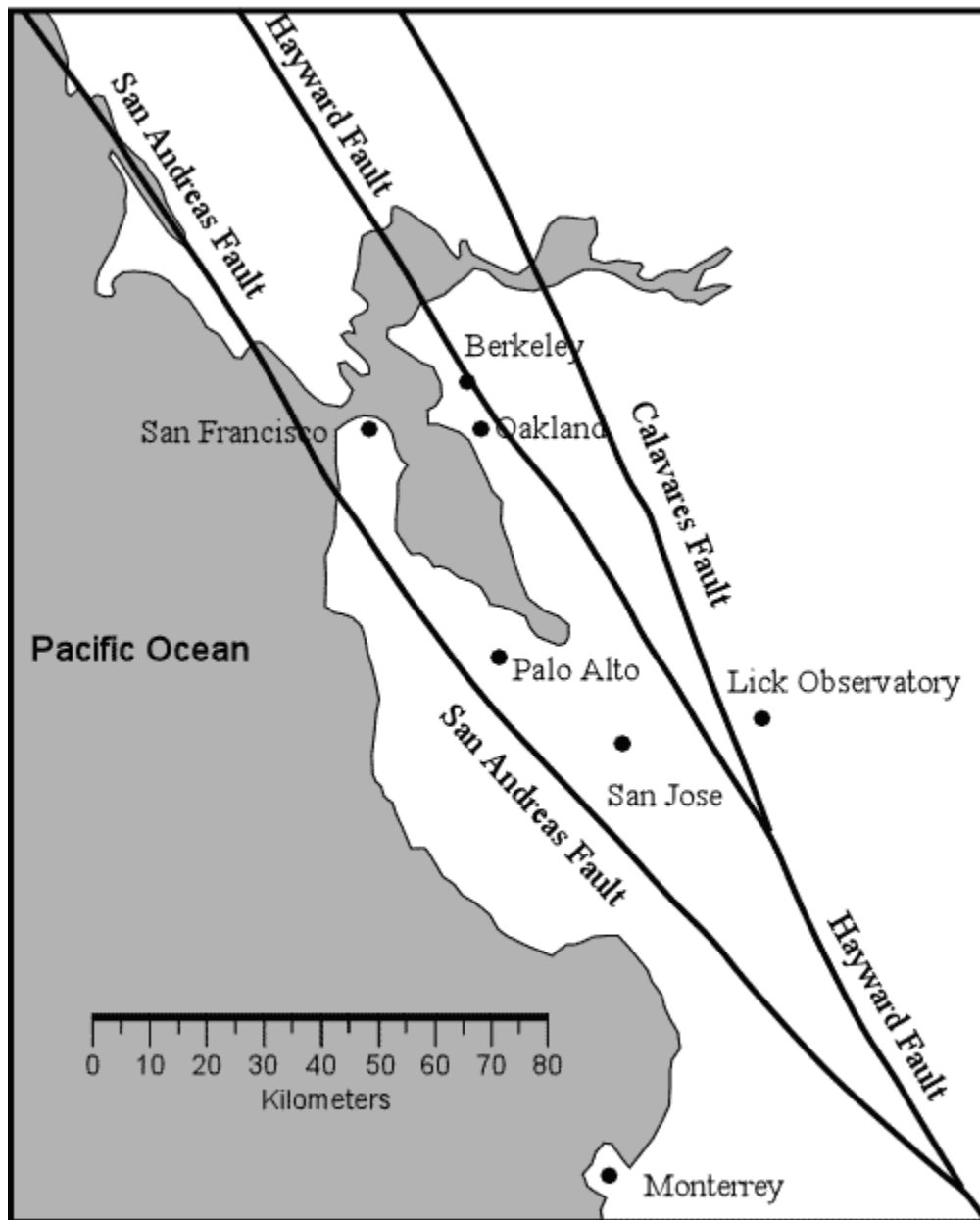


Figure 3

2. On October 17, 1989, just prior to game 3 of the World Series between the San Francisco Giants and the Oakland Athletics, a magnitude 7.1 Earthquake struck northern California (This earthquake is known as the Loma Prieta Earthquake). The earthquake occurred in the mountains west of San Jose California on the San Andreas Fault. As a result of the earthquake, 41 people were killed when a double-decked section of the Nimitz Freeway in Oakland collapsed, crushing people in the cars on the lower deck. A geologic map showing the various rock types present in the Oakland area and the location of the collapsed portion of the freeway (shown as a short dashed line) is depicted below in Figure 4. Between the thick bars is the area where the freeway was double-decked.

