UNDERSTANDING EARTHQUAKE HAZARDS IN WASHINGTON STATE

Modeling a Magnitude 6.8 Earthquake on the Hite Fault Zone in Walla Walla County

Geologic Description

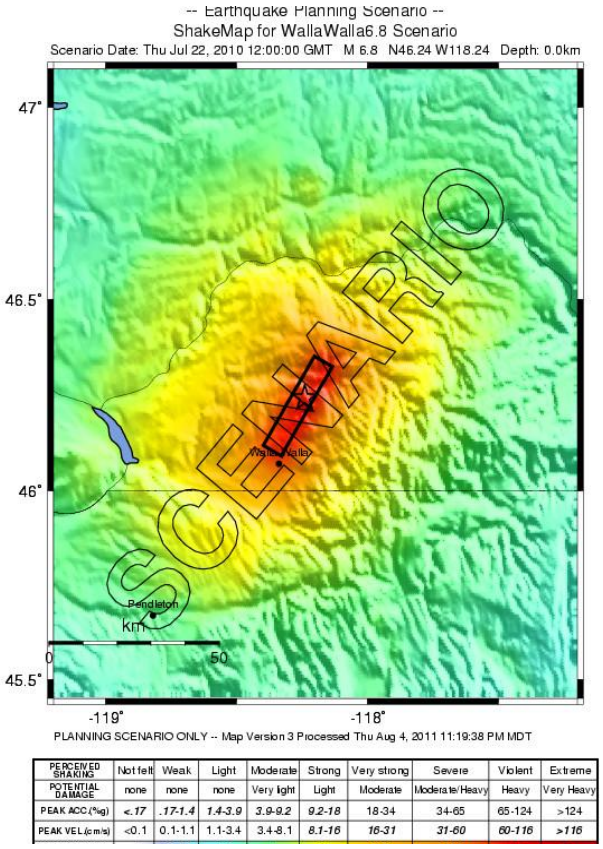
The M6.8 scenario earthquake for the region of Walla Walla is based on an approximately 30 kilometer (19 mile)-long rupture on the Hite fault system. The Hite fault system is a zone of faults that parallels the northeast-trending flank of the Blue Mountains in Oregon and Washington. This fault system is thought to be the suture between the stable North American craton to the east and accreted terranes to the west. The fault zone is about 1.5 kilometers (1mile) wide and consists of fault strands with normal, left-lateral, and right-lateral strike-slip motion. No evidence for Quaternary or recent activity on the Hite fault exists at this time. No detailed fault-slip data exist for the Hite fault.

Type of Earthquake

Most earthquake hazards result from ground shaking caused by seismic waves that radiate out from a fault when it ruptures. Seismic waves transmit the energy released by the earthquake: The bigger the quake, the larger the waves and the longer they last. Several factors affect the strength, duration, and pattern of shaking:

- The type of rock and sediment layers that the waves travel through.
- The dimensions and orientation of the fault and the characteristics of rapid slippage along it during an earthquake.
- How close the rupture is to the surface of the ground.

Deep vs. Shallow: The M6.8 scenario earthquake modeled for the Hite fault zone is a shallow or crustal earthquake. Shallow quakes tend to be much more damaging than deep quakes of comparable magnitude (such as the deep M6.8 Nisqually earthquake in 2001). This is primarily because in deeper quakes, the seismic waves have lost more energy by the time they reach the surface.



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

Figure 1. ShakeMap for a M6.8 earthquake on the Hite fault zone near Walla Walla, Washington. The black polygon is the modeled fault rupture surface.

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Aftershocks: Unlike deep earthquakes, which usually produce few or no aftershocks strong enough to be felt, a M6.8 shallow earthquake like the one in the Walla Walla (Hite fault) scenario may be followed by numerous aftershocks, a few of which could be large enough to cause additional damage.

Other Earthquake Effects

Liquefaction: If sediments (loose soils consisting of silt, sand, or gravel) are water-saturated, strong shaking can disrupt the grain-to-grain contacts, causing the sediment to lose its strength. Increased pressure on the water between the grains can sometimes produce small geyser-like eruptions of water and sediment called *sand blows*. Sediment in this condition is liquefied and behaves as a fluid. Buildings on such soils can sink and topple, and foundations can lose strength, resulting in severe damage or structural collapse. Pipes, tanks, and other structures that are buried in liquefied soils will float upwards to the surface.

Artificial fills, tidal flats, and stream sediments are often poorly consolidated and tend to have high liquefaction potential. For example, in the Walla Walla (Hite fault) scenario, the liquefaction susceptibility of the floor of the Touchet River valley and of the land on either side of the Walla Walla River (as well as many of its tributaries) is rated moderate to high.

Landslides: Earthquake shaking may cause landslides on slopes, particularly where the ground is saturated with water or has been modified (for example, by the removal of stabilizing vegetation). Steeper slopes are most susceptible, but old, deep-seated landslides may be reactivated, even where gradients are as low as 15%. Catastrophic debris flows can move water-saturated materials rapidly and for long distances, mostly in mountainous regions. Underwater slides are also possible, such as around river deltas.

