3.6 Risk Assessment: Earthquake

Description

The location of an earthquake is commonly described by its focal depth and the geographic position of its epicenter. The focal depth of an earthquake is the depth from the Earth's surface to the region where an earthquake's energy originates, also called the focus or hypocenter. The epicenter of an earthquake is the point on the Earth's surface directly above the hypocenter (Shedlock and Pakiser 1997). Earthquakes usually occur without warning and their effects can impact areas of great distance from the epicenter (FEMA 2001).

Figure 3.6.A. Earthquake Damage to the Custer Hotel in Mackay, 1983

Source: Idaho Geological Survey 2009

Idaho's earthquakes result from three causes:

- Plate Tectonics
- Crustal Stretching
- Hotspot/Volcanic Activity

The surface of the earth (the crust) is made up of large masses, referred to as tectonic plates. Many of the world's earthquakes result from forces along the margins of these tectonic plates. These earthquakes occur when pressure resulting from these forces is released in a sudden burst of motion. Such earthquakes are produced in coastal California, Oregon, and Washington. The largest of these distant events may be felt in Idaho.

However, most earthquakes in Idaho have origins (the epicenter) far from plate boundaries. Much of the earth's crust in southern and central Idaho has undergone tremendous stretching, resulting in parallel, linear mountains and valleys. This region is called the Basin and Range and extends into the adjoining States of Montana, Utah, Wyoming, and Nevada. Basin and Range stretching is continuing today. Earthquakes from these crustal movements can also cause severe ground shaking in Idaho.

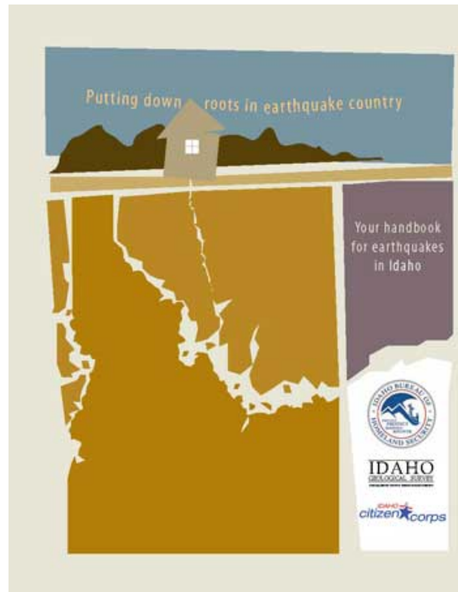
Finally, Idaho earthquakes may be associated with magmatic activity. This activity is associated with the "Yellowstone Hotspot." The hotspot is a conduit carrying molten rock (magma) from deep within the earth into the crust. Pressures within the hotspot zone lead to earthquakes. Although there are currently no surface releases of magma through volcanoes or volcanic vents, the hotspot is very seismically active. Dozens of small earthquakes are recorded in the Yellowstone region each month.

Earthquake Mechanics

Regardless of the source of the earthquake, the associated energy travels in waves radiating outward from the point of release. When these waves travel along the surface, the ground shakes and rolls, fractures form, and water waves may be generated. Earthquakes generally last a matter of seconds, but the waves will travel around the world in a matter of minutes and may cause damage elsewhere.

Breaks in the crust associated with seismic activity are known as "faults" and are classified as either active or inactive. Faults may be expressed on the surface by sharp cliffs or scarps or may be buried below surface deposits.

"Foreshocks" may occur months or minutes before the actual onset of an earthquake. Although smaller than the main shock, some foreshocks are large, damaging earthquakes. "Aftershocks," which range from minor to major, may occur for months after the main earthquake. In some cases, strong aftershocks may cause significant additional damage, especially if the initial earthquake affected emergency management and response functions or weakened structures.



