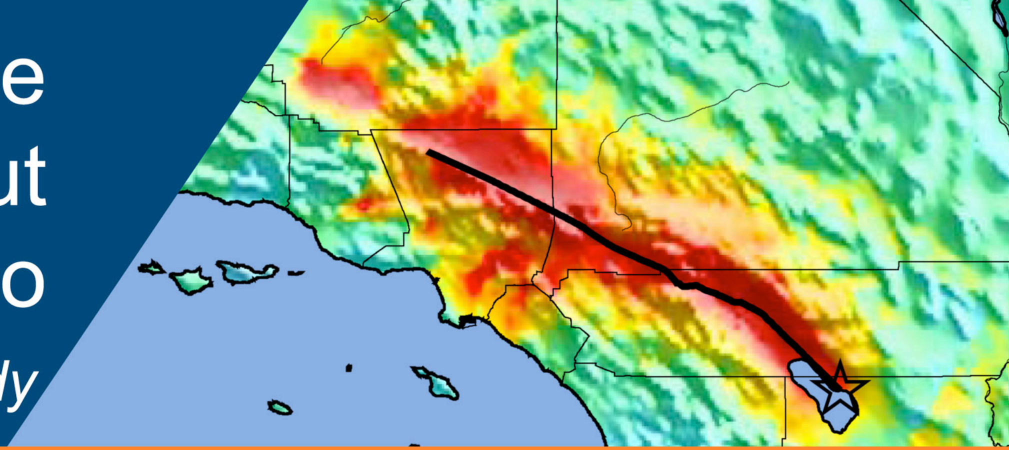
The ShakeOut Scenario

Supplemental Study



Hazardous Materials

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Note: over the course of the ShakeOut Scenario, the project name evolved. Where a study mentions *the SoSAFE Scenario* or *San Andreas Fault Scenario,* it refers to what is now named the ShakeOut Scenario.

Impacts of a M7.8 Southern San Andreas Fault Earthquake: A Hazardous Materials Release Scenario

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Summary

Over 175,000 people would be affected by a hazardous materials release that originates in Los Angeles County as a result of a M7.8 earthquake on the southern San Andreas Fault. This assessment is based on scaling the results of an earlier study by Seligson et al. (1996).

Introduction

It is generally acknowledged that a major earthquake in an industrialized, densely populated area of the U.S. could lead to the release of hazardous chemicals. A large post-earthquake release would present a threat not only to residents in the immediate vicinity of the source, but also to those of surrounding communities. Affected areas would then face a range of emergency management problems. For example, a major earthquake is likely to seriously impair community emergency response capability, making it difficult to effectively deal with secondary emergencies such as hazardous materials releases and fires. Tasks which are normally problematic, such as warning the public about a toxic release and evacuating people from areas that are hazardous, would be much more difficult following a major earthquake. Further, communities are accustomed to responding to hazardous materials releases one at a time, while in an earthquake situation multiple accidents may occur simultaneously, greatly compounding resource problems.

Although there has never been a major incident involving hazardous materials in a U.S. earthquake, smaller releases have occurred in events that were moderate in size. An example is an accident at a chlorine repackaging facility in the 1987 Whittier Narrows Earthquake, in which nearly one ton of chlorine gas was released (FEMA, 1987). While awareness of the problem is growing, there has been little research to date on the seismic sources of hazardous materials releases, and seismic vulnerability models for chemical facilities are almost nonexistent.

The main challenge in approaching this problem from a community perspective is to develop a risk assessment methodology that is sophisticated enough to provide the type of information needed for more effective hazard management, but is also cost-effective to apply on a regional basis. Conducting detailed seismic risk assessments and modeling potential failures in chemical facilities is very time consuming and expensive; few communities can afford to conduct such studies.

Adding to the complexity of the problem, highly hazardous materials number in the thousands and new products are constantly being developed. Before systematic analyses can be undertaken, it is necessary to determine which hazardous substances are likely to pose the biggest threat to the community in an earthquake. In this limited assessment, we have chosen to focus on two hazardous materials; chlorine and ammonia. These substances were selected because: (1) they are responsible for the majority of fatalities and casualties in U.S. hazardous materials incidents; (2) they are present in large quantities in our study area, Greater Los Angeles; and (3) they form clouds that can spread to adjacent areas, thus presenting a hazard beyond the plant gates.

