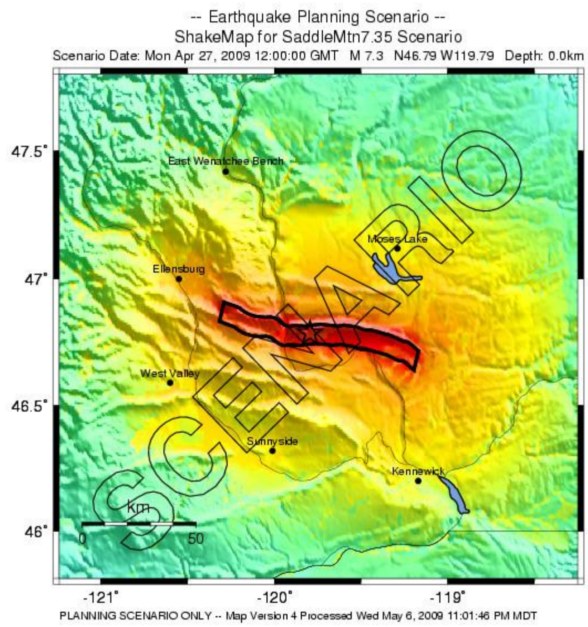
# Modeling a Magnitude 7.4 Earthquake on the Saddle Mountain Fault Zone in South-Central Washington

## Geologic Description

The M7.4 earthquake scenario on the Saddle Mountain fault zone is modeled on a 100 kilometer (62 mile)-long rupture on the Saddle Mountain fault. This fault is an east–west-trending thrust fault mapped along the northern flank of Saddle Mountain, an anticline in the northern part of the Yakima fold and thrust belt. This fold and thrust belt is a structure-tectonic province of the Columbia Basin province and formed as the result of generally north–south contraction. The Yakima fold and thrust belt is a series of generally east–west trending anticlinal ridges and synclinal valleys.

Folding and faulting in the Yakima fold and thrust belt deforms middle to late Miocene Columbia River basalts and late Miocene to Pliocene sediments on top of the basalts, suggesting that deformation began in the mid-late Miocene or younger. The Saddle Mountain fault is a south-dipping thrust fault that cuts the north limb of the Saddle Mountain anticline. Recent deformation is documented along the fault in the Smyrna Bench area. Evidence for Quaternary faulting includes late Pleistocene to Holocene faulting along a graben adjacent to the Saddle Mountain fault and beheaded streams, suggesting recent movement. Geologists have found 6.5 meters (21 feet) of displacement across a fault in the last 40,000 to 20,000 years, yielding a slip rate of 0.16 to 0.33 millimeters per year.




| 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+ |

**Figure 1. ShakeMap for a M7.4 earthquake on the Saddle Mountain fault. The black polygon is the modeled fault rupture for this scenario.**

## 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.

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***Deep vs. Shallow:*** The M7.4 scenario earthquake modeled for the Saddle Mountain 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 earthquakes, the seismic waves have lost more energy by the time they reach the surface.

***Aftershocks:*** Unlike deep earthquakes, which usually produce few or no aftershocks strong enough to be felt, a M7.4 shallow earthquake like the one in this scenario would likely be followed by many 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 Saddle Mountain scenario, the liquefaction susceptibility of the land on either side of the Yakima River and in the Cold Creek Valley is rated moderate to high.

***Landslides:*** Earthquake shaking may cause landslides on slopes, particularly where the ground is water-saturated 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.

**Figure 2. This road failure at Sunset Lake in Tumwater, Washington was caused by the M6.8 Nisqually earthquake in 2001. (Photo: Steven Kramer, University of Washington)**

***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:***
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## Hazus Results for the Saddle Mountain 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 M7.4 scenario earthquake on the Saddle Mountain fault zone, which crosses portions of Kittitas, Grant, Adams, and Franklin counties. Such an event is expected to impact ten counties in Washington, with the most significant effects apparent in Grant County, followed by Yakima, Kittitas, Benton, and Franklin.

***Injuries:*** The number of people injured in this scenario will likely be highest in Grant County, but dozens of injuries are expected in Kittitas, Yakima, Franklin, and Benton counties. Although many of these injuries will not be life-threatening, some will require hospitalization. Serious injuries are expected in Grant, Kittitas, and Franklin counties; some fatalities are likely in Grant and Kittitas. Serious injuries and fatalities are more likely if a quake occurs during or at the end of the business day.

***Damage:*** Thousands of buildings in Yakima, Grant, Benton, Kittitas, and Franklin counties will be damaged. Much of the damage will be slight to moderate, but extensive damage is also expected, particularly in Grant, Kittitas, Yakima, and Franklin counties. In Grant County, nearly 700 buildings are expected to collapse or to be in danger of collapse (complete damage). Most of the damaged buildings will be residential, but the number of commercial and industrial structures will also be high. Many unreinforced masonry buildings will experience partial or complete collapse.

***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. Grant and Yakima counties account for the largest portion of the capital stock loss estimate (over $341 million), followed by Benton ($75 million) and Kittitas (over $74 million).

| *Saddle Mountain Scenario Earthquake* | |
|---|---|
| End-to-end length of fault (kilometers) | 87 |
| Magnitude (M) of scenario earthquake | 7.4 |
| Number of counties impacted | 10 |
| Total injuries (*severity 1, 2, 3, 4) at 2:00 PM | 278 |
| Total number of buildings extensively damaged | 2,520 |
| Total number of buildings completely damaged | 832 |
| Income losses in millions | $146 |
| Displaced households | 405 |
| People requiring shelter (individuals) | 396 |
| Capital stock losses in millions | $590 |
| Debris total in millions of tons | 0.27 |
| Truckloads of debris (25 tons per truckload) | 10,760 |
| People without power (Day 1) | 4,382 |
| People without potable water (Day 1) | 1,533 |

**Table 1. Summary of significant losses in the M7.4 Saddle Mountain earthquake scenario. The counties most likely to be affected are Benton, Franklin, Grant, Kittitas, Lincoln, Walla Walla, and Yakima.**

***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 Grant County (over $45 million) and Yakima County (about $40 million).