An excellent source of additional information on the earthquake hazard in Idaho is the publication *Putting Down Roots in Earthquake Country*

http://www.idahogeology.org/uploads/Putting_Down_Roots_3_19_11.pdf

Idaho has active faults that have produced a number of historic earthquakes. These faults are classified as normal faults and were produced by Basin and Range stretching. The faults extend into the crust at dips of about 60 to 70 degrees. Earthquakes along the faults occur at depths of less than 35 kilometers. Seismologists term these shallow earthquakes.

Types of Damage

While damage can occur by movement at the fault, most damage from earthquake events is the result of shaking. Shaking also produces a number of phenomena that can generate additional damage:

- Ground displacement
- Landslides and avalanches
- Liquefaction and subsidence
- Seiches

Shaking: In minor events, objects fall from shelves and dishes are rattled. In major events, large structures may be torn apart by the forces of the seismic waves. In all but the largest quakes, structural damage is generally limited to older structures that are poorly maintained, constructed, or designed.

Unreinforced masonry buildings and wood frame homes not anchored to their foundations are typical victims. In areas of severe seismic shaking hazard, Intensity VII or higher can be experienced even on solid bedrock. In these areas, older buildings especially are at significant risk. Loose or poorly secured objects also pose a significant hazard when they are loosened or dropped by shaking. These "non-structural falling hazard" objects include bookcases, heavy wall hangings, and building facades. Home water heaters pose a special risk, due to their tendency to start fires when they topple over and rupture gas lines. Crumbling chimneys may also be responsible for injuries and property damage. Dam and bridge failures are significant risks during stronger earthquake events, and may result in considerable property damage and loss of life.

Ground Displacement: Often, the most dramatic evidence of an earthquake is the displacement of the ground along a fault line. The Borah Peak event created a surface fault nearly 22 miles long and generated a scarp face up to 9 feet high in certain locations. Utility lines and roads may be disrupted, but damage directly attributable to ground displacement is generally limited. In rare instances, structure located directly on the fault line may be destroyed by the displacement.