Because of the limited resources devoted to the current effort, we have chosen to base our assessment on hazardous materials release scenarios which were produced several years ago by Seligson et al. (1996) where the effects of three earthquakes in the southern California area were evaluated. In that study, the potential impact of hazardous material release (limited to chlorine and ammonia) on southern California populations was determined from a M8+ earthquake on the southern San Andreas fault, a M7.0 earthquake on the Newport-Inglewood fault, and a M5.9 earthquake on the Whittier-Elsinore fault. This latter event involved the calibration of fragility and hazardous materials release models using data collected after the 1987 Whittier Narrows earthquake.

Study Approach

The purpose of the current study was to describe the impacts of a M7.8 earthquake on the Southern San Andreas Fault on hazardous materials handling facilities in Los Angeles County. Because of the limited resources which were dedicated to this effort, the authors used their judgment in scaling the results of a similar study completed by Seligson and others in 1996. The first author of this report was the Principal Investigator for that effort.

The basis for the current approach was to scale the results of the Seligson report either upward or downward depending on how recently released ground motion intensities by the U.S. Geological Survey (USGS), as reported in its *Multihazards Demonstration Project* (see http://pubs.usgs.gov/of/2007/1255/section4.html), compared with those ground motions initially reported in the Seligson report. Since the measure of ground shaking intensity in the Seligson report was Modified Mercalli Intensity (MMI), this ground motion index was used as the basis for comparison. Furthermore, since the Seligson report only considered hazardous materials release sources in Los Angeles County, the current assessment would not be entirely reflective of what might occur in a San Andreas event that causes damage to facilities in areas outside of Los Angeles County. The current scenario modeled here, however, is still considered significant in that many hazardous materials handling facilities are located in Los Angeles County and the populations that surround these facilities are significant.

Description of Facilities

The group of facilities that were examined in the Seligson study included twenty-two of the largest users of chlorine and anhydrous ammonia in the greater Los Angeles area. As part of this current effort, the authors reviewed the list of facilities considered in the earlier study and confirmed that each facility was still in operation.

The users include petroleum refineries, chemical manufacturers, and wastewater treatment plants. The inventory data for these facilities were obtained from a survey conducted by the South Coast Air Quality Management District (AQMD) in the 1990s. Although local and state laws were in effect at that time that required all users and handlers of hazardous chemicals to report on-site inventories, these programs were fairly new. Thus, the AQMD data were used as the primary data for the original effort.

The facilities store and use varying amounts of chemicals, and are dispersed throughout Los Angeles County. In general, they are broken into three facility types based on chemical usage: chlorine storage facilities, ammonia storage facilities, and ammonia processing facilities. Chlorine storage amounts range from 4 to 1000 tons, while ammonia storage varies from 2 to 206 tons. Table 1 indicates the usage of each facility, and the amount of each chemical stored on-site at the time of the original study. The reader is referred to the Seligson report for more information on each facility including facility type.

Earthquake Scenarios

The three earthquake scenarios that were considered in the Seligson report were:

- M8+ earthquake on the southern San Andreas fault – 300 kms of rupture along the Mojave, San Bernardino Mountain and Coachella Valley segments of the fault;
- M7 earthquake on the Newport-Inglewood fault; and
- M5.9 earthquake on the Whittier-Elsinore fault – a re-creation of the 1987 Whittier Narrows earthquake.

Peak ground accelerations were initially calculated at each facility location using a deterministic magnitude-distance attenuation relationship (Campbell, 1981). These peak ground accelerations were then converted to MMI values using a conversion equation developed by Trifunac (1976). These conversions yielded MMI values equivalent to PGA values for sites located on "basement rock".

