Prompt Assessment of Global Earthquakes for Response

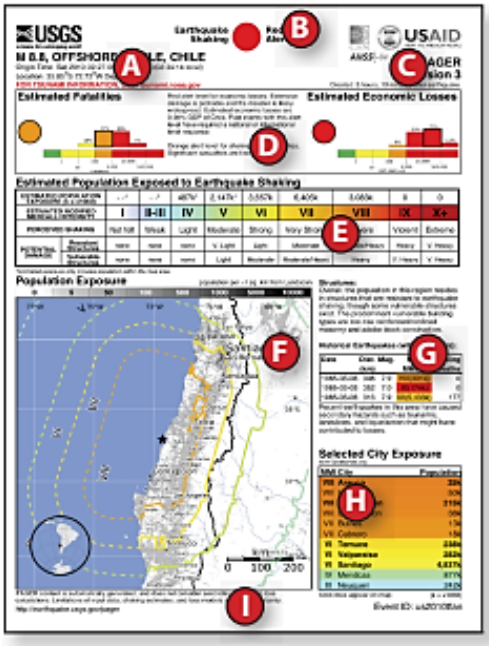
Background

PAGER provides shaking and loss estimates following significant earthquakes anywhere in the world. These estimates are generally available within 30 minutes and are updated as more information becomes available. Rapid estimates include the number of people and names of cities exposed to each shaking intensity level as well as the likely ranges of fatalities and economic losses. PAGER does not consider secondary effects such as landslides, liquefaction, and tsunami in loss estimates at this time. For tsunami warnings see http://tsunami.noaa.gov/.

Information on the extent of shaking will be uncertain in the minutes and hours following an earthquake and typically improves as additional sensor data and reported intensities are acquired and incorporated into models of the earthquake's source. Users of PAGER need to account for uncertainty and always seek the most current PAGER release for any earthquake.

PAGER alerts are available in a one-page summary and Web pages with extended content at http://earthquake.usgs.gov/pager/.

A **Summary of the basic earthquake parameters**, including origin time, local time, magnitude, hypocenter, and the name of the region where the earthquake took place. For events with high likelihood of a tsunami, a link to the NOAA tsunami Web page is provided (bold red text).



B **Earthquake Impact Scale summary alert level.** The higher of the two alert levels (D) is shown as the summary alert at the top-center of the page.

C **The version of the PAGER alert and the time the alert was created.** New versions of the alert are generated when the earthquake information is improved as supplemental ground-shaking constraints become available.

D **Earthquake Impact Scale alert levels** for fatalities (left) and economic losses (right). The alert levels are based on the range of most likely losses due to earthquake shaking; the uncertainty in the alert level can be gauged by the histogram, depicting the percent likelihood that adjacent alert levels (or fatality/loss ranges) occur. Accompanying text clarifies the nature of the alert based on experience from past earthquakes. If the economic alert is yellow or greater, the text will also give a range of economic losses in terms of the country's Gross Domestic Product. The higher level of the two alerts is shown as the summary alert at the top-center of the page (B).

E **Table showing population exposed** to different estimated Modifed Mercalli Intensity (MMI) levels and the possible damage at different intensity levels for resistant and vulnerable structures. MMI describes the severity of an earthquake in terms of its effect on humans and structures and is a rough measure of the amount of shaking at a given location. Unlike earthquake magnitude, intensity varies with distance from the fault. Population outside the map bounds are not included in the totals.

F **Map of MMI contours** plotted over the Landscan (Oak Ridge National Laboratory) population base map. The regions labeled with Roman numeral MMI values are separated by half intensity unit contour lines, e.g., 5.5, 6.5, 7.5. The total population exposure to a given MMI value is obtained by summing the population between the contour lines. This total is shown in the population exposure table (E).

G **Region-specific structure and earthquake commentary.** The Structures comment may contain the most vulnerable building type(s) in the region or a general description of the vulnerability of the buildings in the region. The Historical Earthquakes section includes a table of population exposure and fatalities for three previous nearby earthquakes, and, in some cases, the potential for fires, landslides, liquefaction, or other hazards, based on past earthquakes in the region, will be noted.

H **Table of MMI estimates for selected settlements.** A maximum of 11 settlements that fall within the map boundary are included in the table. The table contains country capitals and the six settlements with the highest estimated intensity. The remaining settlements listed are selected by population. Settlement name, location, and population are obtained from the freely-available GeoNames geographical database (GeoNames.org).