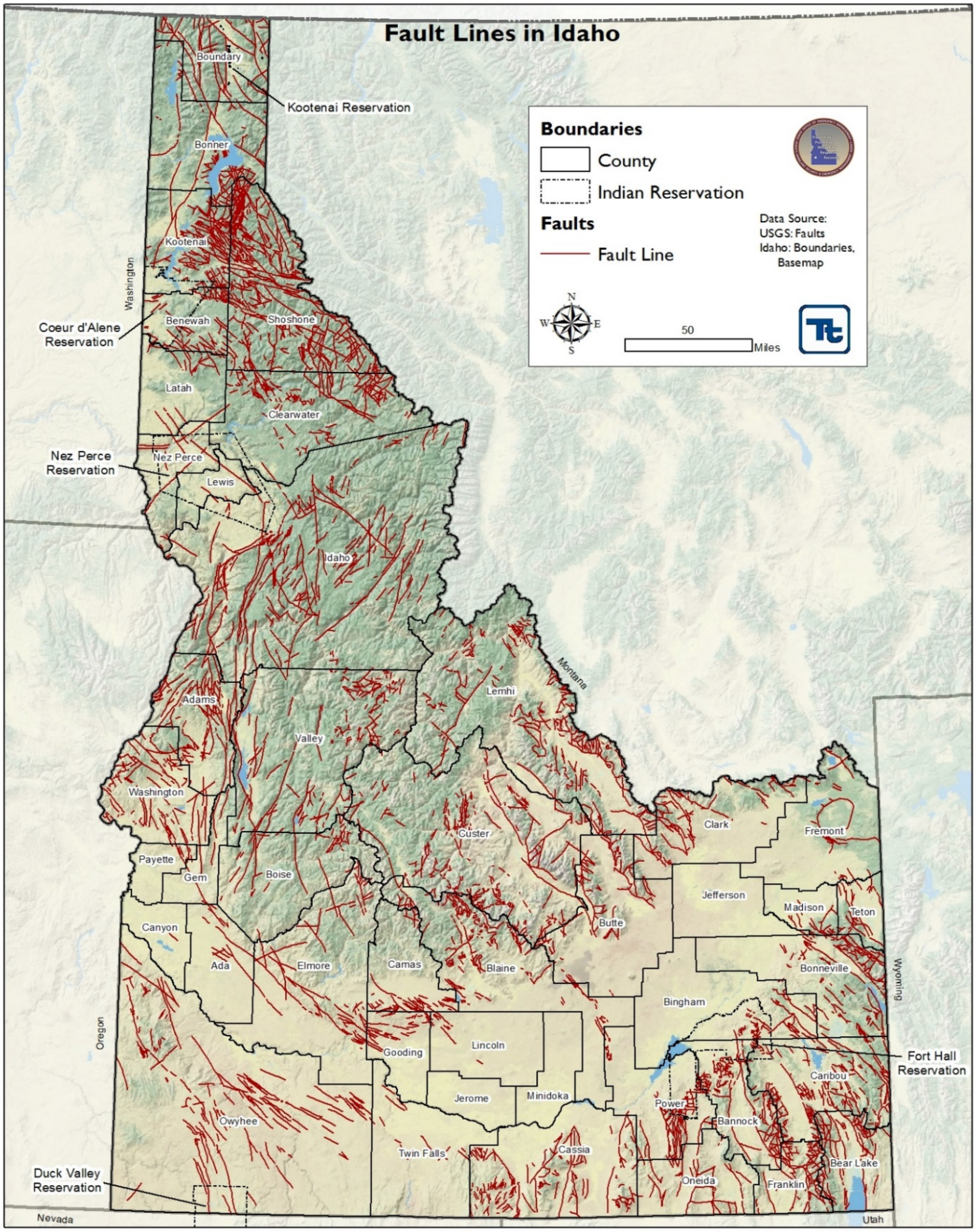
Landslides and Avalanches: Even small earthquake events can cause landslides. Rock falls are common as unstable material on steep slopes is shaken loose, but significant landslides or even debris flows can be generated if conditions are ripe. Roads may be blocked by landslide activity, hampering response and recovery operations. Avalanches are possible when the snowpack is sufficient.

Liquefaction and Subsidence: Soils may liquefy and/or subside when impacted by the seismic waves. Fill and previously saturated soils are especially at risk. The failure of the soils can lead to widespread structural damage. The oscillation and failure of the soils may result in increased water flow and/or failure of wells, as the subsurface flows are disrupted and sometimes permanently altered. Increased flows may be dramatic, resulting in geyser-like water spouts and/or flash floods. Similarly, septic systems may be damaged, creating both inconvenience and health concerns.

Seiches: Seismic waves may rock an enclosed body of water (e.g., a lake or reservoir), creating an oscillating wave referred to as a "seiche." Although not a common cause of damage in past Idaho earthquakes, there is a potential for large, forceful waves similar to a tsunami (tidal wave) to be generated on the large lakes of the State. Such a wave would be a hazard to shoreline development and pose a significant risk on dam-created reservoirs. A seiche could either overtop or damage a dam, leading to flash flooding downstream.

Further, such events may create the right conditions for a hydrothermal explosion. Yellowstone National Park and the adjacent Snake River plain have experienced 18 large hydrothermal explosions over the past 14,000 years, according to the United States Geological Survey (USGS). This is the most frequent type of explosion in the park. Three areas in Yellowstone; Mary Bay, Turbid Lake, and Indian Pond were apparently formed by large hydrothermal explosions. Mary Bay is nearly one mile across.

Figure 3.6.B. Fault Lines in Idaho



Location, Extent, and Magnitude

A majority of earthquakes occur on faults that form the boundaries of earth's tectonic plates. Tectonic forces within the western part of the North American plate combine with high heat flow from the underlying mantle to stretch the crust in a northeast-southwest direction. In response to the stretching, the rigid crust breaks and shifts along the faults. This fault movement produces earthquakes.

