

Background

This project asserts to network Monterey County's current mass care response capabilities following a moment magnitude (M) 7-9 earthquake on the Northern San Andreas Fault. In the event of an earthquake of this magnitude or greater analysis of Monterey County's ability to meet the transportation and sheltering needs of the projected affected population is required.

Numerous earthquake Fault lines exist within Monterey County, California. According to the 2008 Uniform California Earthquake Rupture Forecast,¹ the probability of a magnitude 6.7 or greater earthquake in the Bay Area within the next 29 years is 63 percent.

The October 17, 1989 Loma Prieta 6.9 magnitude earthquake caused damage to numerous buildings in Moss Landing, a number of structures were damaged, with some knocked off of their foundations. Many residents slept outside their homes out of concern for further damage from aftershocks, of which there were 51 with magnitudes higher than 3.0 in the following 24 hours, and 16 more the second day. The earthquake damaged several historic buildings in the Old Town district of Salinas. However, a 7.9 magnitude or greater earthquake is expected to have a much greater impact in Monterey County.

Problem Statement

This project emphasis's the transportation of displaced personnel to shelters and seeks to answer the following questions:

- What are the optimal routes to get people to shelters in the event of numerous road closures in a timely manner?
- How many road closures need to exist before it isn't possible to get people to shelters?

The measure of effectiveness for this model is 11,500 people transported to a shelter within a timely manner.

Assumptions

- Monterey-Salinas Transit District (MST), with a fleet of over 100 vehicles and 5 major transit centers, is the primary agency for public transportation in Monterey Co.
- Shortest routes to the designated destination areas (shelter locations).

Priority Transportation Routes (Monterey Co.)

- SR 68 south to U.S. 101 on U.S. 101 to a point where travel can occur to the east
- County G17 south to U.S. 101 and south on U.S. 101 to a point where travel can occur to the east.

Data Sources

Monterey County is responsible for the transportation and sheltering of displacement

¹ Edward H. Field, et al., *The Uniform California Earthquake Rupture Forecast, Version 2.0 (UCERF 2)*, (USGS Open File Report 2007-1437, 2008). Available at http://pubs.usgs.gov/of/2007/1437/of2007-1437_text.pdf.

personnel following an earthquake. Information from the Monterey County Earthquake Mass Care and Sheltering Plan and the Monterey County Catastrophic Earthquake Mass Transportation/Evacuation plan was used as a basis for the data used in the project analysis.

The shelters and shelter capacities (u_{ij}) were obtained from the American Red Cross.

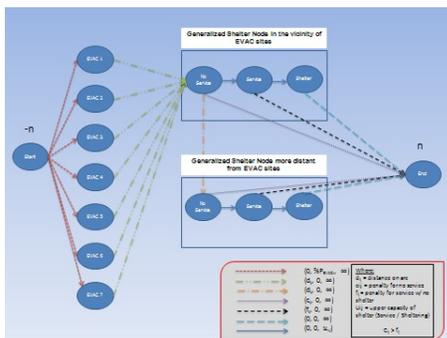
The United States Geological Survey (USGS) provided shake maps and liquefaction maps of Monterey County. The shake maps and liquefaction maps were used to derive initial assumption concerning which roads and would likely be damaged or impassable in the event of a large magnitude earthquake.

Demographic Information for Monterey County	
Population	431,900
Expected number of people to transport from each city	
Carmel High School	170
Monterey Transit Plaza/Pearl	1,280
Edgewater Transit Exchange , Sand City	1,520
MST-Salinas Transit Center	6,900
Big Sur River Inn	35
Monterey-Salinas Bus Stop Shop	695
Monterey-Salinas Transit(MST) Marina Transit Exchange	900
Expected number of People in need of shelter post-earthquake	11,500

Model

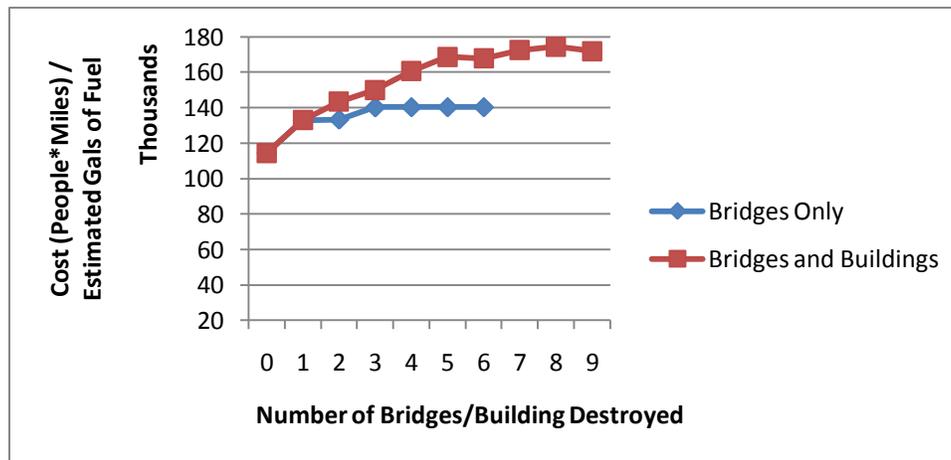
The project model is a Min-Cost Network Flow model. Nodes in the model are the shelters and transit centers. Arcs are the road network that connects them. Additionally, the nodes were connected to themselves with arcs for the shelters' capacity to provide services and housing. The cost on arcs is the distances between shelters. The capacities

on the arcs between shelters are un-capacitated. Dummy nodes are connected to the shelters to collect flow through the different levels of service. These nodes are connected to an end node. The supply and demand are on the transit station and the end node. This depiction of the network allowed for the collection of the data of interest, number of individuals serviced, housed and those that were not serviced not housed.



Results/Conclusions

Run	Total with Penalty	No Service	Serviced	Housed
0	114381.9	0	0	11500
1	133007.4	500	0	11000
2	133373.6	500	0	11000
3	140302.5	500	0	11000
4	140384.1	500	0	11000
5	140384.1	500	0	11000
6	140384.1	500	0	11000



Monterey County has ample shelter housing in the event of a 7.9 M earthquake on the San Andres fault. The bridges that had the highest probability of being damaged did not prevent the flow of personnel to shelters; however the cost did go up in terms of distance. The combined damage to buildings and bridges increased the cost in distance traveled and people not sheltered.

Of the projected 11,500 individuals that are expected to need transportation and shelter only displaced personnel in Big Sur were not able to receive transportation to a shelter.

Finally, the cost for transportation increases as road and bridges are taken out of service. Therefore, the impact of road closures would be a time delay in getting displaced personnel to shelters.

Open Ended Analysis

Areas of additionally analysis can be to look at secondary quakes along the fault lines within Monterey that could be triggered by a large earthquake on the San Andreas Fault and repeat the model based on most likely road closures in further with Monterey, Carmel, and the Pacific Grove area.

Additionally, the model can be expanded to include Handicapped accessibility at shelters and the transportation that would be required to get displaced handicapped personnel to shelter facilities that can adequately house them.