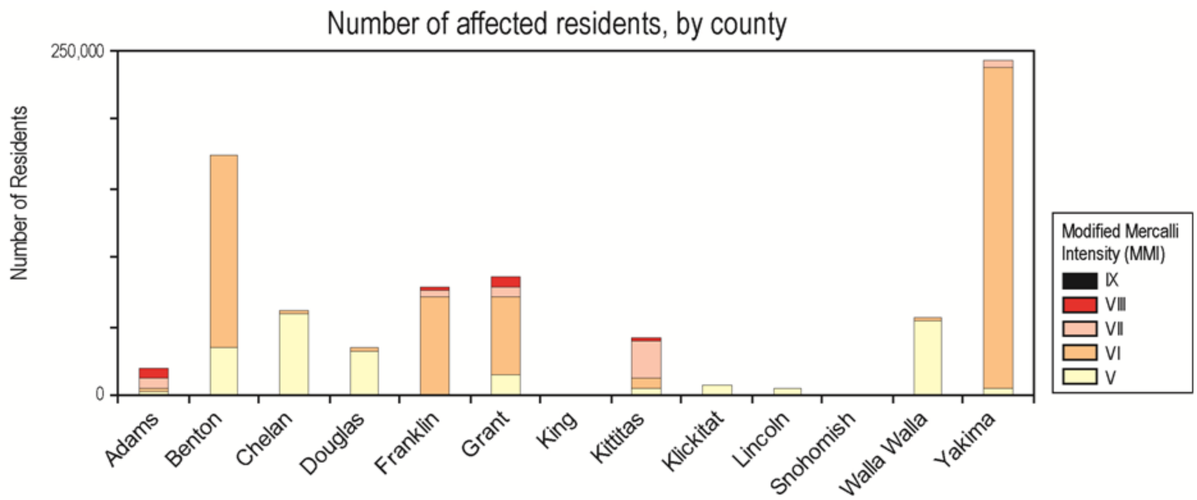
***Impact on Households and Schools:*** The number of people without power or water will be highest in Grant and Kittitas counties. These counties also account for many of the displaced households and individuals in need of shelter. The functionality of schools in Grant and Kittitas will also be affected.

***Debris Removal:*** Following an earthquake, debris (brick, wood, concrete, and steel) must be removed and disposed of. Much of this will come from Grant, Yakima, and Kittitas counties (about 211,000 tons).

***Estimates vs. Actual Damage:*** Although this M7.4 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 potential impacts on different services and business sectors. In Yakima and Benton counties, a greater number of residents will be exposed to strong shaking; Grant, Adams, Kittitas, and Franklin counties, although less populated, will experience more intense ground motions.



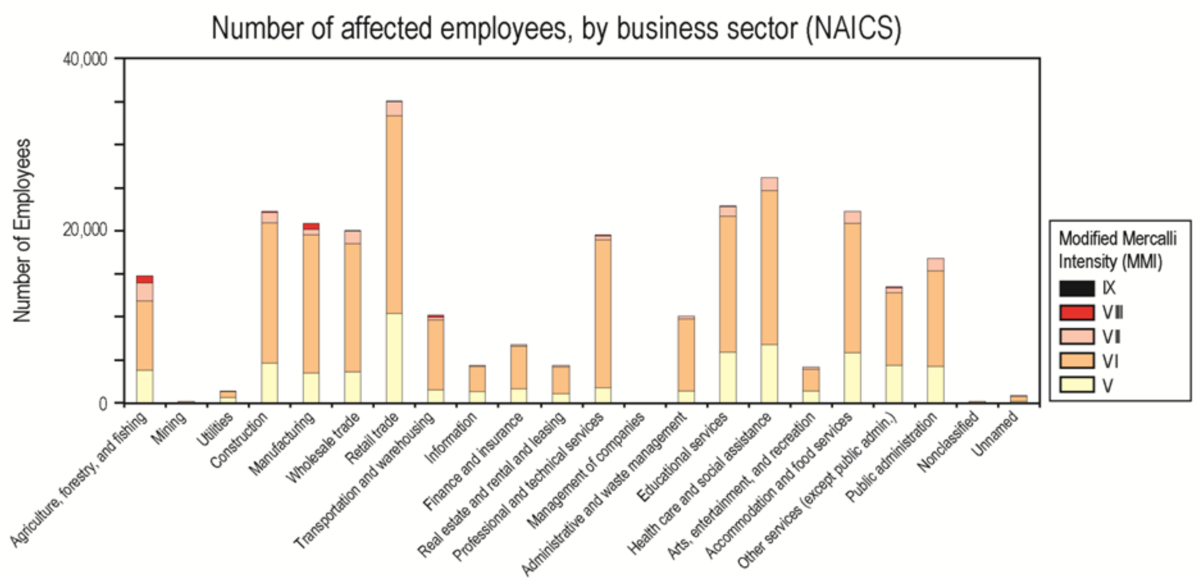




**Figure 3. Number of residents and employees affected by the M7.4 quake projected for the Saddle Mountain fault zone. Modified Mercalli Intensity (MMI) classes indicate peak ground acceleration (PGA) values and the impact of the shaking.**

| | |
|---|---|
| **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. |