As indicated in the previous sections, just as there are multiple sources of seismic activity in Idaho, the location of seismic activity varies as well. Idaho is not located on a plate boundary, but many faults found within the State can produce large earthquakes. Many earthquakes occur along faults; however, Idaho has a considerable number of unmapped faults and many small to moderate earthquakes do not occur on faults. Most earthquakes in Idaho occur along a belt of seismicity called the 'Intermountain Seismic Belt' that extends from the northwest corner of Montana, along the Idaho-Wyoming border, through Utah, and into southern Nevada. Along most of the belt's length, it straddles the boundary between the extending Basin and Range Province to the west and more stable parts of North America to the east.

The important fact regarding Idaho seismicity is that most Idaho earthquakes are not associated with known faults. This is easily seen when plots of recorded seismicity are compared with fault maps. Many, if not most, Idaho earthquakes are not on mapped faults. One explanation for this is Idaho's poor seismic monitoring. A low density of seismic monitoring stations, as exists in Idaho, would result in inherently poor earthquake location precision. Another possibility is that a number of unknown faults exist and that small earthquakes are occurring away from faults. However, large earthquakes generally occur on large, well-known faults.

Figure 3.6.C. Multiple Fault Scarps in the Lost River Fault

Source: Idaho Geological Survey 1983

In Idaho, the Yellowstone Hotspot has interacted with the Basin and Range to create a more complicated pattern of earthquakes and mountain building called the Yellowstone Tectonic Parabola. The Yellowstone Tectonic Parabola is a region of earthquakes, active faulting, and topographic uplift surrounding the eastern Snake River Plain. This plain was formed as the North American continent passed over a stationary plume or "hotspot" of hot rock rising from the earth's mantle. The pattern of earthquake activity in eastern and central Idaho seems to be related to interactions between the hotspot and Basin and Range extension. As a result, a major branch of the Intermountain Seismic Belt extends from the Yellowstone area westward across central Idaho. This zone includes at least eight major active faults and has been the site of many earthquake swarms and seismic events. Geological and seismological studies show that earthquakes are likely to happen in any of several active zones in Idaho and adjacent states (Idaho Geological Survey 2017). Large, damaging earthquakes are most likely to occur in the mountainous regions of eastern and central Idaho, north and south of the Snake River Plain; however, all parts of the State have at least a moderate threat from earthquakes.

Geologists divide the region into five tectonic belts based on historical earthquake activity and the age and amount of movement on prehistoric faults. Within the Snake River Plain, earthquake activity is very low. Earthquake activity increases and faults become younger away from the plain, culminating in a band of youthful, active faults that forms the tectonic parabola on the east. Faulting and earthquakes in western and northern Idaho are not well-explained by the Yellowstone tectonic parabola model.

The extent and magnitude of earthquakes are measured in two ways:

- Magnitude (as measured by the Richter Scale) – measures the energy that is released
- Intensity (as measured by the Modified Mercalli Intensity Scale [MM]) – measures physical effects

Seismic waves are the vibrations from earthquakes that travel through the Earth and are recorded on instruments called seismographs. The magnitude or extent of an earthquake is a measured value of the earthquake size, or amplitude of the seismic waves, using a seismograph. The Richter magnitude scale (Richter scale) was developed in 1932 as a mathematical device to compare the sizes of earthquakes. The Richter scale is the most widely known scale that measures the magnitude of earthquakes. It has no upper limit and is not used to express damage. An earthquake in a densely populated area, which results in many deaths and considerable damage, may have the same magnitude and shock in a remote area that did not experience any damage. Table 3.6.D presents the Richter scale magnitudes and corresponding earthquake effects.

