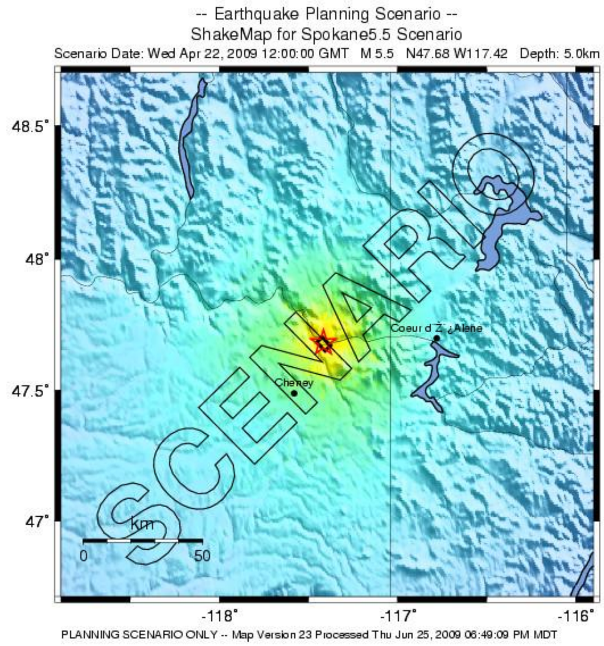
Modeling a Magnitude 5.5 Earthquake on the Latah Fault Zone in Spokane County

Geologic Description

The Spokane scenario is modeled using a M5.5 earthquake on the Latah fault. The Latah fault is inferred to follow a northwest–southeast (almost due north–south) topographic lineament along the modern courses of Hangman Creek and the Spokane River near Spokane. The fault was mapped using topographic lineaments and stratigraphic mismatches across the Hangman Creek watershed. East of the fault, thick deposits of late Miocene Latah Formation with thinner channel fill and invasive flows of Grande Ronde Basalt of the Columbia River Basalt Group (CRBG) are mapped. West of the fault, typical 30 meter (19 foot)-thick flows of Grande Ronde Basalt are intercalated with thin layers of Latah Formation on volcaniclastic sediment. Flows of the Priest Rapids Member of the Wanapum Basalt (CRBG) overlie both units on either side of the fault and do not exhibit appreciable offset, suggesting that most movement on the Latah fault occurred prior to the eruption of the Priest Rapids flows about 14.3 million years ago. No paleoseismology or slip-rate information exists for this fault.



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 M5.5 earthquake on the Latah fault near Spokane.

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 M5.5 scenario earthquake modeled for the Latah fault is a shallow or crustal earthquake. Shallow earthquakes tend to be much more damaging than deep earthquakes of comparable magnitude (such as the deep M6.8 Nisqually earthquake in 2001). This is primarily

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because in deeper quakes, 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 M5.5 shallow earthquake like the one in this scenario will likely 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 Latah fault scenario, the liquefaction susceptibility of the land on either side of some parts of the Spokane and Little Spokane rivers 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. One of many chimneys in Olympia, Washington, that collapsed during the M6.8 Nisqually earthquake in 2001.

(Photo: Karl Wegmann, Washington State Department of Natural Resources)

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Hazus Results for the Spokane (Latah 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 M5.5 scenario earthquake on the Latah fault in Spokane County. Such an event is expected to impact six counties in Washington, with the most significant effects apparent in Spokane County.

Injuries: Injuries are most likely in Spokane County, where several dozen injuries are expected. Most will not be serious enough to require hospitalization. The number of injuries will be higher if the earthquake occurs during the afternoon, when people are at work and children in school, or at the end of the business day.

Damage: The earthquake is expected to cause slight damage to buildings in some surrounding counties (such as Stevens County). Damage to the contents and non-structural elements of buildings is also anticipated (such as in Pend Oreille County).

Buildings in Spokane County will suffer the most damage in this scenario. More than 15,000 buildings in Spokane County are expected to sustain some damage. In most cases, the damage will be slight to moderate, but for several dozen buildings, the damage is likely to be extensive. Most of these damaged buildings will be residential or commercial, although other categories of buildings, such as industrial facilities, will also be affected. Many unreinforced masonry and non-ductile concrete 'tilt up' buildings will likely sustain extensive damage or experience 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. Spokane County accounts for the largest portion of the capital stock loss estimate (nearly $361 million).