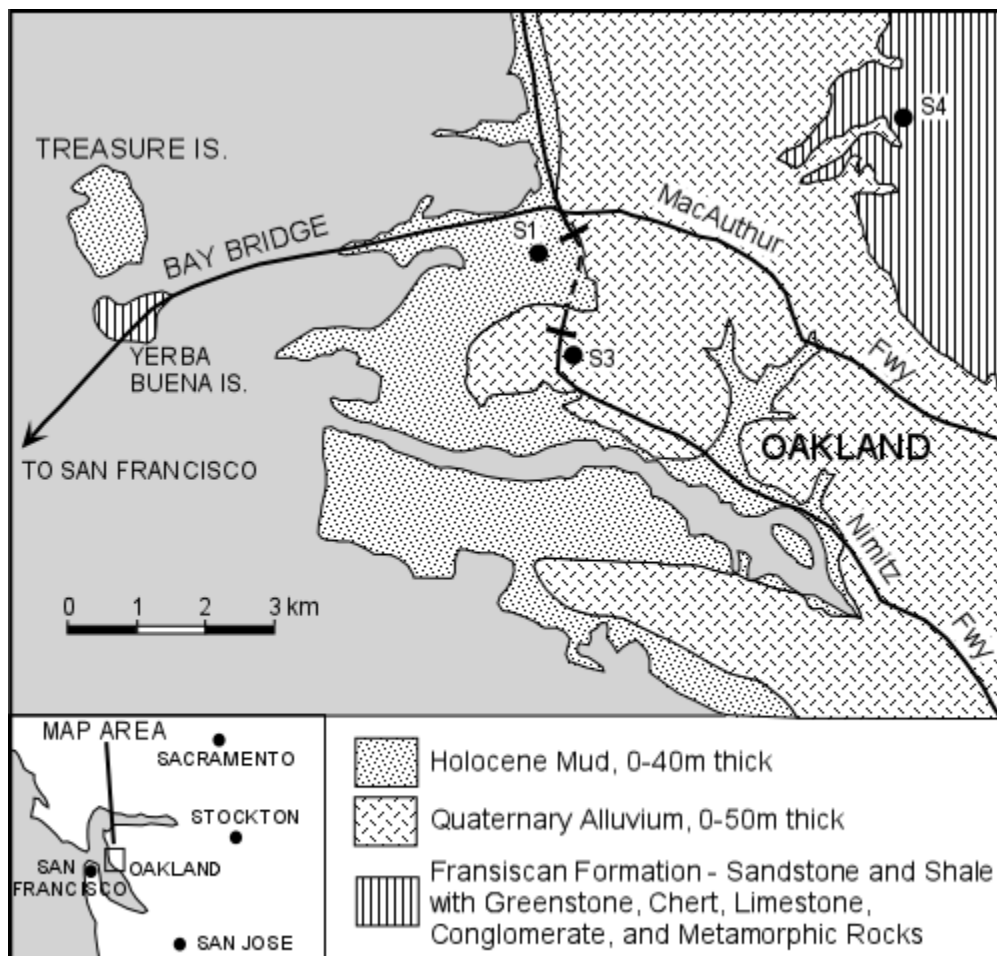
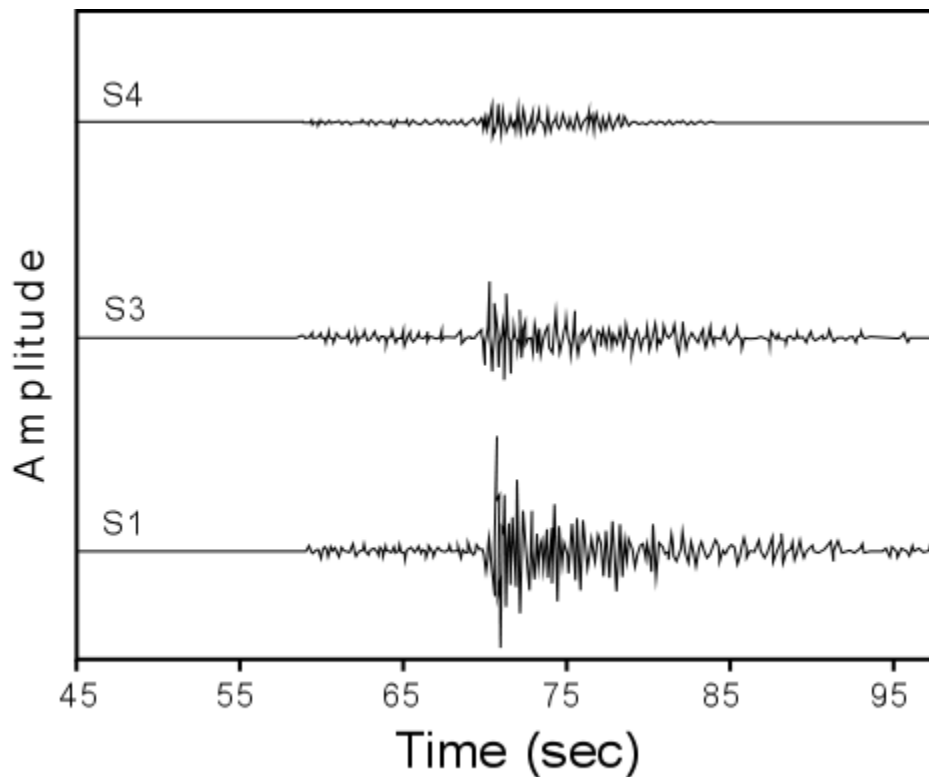