Table 3.6.D. Richter Magnitude Scale

Richter Magnitude	Earthquake Effects
2.5 or less	Usually not felt, but can be recorded by seismograph
2.5 to 5.4	Often felt, but causes only minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake; serious damage
8.0 or greater	Great earthquake; can totally destroy communities near the epicenter

Source: Michigan Tech University 2007

Magnitude is calculated by seismologists from seismograph readings and is most useful to scientists comparing the power of earthquakes. Magnitude is often described using the Richter scale. An earthquake of Magnitude 2.5 or less is usually not felt. Dishes rattling and china shaking occur at Magnitude 3.0, and magnitudes greater than 6.5 are devastating events when the earthquake strikes in or near a populated area.

The moment magnitude scale (MMS; denoted as Mw or M) is now more widely used by seismologists to measure the size of earthquakes. The scale was developed in the 1970s to succeed the 1930s-era Richter magnitude scale (ML). Even though the formulas are different, the new scale retains a continuum of magnitude values similar to that defined by the older one. Under suitable assumptions, as with the Richter magnitude scale, an increase of one step on this logarithmic scale corresponds to a 101.5 (about 32) times increase in the amount of energy released, and an increase of two steps corresponds to a 103 (1,000) times increase in energy. Thus, an earthquake of Mw of 7.0 releases about 32 times as much energy as one of 6.0 and nearly 1,000 times that of 5.0. (Hanks & Kanamori, 1979). The moment magnitude is based on the seismic moment of the earthquake, which is equal to the shear modulus of the rock near the fault multiplied by the average amount of slip on the fault and the size of the area that slipped (USGS, 2009). Since January 2002, the MMS has been the scale used by the United States Geological Survey to calculate and report magnitudes for all modern large earthquakes.

The intensity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features, and varies with location. The Modified Mercalli Intensity Scale is a subjective description of the physical effects of the shaking, based on observations at the event site. The damage from earthquake shaking is affected by several factors, such as distance from the epicenter and local geology and soils. On the Modified Mercalli Intensity Scale, a value of I is the least intense motion, and XII is the greatest ground shaking. Unlike magnitude, intensity can vary from place to place and is evaluated from people's reactions to events and the visible damage to man-made structures.

The Modified Mercalli scale expresses intensity of an earthquake; the scale is a subjective measure that describes how strong a shock was felt at a particular location. The Modified Mercalli scale expresses the intensity of an earthquake's effects in a given locality in values ranging from I to XII. Table 3.6.E summarizes earthquake intensity as expressed by the Modified Mercalli scale.

Table 1.6.E. Modified Mercalli Intensity and Peak Ground Acceleration Equivalents

