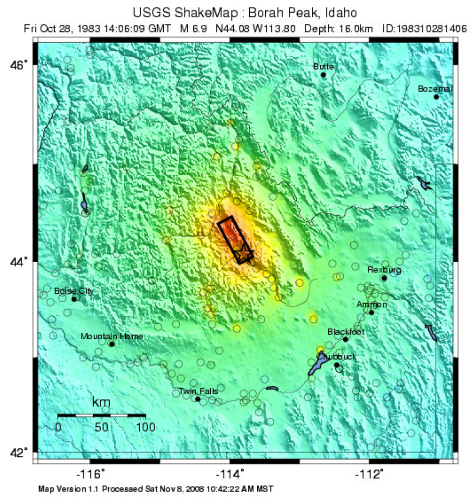

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16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

Borah Peak Earthquake HAZUS Scenario Project Executive Summary

Idaho Bureau of Homeland Security
Idaho Geological Survey
Western States Seismic Policy Council

12/30/2008

The HAZUS-MH analysis of the Borah Peak Earthquake was accomplished by the Idaho Bureau of Homeland Security (BHS) in partnership with the Idaho Geological Survey (IGS) and the Western States Seismic Policy Council (WSSPC). Major contributors to this project include; Julie Sendra, GIS Manager, BHS; Bill Phillips, Geologist, IGS; Mark Stephensen, Mitigation Planner, BHS, Patti Sutch, Executive Director, WSSPC; and Dave Jackson, State Hazard Mitigation Officer, BHS.

Introduction – Purpose, Scope and Background

The October 28, 1983 Mw 6.9 Borah Peak Earthquake is the largest historic earthquake to strike Idaho both in terms of magnitude and property damage. It has long served as the model scenario for emergency planning and hazard mitigation for emergency managers in Idaho. It works well as a model scenario in Idaho because it occurred in a rural area similar to the bulk of Idaho's seismic risk exposure. In this study, the Hazards U.S. Multi-Hazard (HAZUS-MH) methodology and software is used to estimate potential losses from a present-day earthquake with the same source characteristics as the Borah Peak event.

This project was done to establish a baseline for earthquake scenario development using the HAZUS-MH software. This is an important step for the evolution of Idaho's earthquake program. This project introduced several partners to the HAZUS-MH software and its application for scenario development to support emergency planning, hazard mitigation and public education/outreach activities. Most importantly, this project helped to identify existing gaps in available data sets that impact the accuracy and utility of earthquake loss models using the HAZUS-MH software.

The earthquake occurred along the Warm Springs and Thousand Springs segments of the Lost River Fault in a rural portion of eastern Idaho about 200 km northeast of Boise. This region contains a number of Basin-and-Range style normal faults with latest Quaternary-Holocene activity. Two deaths were caused in the nearby town of Challis. Property damage estimated at $12.5 million [**1983 dollars**] was largely restricted to Challis and another nearby town, Mackay. Spectacular surface faulting occurred along a 34-km-long zone. Other geologic effects included rock falls and landslides on steep slopes of the Lost River Range, and water fountains, sand boils, and fluctuations in water levels in wells and springs.

Source parameters of the earthquake (epicenter location, magnitude, rupture orientation, depth, attenuation function, and return period) were imported from the Shakemap Atlas Project of the U.S. Geological Survey (Allen and others, 2008; http://earthquake.usgs.gov/eqcenter/shakemap/atlas.php). This project produced maps of peak ground motions and intensity for about 1,000 recent and historical global earthquakes using established ShakeMap methodology and constraints from macroseismic intensity data, instrumental ground motions, regional topographically-based site amplifications, and published earthquake rupture models. The chief advantage of using the ShakeMap Atlas data for a HAZUS-MH scenario is that it provides a consistent and quantitative description of the distribution of shaking intensity for the Borah Peak earthquake.

HAZUS-MH Scenario Run Results

The HAZUS-MH scenario run included an area of 12 counties that are contiguous to the epicenter of the quake. The scenario area includes 25,812 square miles and 17 census tracts. The population of the scenario area is 62,289 people in roughly 23,000 households according to the 2000 Census Bureau data.

Critical infrastructure identified in the scenario includes 4 hospitals, 65 schools, 11 fire stations, 21 law enforcement facilities and 1 emergency operation center, 67 dams (18 high hazard) and 19 hazardous materials sites. The scenario also included 7 transportation systems and 6 utility systems. More detailed information can be found within the attached HAZUS-MH Borah Shake Map Scenario report.

The total estimated economic loss based on the scenario run is $37,000,000. This amount includes the roughly $12,260,000 in building related losses. The scenario indicates that roughly 9% of the losses were related to business interruption and that over 70% of the total loss was sustained by residential occupancies.

Issues

The estimated economic loss and impact to buildings and infrastructure generally seem to be aligned with the historical data for the 1983 Borah Peak Earthquake. Even though the study area is still considered rural, significant growth has occurred and has not been completely accounted for in the data sets that drive the HAZUS-MH model. The most significant data shortfalls seem to be within the critical infrastructure and critical facilities data sets and local geological information.

There are several key indicators that show our data sets for critical infrastructure are incomplete. The 11 fire stations, 1 emergency operations center and 65 schools are very low numbers. We know these numbers are low because each county has at least one emergency operation center and at least one fire station. The total number of 6 utility systems does not account for the municipal water or sewer systems within the study area. There are multiple utility CO-OPs within the area in addition to state and county communication sites that were not included in the analysis. The study area also includes the Idaho National Laboratory which has extensive infrastructure and some nuclear and hazardous materials facilities. Data from this facility was unavailable at the time and consequently was not included in the analysis.