Figure 4

On the map, the areas marked as Holocene mud are areas that were formerly occupied by San Francisco Bay, but have been filled with loose sediment in the last 100 years, the mud contains lots of water in the pore spaces between the grains. The areas marked Quaternary Alluvium are areas underlain by unconsolidated sediment deposited by streams over the last 2 million years. The area marked Franciscan Formation is underlain by solid sedimentary, igneous, and metamorphic rocks with a thin cover of soil.

Several days after the magnitude 7.1 earthquake, small aftershocks shook the area. All had epicenters near the main shock of October 17. Seismologists placed several portable seismometers at stations S1, S3, and S4 (as shown on the map) and recorded these aftershocks. Seismographic recordings for one of these aftershocks, a magnitude 4.1 earthquake, for each of the three stations are shown in Figure 5, below. Note that the epicenter of the aftershock was far enough away that all of the recording stations could be considered to be about the same distance from the earthquake.



**Figure 5**

- a. What observations can you make about the seismic response (degree of shaking) on the three types of materials underlying the area? (**2 points**)
  - b. What conditions were likely responsible for the double-decked Nimitz Freeway freeway to collapse where it did? (**3 points**)
  - c. Considering that New Orleans is built on water-saturated river muds, how do you think New Orleans would fare if there were a major earthquake nearby? (**2 points**)
3. Three of the factors that are largely responsible for building damage during an earthquake are the degree of ground shaking, type of building construction, and liquefaction. This exercise is designed to explore these relationships. Imagine that you are given the opportunity to become the San Francisco Bay Area regional manager for Denyallclaims Insurance Company. Because this company has such a high profit margin, they can afford to provide housing for their regional managers. Thus, one of the perks of the job is that they will give you title to a house in one of the prestigious suburbs of San Francisco, Mill Valley, located on the Marin Peninsula, north of San Francisco. The company is offering you a choice between three different homes that they have somehow acquired. Because you know that the San Francisco Bay Area is prone to earthquakes and you also know that you will have to pay the insurance premiums for both home owner's and earthquake insurance, you want to make the best choice of which home to take based on safety concerns and the ability of the house to withstand damage from possible future earthquakes. Since Denyallclaims requires that you purchase insurance from them, you know that the premiums that you will pay will depend on the home's vulnerability and susceptibility to earthquake damage. While surfing the web, you have found a web site

produced by the Association of Bay Area Governments (ABAG) that provides information that will help you in making a decision -

<http://www.abag.ca.gov/bayarea/eqmaps/>

This site provides maps and information on such things as intensity of ground shaking, liquefaction, and the response of types of building construction to earthquakes, among lots of other useful information.

The homes from which you get to choose are the following, all within the 94941 zip code:

- 50 Plymouth Av (Single Family Wood Frame 2 story house built before 1940)\*
- 75 Avon Av (Single Family Wood Frame 2 story house built after 1939)
- 170 Walnut Av (Unreinforced Masonry 2 story house)

\*Note that this exercise is hypothetical. The actual existence of houses at these addresses is not known with certainty, nor are the construction characteristics at any of these houses known. Any resemblance to actual houses or addresses is purely coincidental and is unintended.