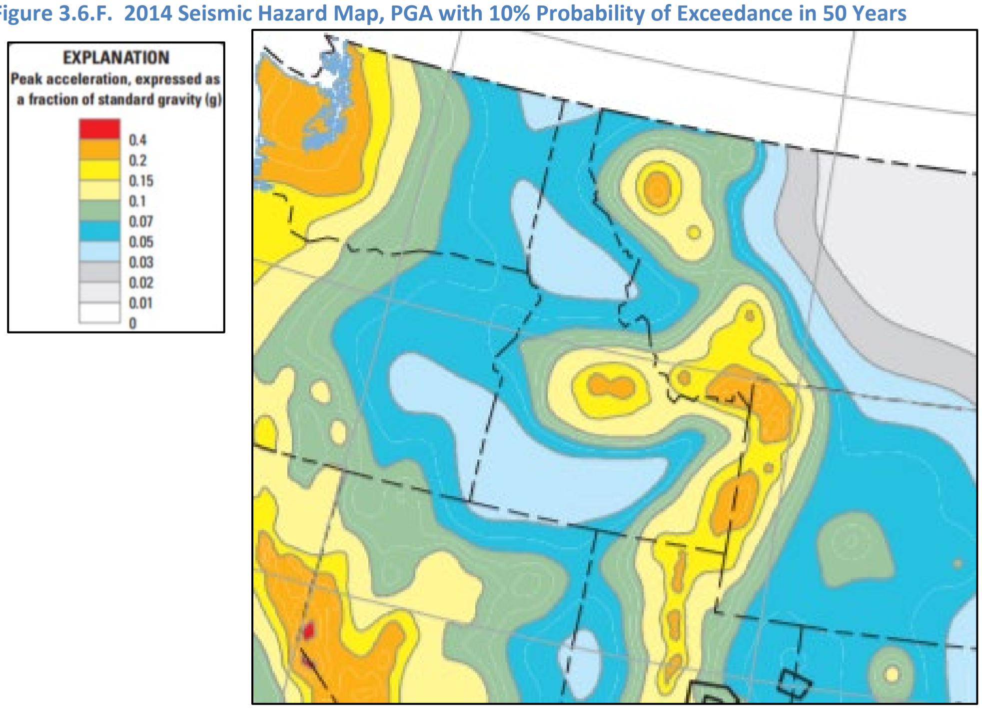
Modified Mercalli Scale	Perceived Shaking	Potential Structure Damage		Estimated PGA[a] (%g)
		Resistant Buildings	Vulnerable Buildings	
I	Not Felt	None	None	<0.17%
II-III	Weak	None	None	0.17% – 1.4%
IV	Light	None	None	1.4% – 3.9%
V	Moderate	Very Light	Light	3.9% – 9.2%
VI	Strong	Light	Moderate	9.2% – 18%
VII	Very Strong	Moderate	Moderate/Heavy	18% – 34%
VIII	Severe	Moderate/Heavy	Heavy	34% – 65%
IX	Violent	Heavy	Very Heavy	65% – 124%
X – XII	Extreme	Very Heavy	Very Heavy	>124%

Sources: USGS, 2008; USGS, 2010

a. PGA measured in percent of g, where g is the acceleration of gravity

Another way to measure intensity is through ground acceleration. This is expressed as either “peak ground acceleration” (PGA) or “spectral acceleration” (SA) expressed relative to the acceleration of gravity (g) and determined by seismographic instruments. While Mercalli (MM) and PGA intensities are arrived at differently, they correlate reasonably well. SA is the basis for the vulnerability. What is important here is that ground and spectral accelerations are quantitative measures, while MM is qualitative. Engineers and others interested in designing earthquake-resistant structures need the quantitative information, but a great deal of useful data can quickly be gathered by untrained people with the qualitative MM scale. Both PGA and SA have units of acceleration of gravity (or percent of acceleration of gravity). PGA and SA are further defined at:
http://earthquake.usgs.gov/learn/glossary/?term=spectral%20acceleration%20%28SA%29
According to USGS Earthquake Hazards Program, PGA maps (also known as earthquake hazard maps) are used as planning tools when designing buildings, bridges, highways, and utilities so that they can withstand shaking associated with earthquake events. These maps are also used as planning tools for the development of building codes that establish construction requirements appropriate to preserve public safety. The USGS PGA maps show a certain probability (2 percent for 10 percent) of being exceeded in a 50-year period. The PGA is measured in numbers of g’s (the acceleration associated with gravity). Figure 3.6.F shows the PGAs with a 10-percent exceedance in 50 years for Idaho. Northwestern and southwestern Idaho is in a low hazard area, while central and southeastern Idaho is in a medium to high-hazard area.

Figure 3.6.F. 2014 Seismic Hazard Map, PGA with 10% Probability of Exceedance in 50 Years



Source: USGS 2014
g% Percent acceleration force of gravity
PGA Peak ground acceleration