BE PREPARED WHEREVER YOU ARE: **Develop a plan and a disaster supply kit. When you're prepared, you feel more in control and better able to keep yourself and your family safe.**
LEARN MORE ABOUT WHAT YOU CAN DO: **www.emd.wa.gov**

Figure 2. Historic buildings in Seattle's Pioneer Square suffered significant damage during the M6.8 Nisqually earthquake in 2001. (Photo: FEMA/Kevin Galvin)

Hazus Results for the Walla Walla (Hite Fault) Scenario

Hazus is a nationally applicable standardized methodology developed by FEMA to help planners estimate potential losses from earthquakes. Local, state, and regional officials can use such estimates to plan risk-reduction efforts and prepare for emergency response and recovery.

Hazus was used to estimate the losses that could result from a M6.8 scenario earthquake on the Hite fault zone in the southeastern quarter of Walla Walla County. Such an event is expected to impact ten counties in Washington, with the most significant effects in Walla Walla County.

Injuries: Injuries are most likely in Walla Walla County, and this county alone accounts for the majority of the scenario's injuries and estimated casualties. While most of the injuries will not be life-threatening, many will require hospitalization and at least several dozen may be life-threatening if not treated promptly. Some fatalities are also expected, possibly as many as 50. The number of injuries and fatalities tends to be higher if an earthquake occurs during or at the end of the business day.

Damage: The earthquake is expected to damage buildings in all of the surrounding counties, although for some counties (such as Garfield and Whitman), the damage is anticipated to be slight. Walla Walla County will have the highest number of damaged buildings (over 16,000). Of these, more than 2,600 may be extensively damaged and more than 1,300 could suffer collapse or be in danger of collapsing (complete damage). While damage to most buildings in Columbia and Franklin counties will be slight to moderate, extensive damage is expected in some cases (primarily in Columbia County). Most of the damaged buildings will be residential or commercial structures, although other types of buildings, such as industrial facilities, will also be affected.

Economic Losses Due to Damage: Capital stock losses are the direct economic losses associated with damage to buildings, including the cost of structural and non-structural damage, damage to contents, and loss of inventory. Walla Walla County accounts for the largest portion of the capital stock loss estimate (over $833 million).

WALLA WALLA (HITE FAULT) SCENARIO EARTHQUAKE	
End-to-end length of fault (kilometers)	31
Magnitude (M) of scenario earthquake	6.8
Number of counties impacted	10
Total injuries (*severity 1, 2, 3, 4) at 2:00 PM	795
Total number of buildings extensively damaged	2,700
Total number of buildings completely damaged	1,354
Income losses in millions	$265
Displaced households	1,321
People requiring shelter (individuals)	1,011
Capital stock losses in millions	$856
Debris total in millions of tons	0.49
Truckloads of debris (25 tons per truckload)	19,480
Households without power (Day 1)	1,743
Households without potable water (Day 1)	19,321

Table 1. Summary of significant losses in the M6.8 Walla Walla (Hite fault) earthquake scenario. Among the counties likely to be affected are Walla Walla, Columbia, Franklin, Benton, Garfield, and Whitman.

***Injury severity levels: 1—requires medical attention, but not hospitalization; 2—not life-threatening, but does require hospitalization; 3—hospitalization required; may be life-threatening if not treated promptly; 4—victims are killed by the earthquake**

Income losses, including wage losses and loss of rental income due to damaged buildings, are also highest in Walla Walla County (over $261 million).

Impact on Households and Schools: Walla Walla County accounts for nearly all of the estimated displaced households and individuals in need of shelter. Schools in Walla Walla County will be only 42% functional on Day 1 following the earthquake.

Debris Removal: Following an earthquake, debris consisting of brick, wood, concrete, and steel must be removed and disposed of. Most of this will come from Walla Walla County (about 482,000 tons).

Estimates vs. Actual Damage: Although this M6.8 earthquake scenario was modeled using the best scientific information available, it represents a simplified version of expected ground motions. The damage resulting from an actual earthquake of similar magnitude is likely to be even more variable

and will depend on the specific characteristics and environment of each affected structure.

Other Tools: Community planners can also look at how a large earthquake may impact local resources and people's lives and livelihoods. The following graphs illustrate variations in such impacts: The first shows the levels of shaking that residents are likely to experience; the second shows the possible impact on different services and business sectors. Note that in Benton and Franklin counties, the largest number of residents will be exposed to less severe (MMI V) shaking, whereas residents of Walla Walla and Columbia counties, although fewer in number, will experience more intense ground motions.