In order to account for variations in local ground conditions from "basement rock", MMI modifiers were added to the "basement rock" MMI values. These modifiers were based on Evernden and Thomson's (1985) site soil classifications and local soil information. Data on generalized local ground conditions for the study area were derived from published geologic maps, including maps generated by Tinsley and Fumal (1985), from their study of the areal variations in shaking response due to earthquakes in southern California.

For the USGS Multihazard Demonstration Project, MMI values were provided by Keith Porter at the University of Colorado at Boulder. As part of the current effort, the locations of the 22 facilities were plotted directly onto the USGS MMI map.

Table 2 shows a comparison of the different MMIs. The comparison indicates that the ground motions computed in the more recent USGS study are generally higher than those produced by the Seligson report for the San Andreas event, but nearly equal to those produced by the Seligson report for the Newport-Inglewood event. Figure 1 shows a map of facility locations plotted on the USGS MMI map.

Impact Criteria

The impacts of hazardous materials release are expressed in terms of percent of population exposed. Potential zones of vulnerability were established in the Seligson study based on specific health criteria or levels of concern for both Cl_2 and NH_3. The chemical-specific health criteria used were based on the Emergency Response Planning Guidelines (ERPGs) developed by a committee of the American Industrial Hygiene Association (AIHA). The threshold criteria used was ERPG 3, "the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects." This exposure level is 20 ppm for Chlorine and 1000 ppm for Ammonia. The reader is referred to the Seligson et al. report for a description of the population exposure methodology, i.e., plume modeling and exposure analysis.

Results

Based on the assumption that the ground shaking intensities (MMI) for the USGS M7.8 San Andreas earthquake are similar to those produced in the Seligson report for its M7 Newport-Inglewood event, we conclude that the impacts from the USGS scenario will be on the same order of magnitude as those presented by Seligson's Newport-Inglewood scenario. Table 3 shows the results of both the Newport-Inglewood scenario and the M8+ scenario as originally presented by the Seligson report. These are provided for reference.

Since the populations in Los Angeles and Orange Counties have grown since the release of the Seligson et al. (1996) study, we have scaled the exposed population numbers for those counties by factors of 1.3 and 1.6, respectively. Given this scaling, we estimate that the total number of people that will be exposed to a hazardous materials release in a large San Andreas event would be over 175,000. The population centers that will be most affected will be those that are located near facilities with high intensities, i.e., facilities 5 and 8. These facilities are located near the cities of Vernon, Commerce, Maywood, Bell Gardens and Bell.

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TABLE 1. Chemical Facility Use and Storage - Los Angeles County (as determined by Seligson et al, 1996)

Facility	Facility Type			Chemical Storage	
	Chlorine Storage	Ammonia Storage	Ammonia Processing	Chlorine (Tons)	Ammonia (Tons)
1	x		x	4	40
2	x		x	32	57
3	x		x	8	26
4	x		x	12	206
5	x			180	
6	x			5	
7	x		x	10	15
8	x			450	
9	x			5	
10		x			26
11	x			454	
12	x	x		1000	14
13	x			25	
14	x		x	20	15
15	x	x		270	1
16	x			90	
17	x			48	
18		x			26
19	x		x	10	10
20	x			6	
21	x	x		24	2
22		x			100
Total	19	6	7	2653 Tons	538 Tons

TABLE 2. MMI Comparisons between Seligson et al. (1996) report and USGS Demonstration Project

	San Andreas Scenario		Seligson et al.1996 Newport-Inglewood Scenario M7
Facility Number	Seligson et al. 1996 Report M8.3	USGS M7.8	
1	8	8	9
2	7	9	9
3	7	9	9
4	8	8	9
5	8	10	9
6	8	9	10
7	7	9	9
8	8	10	9
9	8	9	8
10	8	9	8
11	7	9	9
12	8	8	9
13	8	8	9
14	8	8	9
15	8	9	8
16	8	9	9
17	8	8	9
18	8	8	7
19	7	9	9
20	8	9	9
21	7	8	9
22	8	9	8

TABLE 3. Population Exposure to Hazardous Materials by County (Seligson et al., 1996)[1]