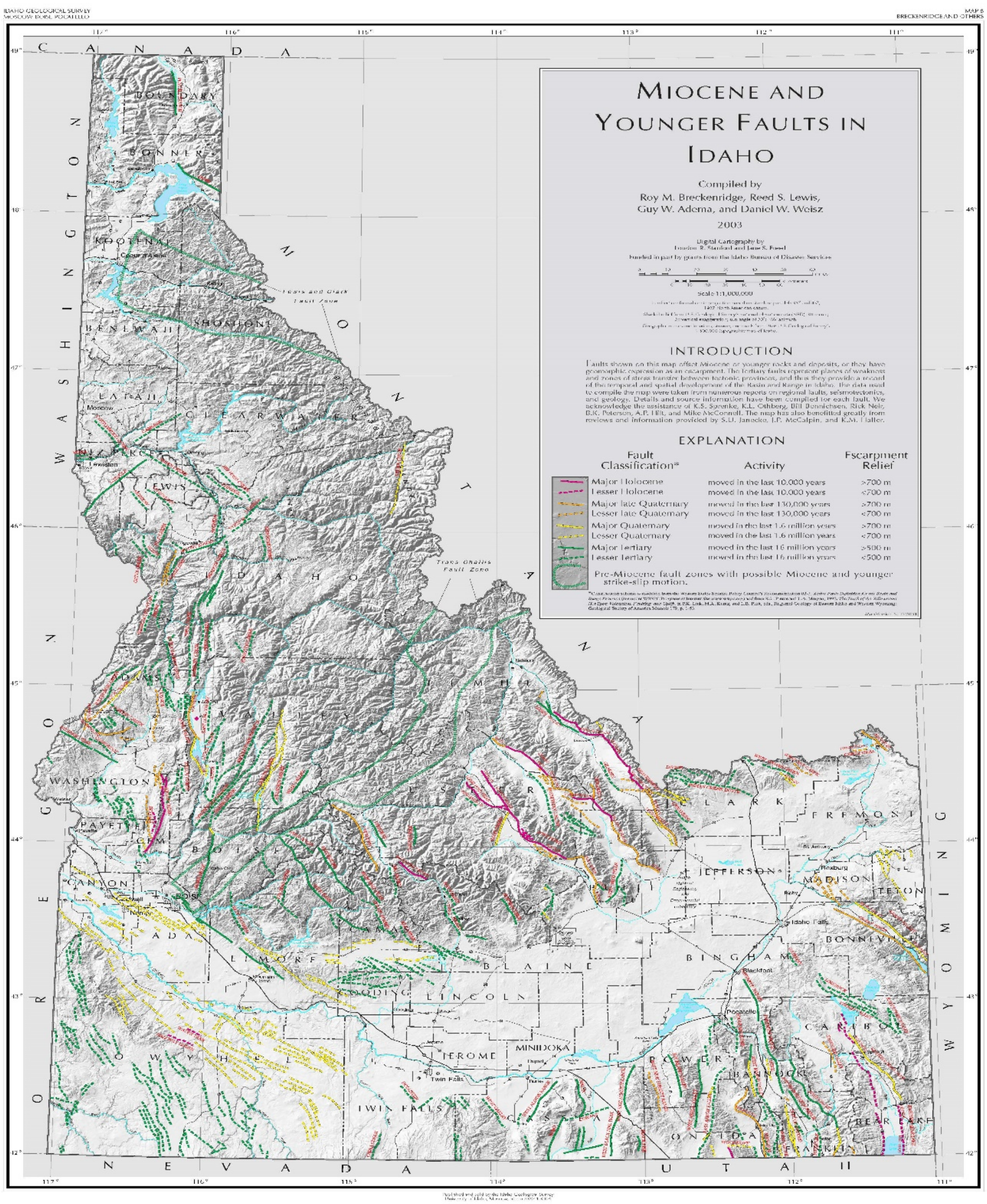
Figure 3.6.G, below, correlates PGA and MM. Additional information can be found on the USGS website (http://earthquake.usgs.gov/earthquakes/shakemap/background.php).

Figure 3.6.G. Correlation between Ground Acceleration and Intensity / Source: United States Geological Survey

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+

Geologic evidence shows that movement on the faults in and around Idaho can cause earthquakes of magnitude 6.5 to 7.5, with potentially catastrophic effects.