I **Footer**, including a link to the PAGER Web page, the event-identification number, and a disclaimer noting that the content was automatically generated and has additional sources of uncertainty. All possible uncertainties are not considered in the determination of estimated earthquake fatalities and economic losses; the actual impact of the earthquake may differ from PAGER's automatically generated estimate.

PAGER (Prompt Assessment of Global Earthquakes for Response)
https://earthquake.usgs.gov/data/pager/

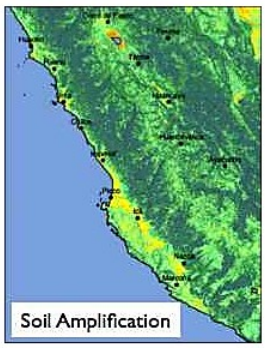
PAGER Distribution:

- There is up to a 5-minute delay from the time the initial earthquake solution is posted to the web and when the PAGER results are available to view.
- Earthquakes larger than M5.5, PAGER estimates are generally available online within 20-30 minutes of the earthquake's occurrence and are updated as more information becomes available.
- USGS may distribute PAGER for earthquakes as small as M3.5 – M4.0.
- Earthquakes that result in initial "**orange**" or "**red**" PAGER alert levels, seismologists will further review the earthquake information as well as the PAGER results prior to releasing loss information to users. This may result in additional delays on the order of 10 to 20+ minutes.
- For initial "**orange**" or "**red**" alerts, exposure-based PAGER information will still go out immediately to all users.

PAGER uses a new Earthquake Impact Scale (EIS) that is based on two complementary criteria:

- Estimated cost of damage; yellow, orange, and red thresholds are estimated losses reaching $1 million, $100 million, and $1 billion.
- Estimated ranges of fatalities; thresholds for yellow, orange, and red alert levels are 1, 100, and 1,000.

Alert Level and Color	Estimated Fatalities	Estimated Losses (USD)
Red	1,000+	$1 billion +
Orange	100 - 999	$100 million - $1 billion
Yellow	1-99	$1 million - $100 million
Green	0	< $1 million



Steps in the PAGER Process

1. After the magnitude and hypocenter of an earthquake are determined, Global ShakeMap retrieves any strong ground motion data and intensities reported by people via the USGS "Did You Feel It?" system. The colored circles show the reported intensity at a city and the circle's size is proportional to population.

2. ShakeMap generates a soil/rock site-specific ground-motion amplification map based on topographic slope. This map accounts for the tendency of soft-soil sites to experience stronger ground motion amplification than rock sites.

3. Information about the fault geometry and size (black rectangle) is added when it becomes available. The ShakeMap system then produces regional ground shaking estimates (yellow contours) using the reported intensities, the site-specific ground-motion amplification map, and seismic wave attenuation equations that account for the variation of seismic shaking intensity with magnitude, fault distance and depth.

4. The ShakeMap system then converts the estimated ground motions to a map of seismic intensity.

5. The population affected at each intensity level is computed and intensities and populations at nearby cities tabulated by combining the map of intensity with the Landscan population database.

6. Based on the population exposed to each shaking intensity level, the PAGER system estimates total shaking-related losses based on country-specific models developed from economic and casualty data collected from past earthquakes.

7. The alert levels are determined by estimated ranges of fatalities and economic loss, with the higher of the two setting the overall alert level. The alert level determines which users are actively notified, and, at the same time, all PAGER content is automatically distributed to the web on the USGS Earthquake Hazards Program Web pages, as part of the earthquake summary information, for immediate consumption.

USGS twoPAGER

twoPAGER Distribution:

- Following the initial distribution of the PAGER, USGS may distribute a "twoPAGER".
- The twoPAGER report will supplement the standard onePAGER alerts for significant domestic earthquakes (for any events likely to have caused fatalities; or, PAGER's **orange** alert level or higher, signifying more than US$100M in estimated damage).
- As soon as Hazus runs are completed and reviewed, the second alert page will be created with comprehensive Hazus loss model results. Including estimates of:
    - Affected population
    - Economic impact
    - Non-fatal injuries
    - Displaced households
    - Damage to structures
    - Post-earthquake safety tagging needs

The USGS twoPAGER consists of the PAGER plus the Hazus-PAGER. The top portion depicts PAGER loss model estimates and the lower portion presents Hazus loss model estimates. The alert level color-coded arrow connects the loss models, allowing for PAGER/Hazus economic loss model comparison. Example below.