You should use the links to the interactive liquefaction maps and shaking maps to first determine the susceptibility of each of these homes to liquefaction and shaking during a worst case scenario earthquake - specifically, an earthquake where the entire northern portion of San Andreas fault moves and generates a Magnitude 7.9 earthquake like it did in 1906. Proceed as follows:

First, click on the link to the **Liquefaction Maps/Info**. On the page that opens, click on the link to "**Interactive (GIS) SUSCEPTIBILITY Map - "Zoom in" capability!**". This will open the ABAG GIS (Geographic Information System) page. Read the Notice on the page and adjust your display as necessary, then click on the circular image in the center to go to the Liquefaction GIS site. A map showing Liquefaction Susceptibility for the entire San Francisco Bay Area will load. Notice that the various buttons occur on both the left and right-hand side of the map. Of particular importance are the buttons to Zoom in/out and the button for Help. Notice that the map is at a scale much too large to be useful. You will need to zoom in to the area you are interested in to get useful information. Since you know the addresses of the properties are you interested in, you can click on the down arrow next to "Map a Location". in the lower right, then select "Search by Address", then click on the "Find Address" button. In the upper box enter the street address of the first property you are interested in (i.e. 50 Plymouth Av), then in the Zip Code box, enter the zip code (i.e. 94941). Finally, click on the "Locate" button. A zoomed in map will load showing the location of the address you entered. You can zoom in a bit further if you click the + sign under zoom in on the left. To see what the different colors mean, click the "view legend" button on the left. You can then use the Legend on the right to determine the Liquefaction Susceptibility for the property. Repeat the procedure for each of the other two properties.

Since you can't produce a map that shows all three addresses at the same time, remember where each address is located so that you can print one map and put the

locations of the three properties on one map by hand, otherwise you will have to remember the locations of the three different properties for the next part of the exercise.

Next, go back to the main ABAG Earthquake Maps page - <http://www.abag.ca.gov/bayarea/eqmaps/> and click on the link to **Shaking Maps/Info**. Then click on the link to **NEW Interactive (GIS) Maps for Future Earthquake Scenarios**. Wait for the page to completely load, then check to make sure the box next to "Entire San Andreas (1906 Quake)" is checked. As you did above, you want to locate each property, so click on the down arrow next to Map Location and bring up a map showing the location of each property. Again Once the map loads, you can zoom in a bit further if you click the + sign under "zoom in" on the left. To see the legend, click on the button on the left hand side of the screen to "View Legend". Note the **Modified Mercalli Intensity Shaking Severity Level** for each property. Note that you do not have to turn in any printed copies of these maps for this part of the homework exercise. Answer the following question -

- a. For each property, what is the Liquefaction Susceptibility and the Shaking Severity Level, including Modified Mercalli Intensity Scale value for an earthquake similar to the 1906 earthquake? (**3 points**)
- b. From your acquired knowledge of the relationships between shaking intensity, liquefaction, and the type of geologic material underlying an area, make an educated guess about the topography and materials that underlie each of the three properties (**3 points**).

Before you use the answers to the above questions to decide which property you will accept from Denyallclaims, you should consider the type of construction involved in each of the houses.

To determine the effects of construction type during the shaking of the worst case scenario earthquake, from the main ABAG page click on the link to **Shaking Maps/Info**. Then click on **How and Why Does ABAG Make These Maps?** and then on **What Does Ground Shaking Intensity REALLY Mean?** Page down, looking at the pictures of various types of construction damaged in other earthquakes as you go, then look at Table 1. From the information you obtained above on Modified Mercalli Intensity Scale shaking and knowledge of the construction type for each address, answer the following question:

- c. Which property would you accept from Denyallclaims based on all of the information available and your desire to have the safest and least susceptible house available, keeping in mind that Table I does not say anything about possible damage that may result from liquefaction? Discuss the reasoning used to obtain your answer. (**3 points**)
4. On the internet, use the search engine of your choice (I recommend [www.google.com](http://www.google.com)) to find information about a major earthquake that occurred in the U.S. or Canada in the year 1700. Then answer the following questions about the earthquake.
    - a. Where did this earthquake occur and how big was it? (**2 points**)

- b. Considering that humans capable of recording information about the earthquake did not live in the area at the time of the earthquake, how do scientists know the exact date, time and size of this earthquake? (*2 points*)
  - c. What is the plate tectonic setting of the area where the earthquake occurred? (*1 point*)
  - d. What implications does this have for future earthquake potential in this region? Specifically, what major cities could be affected by future earthquakes that occur in this area? (*2 points*)
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