	County	Population Exposed	Total Population	Percent Exposed
Scenario 1: M 7.0 Newport/Inglewood Event	Los Angeles	132,509	7,477,503	1.800%
	Orange	491	1,932,709	0.030%
	Riverside	0	663,166	n/a
	San Bernardino	0	895,016	n/a
	Ventura	0	529,174	n/a
Scenario 2: M 8.3 San Andreas Event	Los Angeles	20,546	7,477,503	0.300%
	Orange	217	1,932,709	0.010%
	Riverside	0	663,166	n/a
	San Bernardino	0	895,016	n/a
	Ventura	0	529,174	n/a
Scenario 3: M 5.9 Whittier/Narrows Earthquake	Los Angeles	6,503	7,477,503	0.090%
	Orange	157	1,932,709	0.008%
	Riverside	0	663,166	n/a
	San Bernardino	0	895,016	n/a
	Ventura	0	529,174	n/a

Note: Only hazardous materials sites in Los Angeles County were considered in the Seligson et al. (1996) study.

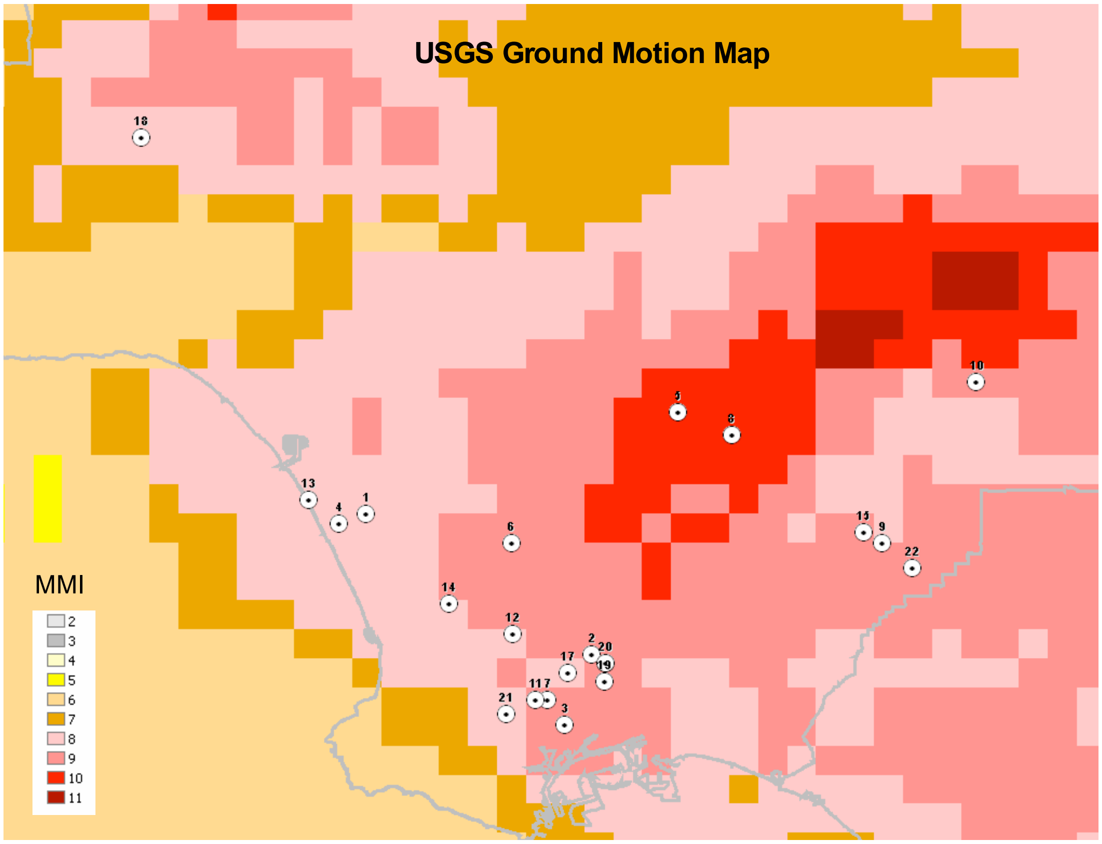

Figure 1. Facility Locations and MMI Values from USGS Demonstration Project.