Data sets for irrigation canals were not included in the analysis because the data sets were not available. The preeminent use of irrigation in the study area is an important factor that the model should take into consideration. This absence of this information likely reduced agricultural impacts and infrastructure losses in the scenario model significantly from what we would expect to see following a similar earthquake.

Historic records for the 1983 Borah Peak Earthquake extend damage to schools and older buildings into Gooding County which was not included in the study. Gooding County was eliminated from the study area because it was not included in the USGS ShakeMap for the Borah Peak earthquake. Since it was not included on the ShakeMap, no numeric shake values were assigned to the census tracts within Gooding County. Without numeric shake values assigned to census tracts, no impact or damage would be reflected in the model. The initial HAZUS-MH run for the scenario indicated that no damage occurred in Gooding County where in fact, several older homes were damaged and a school building had to be demolished.

Recommendations for Future Work

The following recommendations for future work are based on our analysis of data shortfalls needed to produce an accurate loss estimation model using HAZUS-MH for earthquakes in Idaho. These recommendations will apply uniformly across the state to enable us to run earthquake loss estimation models using HAZUS-MH for other faults and locations in Idaho as well.

- Work with county and municipal governments to develop more complete data sets for public infrastructure and building stock.
- Work with private utility companies to include railroads, communication providers, power and natural gas providers, water companies, pipeline companies, to develop more complete data sets for lifelines.
- Identify school districts, fire districts and other special districts and work with them to develop more complete data sets regarding their resources.
- Produce digital liquefaction susceptibility maps and NEHRP soil class maps at scale of 1:24,000 for areas of population concentration beginning with the largest communities in areas with an extreme earthquake hazard and working down to the smaller communities with high and then moderate earthquake hazard.
- Work with the Idaho National Laboratory to develop data sets for use in HAZUS for their facilities.
- Develop a partnership with the Idaho National Laboratory to leverage their research and appropriate expertise to refine and improve our seismic loss estimation modeling using HAZUS-MH.
- Develop appropriate agricultural data sets for inclusion in future HAZUS-MH scenario runs.
- Calibrate data sets for federally recognized critical infrastructure sectors for inclusion into future HAZUZ-MH seismic scenario runs.
- Complete base-line HAZUS-MH scenario runs for other high risk faults and communities within Idaho.

The following is the output of HAZUS showing earthquake parameters.

Scenario Name	BorahShakeMap
Type of Earthquake	[normal, USGS Quaternary fault database, http://earthquake.usgs.gov/regional/qfaults/mt/dub.html]
Fault Name	Lost River [Thousand Springs and Warm Springs segments, USGS Quaternary fault database, http://earthquake.usgs.gov/regional/qfaults/mt/dub.html]
Historical Epicenter ID#	198310281406
Probabilistic Return Period	Unable to determine from ShakeMap
Longitude of Epicenter	W 111.80
Latitude of Epicenter	N 44.08
Earthquake Magnitude	Mw 6.9
Depth (Km)	16.0
Rupture Length (Km)	34 [USGS Quaternary fault database, http://earthquake.usgs.gov/regional/qfaults/mt/dub.html]
Rupture Orientation (degrees)	152 [Mendoza and Hartzell, 1988; citation given in Allen et al., 2008]
Attenuation Function	Unable to determine from ShakeMap

Information on SHAKEMAP methodology from the ShakeMap metadata file.

For this version of the map in question, a finite fault was incorporated to modify the source-receiver distance used in the attenuation model above. The coordinates of the fault (or fault surface) were: Latitude Longitude Depth 44.052 -113.668 1.000 44.464 -113.974 1.000 44.390 -114.168 21.105 43.978 -113.861 21.105 44.052 -113.668 1.000
Site corrections are then used to interpolate from ground motions recorded on a fairly sparse, non-uniformly spaced network of stations to maps showing spatially continuous functions (i.e., contours). Prior to interpolation, we reduce the ground motion amplitudes to a common reference, in this case bedrock motions. Peak ground motion amplitudes from the seismic stations are corrected to rock site conditions; and the observations (corrected to rock) and the coarse phantom stations (computed for rock) are then interpolated to a fine rock site grid (roughly 1.6-km spacing). We scale the peak acceleration (PGA) amplitude with the Borcherdt et al. (1994) short-period amplification factors while the peak ground velocity (PGV) values are corrected with the mid-period factors. Response spectral values are scaled by the short-period factors at 0.3 sec, and by the mid-period response at 1.0 and 3.0 seconds. The site correction procedure is applied so that the original data values are returned at each station; hence, the actual recorded motions are preserved in the process and the final contours reflect the observations

wherever they exist.

Next, the interpolated rock grid is corrected at each point for local site amplification and instrumental intensity map is generated by relating the peak ground acceleration or velocity at each grid point to intensity as described by Wald et al. (1999). This fine grid is saved and exported to the file "grid.xyz". A continuous surface is also fit to the fine grid to produce the contour maps and GIS formatted maps.]

References:

Allen, T.I., Wald, D.J., Hotovec, A.J., Lin, K., Earle, P.S., and Marano, K.D., 2008, An Atlas of ShakeMaps for selected global earthquakes: U.S. Geological Survey Open-File Report, 2008-1236, 34 p.