Content of the twoPAGER

A **Summary of the basic earthquake parameters**, including origin time, local time, magnitude, hypocenter, and the name of the region where the earthquake took place. For events with high likelihood of a tsunami, a link to the NOAA tsunami Web page is provided (bold red text).

B **PAGER Earthquake Impact Scale summary alert level**. The higher of the two PAGER alert levels is shown as the summary alert at the top-center of the page.

C **The version of the PAGER alert and the time the alert was created**. New versions of the alert are generated when the earthquake information is improved as supplemental ground-shaking constraints become available.

D **PAGER alert level information** for fatalities (left) and economic losses (right). Text (center) clarifies the nature of the alert based on experience from past earthquakes.

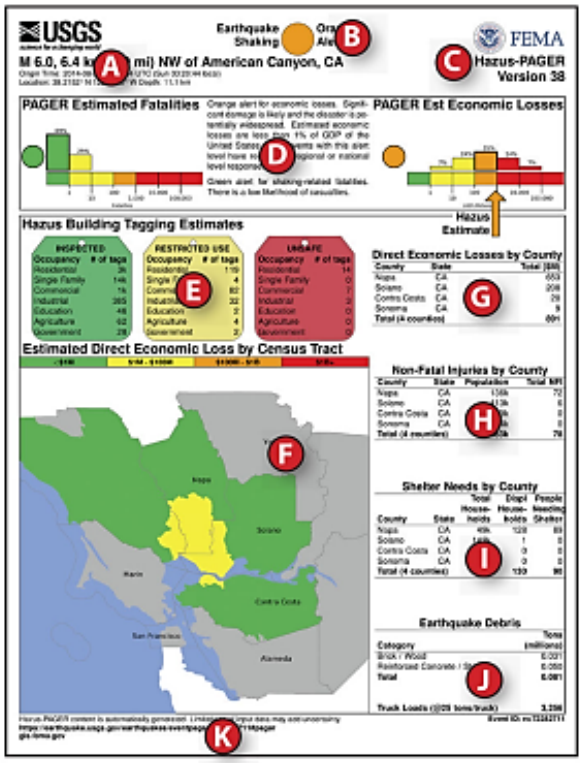
E **Distribution of buildings by Hazus occupancy type and tag color**. (Left / Green) The total number of buildings in the counties nearest to the epicenter based on their occupancy type. (Center / Yellow) Number of buildings with extensive damage, "yellow tagged". (Right / Red) Number of buildings with complete damage (collapsed), "red tagged".

F **Map of estimated direct economic losses by Census Tract**, color-coded in ranges of millions of Dollars (see legend above the map for loss ranges). Census Tract boundaries are not shown. Thin black lines deliniate County boundaries, thick black lines deliniate State boundaries.

G **Table of Hazus-estimated total direct economic losses** in millions of dollars for seven counties with the highest estimated losses. Losses are only given when available; nearby counties where Hazus losses were not calculated will show losses as --.

H **Table of Hazus-estimated non-fatal injuries** for seven counties with the highest estimated losses. Losses are only given when available; nearby counties where Hazus losses were not calculated will show losses as --.

I **Table of Hazus-estimated shelter needs by county**, given as number of displaced households and number of people needing shelter for seven counties with the highest estimated losses. Losses are only given when available; nearby counties where Hazus losses were not calculated will show losses as --.



J **Table of Hazus-estimated debris** in millions of tons by material type and total number of truck loads.

K **Footer**, including a link to the PAGER Web page, the USGS event-identification number, and a disclaimer noting that the content was automatically generated and has additional sources of uncertainty. All possible uncertainties are not considered in the determination of estimated losses; the actual impact of the earthquake may differ from the PAGER and Hazus automatically generated estimates. For events with high likelihood of a tsunami, a link to the NOAA tsunami Web page is provided (bold red text).

Example PAGER *for a M7.1 scenario modeled after the 1886 Charleston, South Carolina, earthquake.*

USGS science for a changing world

Earthquake Shaking — Red Alert

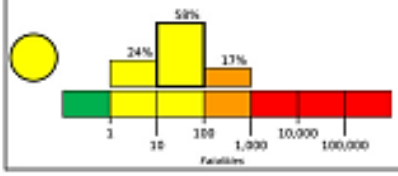
GSN ANSS USAID FROM THE AMERICAN PEOPLE

M 7.1, Scenario Charleston fit

Origin Time: 2017-05-12 18:52:32 UTC (Fri 14:52:32 local)
Location: 33.0286° N 80.1912° W Depth: 20.2 km

PAGER Version 1

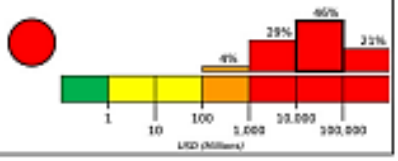
Estimated Fatalities



Red alert for economic losses. Extensive damage is probable and the disaster is likely widespread. Estimated economic losses are less than 1% of GDP of the United States. Past events with this alert level have required a national or international level response.