SPOKANE (LATAH FAULT) SCENARIO EARTHQUAKE	
End-to-end length of fault (kilometers)	5
Magnitude (M) of scenario earthquake	5.5
Number of counties impacted	6
Total injuries (*severity 1, 2, 3, 4) at 2:00 PM	34
Total number of buildings extensively damaged	36
Income losses in millions	$28
Capital stock losses in millions	$361
Debris total in millions of tons	0.04
Truckloads of debris (25 tons per truckload)	1,560

Table 1. Summary of significant losses in the M5.5 Spokane (Latah fault) earthquake scenario. The counties most likely to be affected are Adams, Ferry, Pend Oreille, Spokane, Stevens, 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**

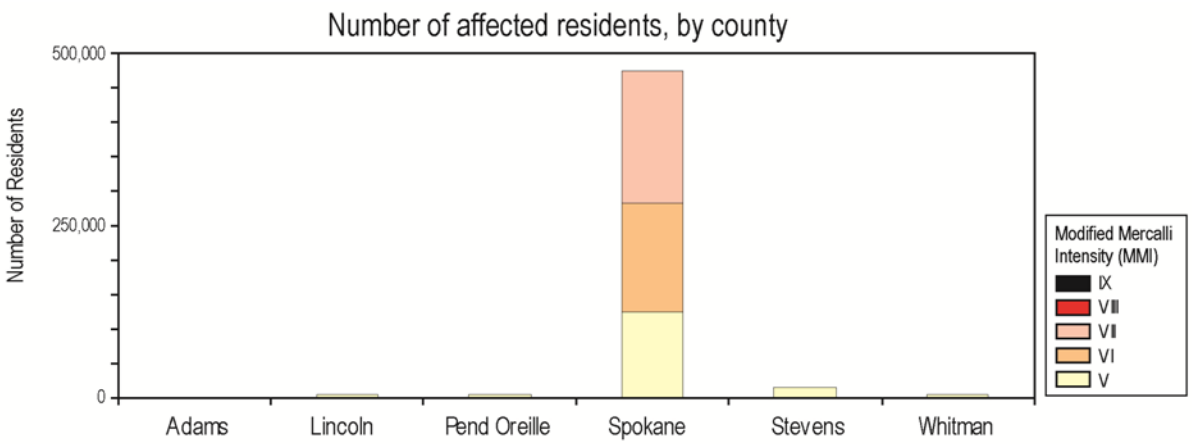
Income losses, including wage losses and loss of rental income due to damaged buildings, are also highest in Spokane County (over $28 million).

Impact on Households and Schools: Spokane County accounts for all of the estimated displaced households and individuals in need of shelter. Schools in Spokane County may lose some functionality on Day 1 following the earthquake, but the overall impact on schools is not expected to be significant.

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 Spokane County (about 40,000 tons).

Estimates vs. Actual Damage: Although this M5.5 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 is likely to 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 even where structural damage to buildings is slight, the shaking may be strong enough to damage furnishings and inventories.



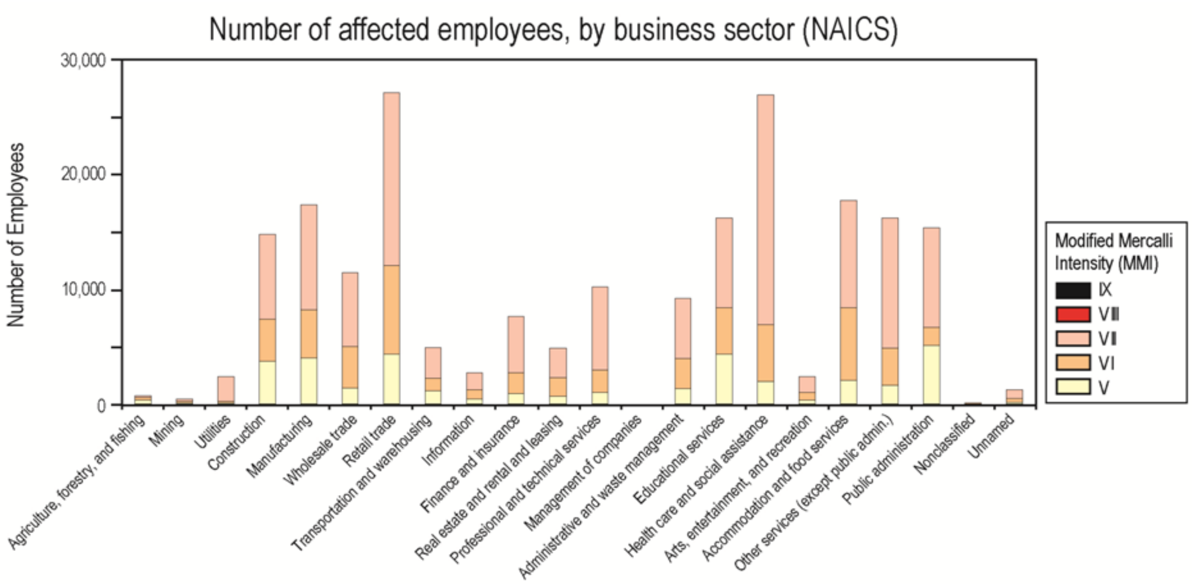


Figure 3. Number of residents and employees affected by the M5.5 earthquake projected for the Latah fault. The Modified Mercalli Intensity (MMI) classes indicate peak ground acceleration (PGA) values and the impact of the shaking.

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.