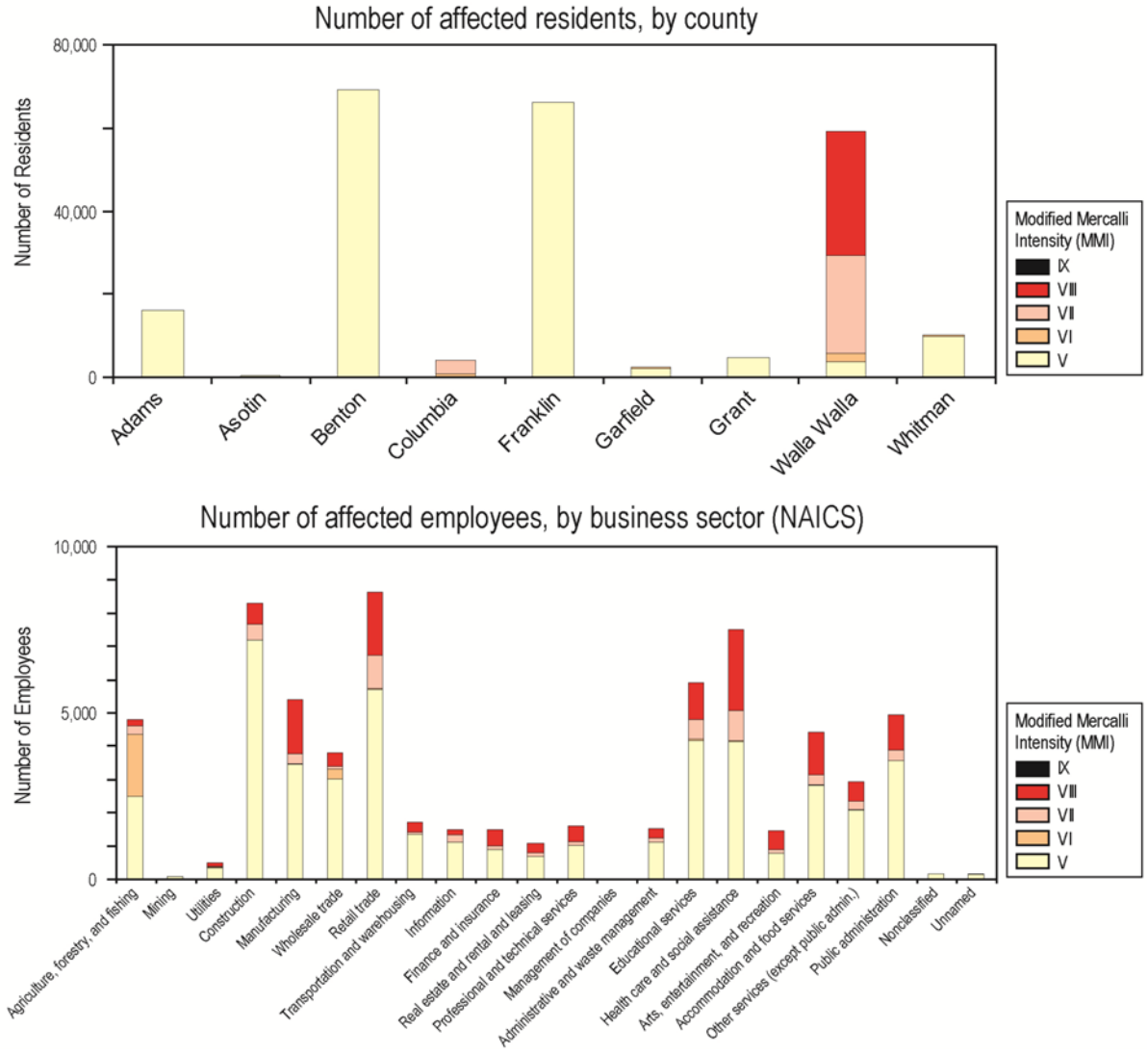

Figure 3. Number of residents and employees affected by the M6.8 earthquake projected for the Hite fault. The Modified Mercalli Intensity (MMI) classes indicate peak ground acceleration (PGA) values and the impact of the shaking.

V. Rather Strong (PGA 3.9–9.2 *g*)	Felt outside by most. Dishes and windows may break. Large bells ring. Vibrations like large train passing close to house.
VI. Strong (PGA 9.2–18 *g*)	Felt by all; people walk unsteadily. Many frightened and run outdoors. Windows, dishes, glassware broken. Books fall off shelves. Some heavy furniture moved or overturned. Cases of fallen plaster. Damage slight.
VII. Very Strong (PGA 18–34 *g*)	Difficult to stand. Furniture broken. Damage negligible in buildings of good design & construction; slight-moderate in other well-built structures; considerable in poorly built/badly designed structures. Some chimneys broken.
VIII. Destructive (PGA 34–65 *g*)	Damage slight in specially designed structures; considerable in ordinary substantial buildings (partial collapse); great in poorly built structures. Fall of chimneys, factory stacks, columns, walls. Heavy furniture moved.
IX. Violent (PGA 65–124 *g*)	General panic; damage considerable in specially designed structures; well designed frame structures thrown out of plumb. Damage great in substantial buildings: partial collapse. Buildings shifted off foundations.