Yellow alert for shaking-related fatalities. Some casualties are possible.

Estimated Economic Losses

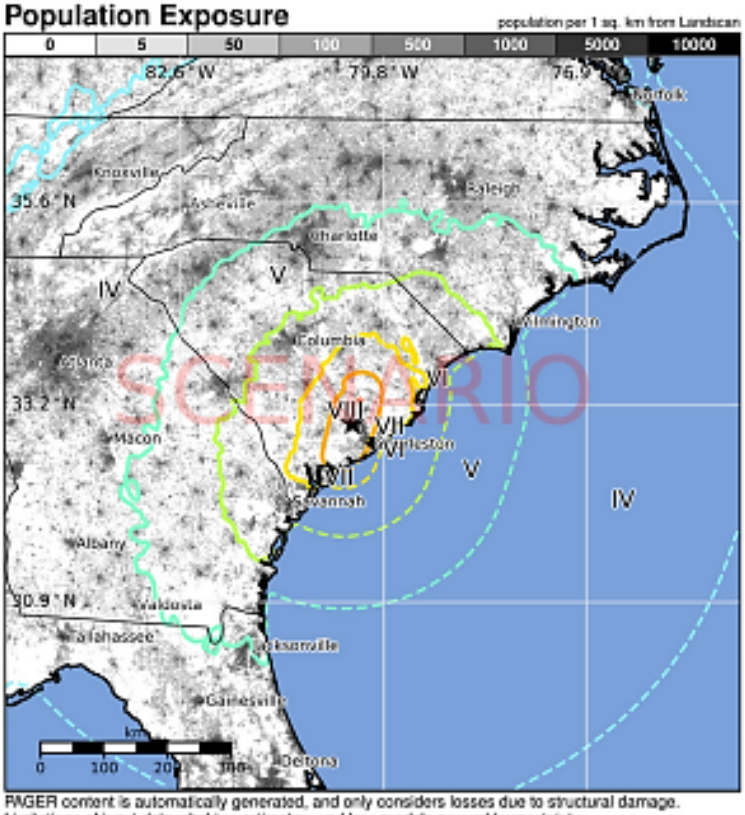


Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k=x1000)		–*	333k*	26,885k*	7,175k	2,595k	627k	531k	37k	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	None	None	None	V. Light	Light	Moderate	Mod./Heavy	Heavy	V. Heavy
	Vulnerable Structures	None	None	None	Light	Moderate	Mod./Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure



Structures

Overall, the population in this region resides in structures that are resistant to earthquake shaking, though vulnerable structures exist. The predominant vulnerable building types are unreinforced brick masonry and reinforced masonry construction.

Historical Earthquakes

Date (UTC)	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
1974-09-02	232	4.9	V(12k)	–
1974-11-22	14	4.7	V(18k)	–

Selected City Exposure

from GeoNames.org

MMI	City	Population
IX	Centerville	5k
IX	Lincolnville	1k
IX	Summerville	43k
VIII	Meggett	1k
VIII	Hollywood	5k
VIII	Sangaree	8k
VI	**Columbia**	**129k**
IV	**Raleigh**	**404k**
IV	**Atlanta**	**420k**
IV	**Tallahassee**	**181k**
IV	Richmond	204k

bold cities appear on map. (k = x1000)

PAGER content is automatically generated, and only considers losses due to structural damage. Limitations of input data, shaking estimates, and loss models may add uncertainty.
http://earthquake.usgs.gov/data/pager/

Event ID: usaceus.0.37.m7p1.se

Example twoPAGER (*second page) for a M7.1 scenario modeled after the 1886 Charleston, South Carolina, earthquake.*

USGS science for a changing world

Earthquake Shaking — Red Alert

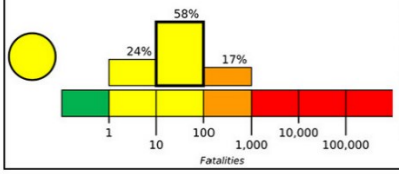
FEMA

M 7.1, Scenario Charleston flt

Origin Time: 2017-05-12 18:52:32 UTC (Fri 14:52:32 local)
Location: 33.0286° N 80.1912° W Depth: 20.2 km

Hazus-PAGER Version 1

PAGER Estimated Fatalities



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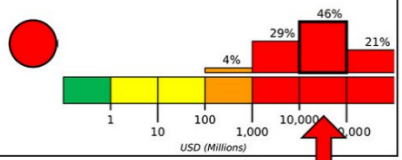
PAGER Est Economic Losses



Hazus Estimate

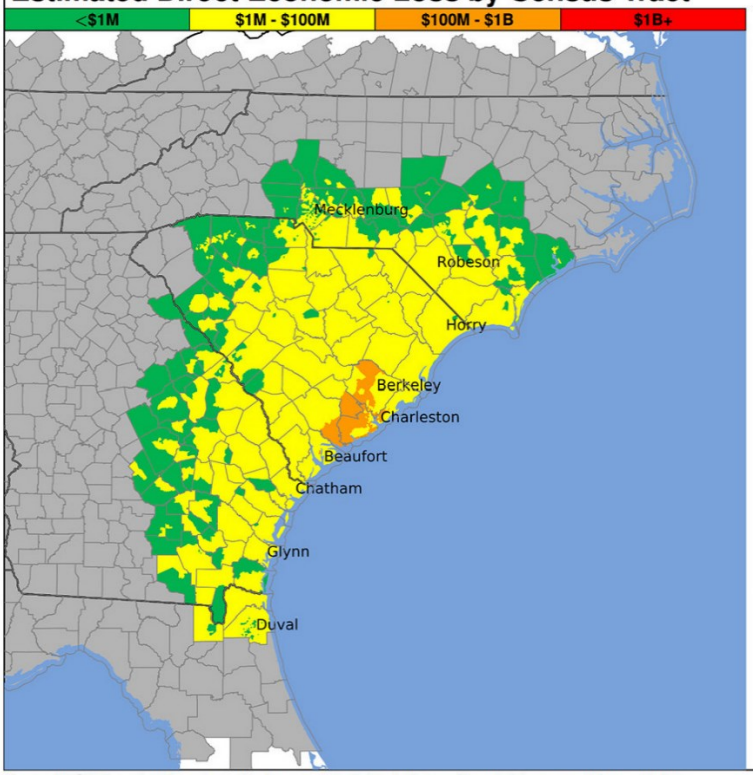
Hazus Building Tagging Estimates

INSPECTED	
Occupancy	# of tags
Residential	179k
Single Family	323k
Commercial	29k
Industrial	7k
Education	1k
Agriculture	2k
Government	953

RESTRICTED USE	
Occupancy	# of tags
Residential	29k
Single Family	28k
Commercial	5k
Industrial	1k
Education	203
Agriculture	279
Government	171

UNSAFE	
Occupancy	# of tags
Residential	16k
Single Family	10k
Commercial	3k
Industrial	1k
Education	139
Agriculture	154
Government	106

Estimated Direct Economic Loss by Census Tract



Direct Economic Losses by County

County	State	Total ($M)
Charleston	SC	10,778
Dorchester	SC	7,058
Berkeley	SC	5,897
Beaufort	SC	1,218
Horry	SC	817
Chatham	GA	758
Richland	SC	534
Total (122 counties)		**33,741**

Non-Fatal Injuries by County

County	State	Population	Total NFI
Charleston	SC	350k	4k
Dorchester	SC	137k	4k
Berkeley	SC	178k	4k
Beaufort	SC	162k	290
Horry	SC	269k	181
Chatham	GA	265k	151
Richland	SC	385k	110
Total (122 counties)		**10,877k**	**15k**

Shelter Needs by County

County	State	Total House-holds	Displ House-holds	People Needing Shelter
Charleston	SC	144k	13k	8k
Dorchester	SC	50k	10k	6k
Berkeley	SC	65k	7k	5k
Beaufort	SC	65k	685	423
Horry	SC	112k	595	344
Chatham	GA	103k	527	380
Richland	SC	145k	330	236
Total (122 counties)		**4,190k**	**35k**	**23k**

Earthquake Debris

Category	Tons (millions)
Brick / Wood	5.065
Reinforced Concrete / Steel	5.000
Total	**10.065**
Truck Loads (@25 tons/truck)	**402,603**

Hazus-PAGER content is automatically generated. Limitations of input data may add uncertainty.
http://earthquake.usgs.gov/data/pager/
gis.fema.gov

Event ID: usceus_0_37_m7p1_se