Figure 3.6.H List of Faults in Idaho



Source: USGS http://www.idahogeology.org /An additional Google Earth KMG map can be found at http://www.idahogeology.org/Services/GeologicHazards/Faults/Google/IGS_FAULTS_v11-15-06.kmz

Severity

The severity of an earthquake can be expressed in terms of intensity or magnitude. Intensity represents the observed effects of ground shaking on people, buildings and natural features. Magnitude is related to the amount of seismic energy released at the hypocenter of an earthquake. It is determined by the amplitude of the earthquake waves recorded on instruments. Whereas intensity varies depending on location with respect to the earthquake epicenter, magnitude is represented by a single, instrumentally determined value for each earthquake event. The severity of an earthquake event can be measured in the following terms:

How hard did the ground shake?
How did the ground move? (Horizontally or vertically)
How stable was the soil?
What is the fragility of the built environment in the area of impact?

The severity of a seismic event is directly correlated to the stability of the ground close to the event's epicenter. The difference in severity between intensity ranges can be immense. A poorly built structure on a stable site in Boise is far more likely to survive a large earthquake than a well-built structure on an unstable site. Thorough geotechnical site evaluations should be the rule of thumb for new construction in the planning area until creditable soils mapping becomes available.

Factors Contributing to Damage

The damage associated with each earthquake is subject to four primary variables:

- The nature of the seismic activity
- The composition of the underlying geology and soils
- The level and quality of development of the area struck by the earthquake
- The time of day

Seismic Activity: The properties of earthquakes vary greatly from event to event. Some seismic activity is localized (a small point of energy release), while other activity is widespread (e.g., a long section of fault rupturing at once). Earthquakes can be very brief (only a few seconds) or last for a minute or more. The depth of release and type of seismic waves generated also play roles in the nature and location of damage; shallow quakes will hit the area close to the epicenter harder, but tend to be felt across a smaller region than deep earthquakes.

Geology and Soils: The surface geology and soils of an area influence the propagation (conduction) of seismic waves and how strongly the energy is felt. Generally, stable areas (e.g., solid bedrock) experience less destructive shaking than unstable areas (e.g., fill soils). The siting of a community or even individual buildings plays a strong role in the nature and extent of damage from an event.

Development: A small earthquake in the center of a major city can have far greater consequences than a major event in a sparsely populated place. The two major Idaho earthquakes, Hebgen Lake (1959) and Borah Peak (1983), were very strong but occurred in isolated areas with small populations. The damage, compared to that of earthquakes of similar magnitude in heavily populated areas, was relatively light.

Time of Day: The time of day that an event occurs controls the distribution of the population in an affected area. On work days, the majority of the community will transition between work or school and home, so the time of day will affect the location of the population. The relative seismic vulnerability of each location can strongly influence the loss of life and injury resulting from an event.

Warning Time

There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. An Earthquake Early Warning System is being developed by the USGS for the west coast of the United States. This system uses existing seismic networks to detect moderate to large earthquakes very rapidly so that a warning can be sent before destructive seismic waves arrive to locations outside the area where the earthquake begins. These warnings will allow people to take protective action and can also trigger automatic responses to safeguard critical infrastructure (USGS 2012).

Relationships to Other Hazards

Secondary Impacts

Earthquakes do have the ability to initiate and impact a number of other hazards, both natural and human-caused. Avalanches and landslides are two hazards that can be initiated by a seismic event. Dams, levees, and canals are also at risk of damages that could be caused by an earthquake or the resulting seiches. These damages have the possibility of causing the structures to fail, thereby producing a dam/levee/canal failure hazard event. Uplift and displacement from a major seismic event could also result in the re-routing of existing streams, the result of which could be flooding. The damages that could result from an earthquake would certainly have an opportunity to initiate fires. Fires can result from gas lines or power lines that are broken or downed during the earthquake. It may be difficult to control a fire, particularly if the water lines feeding fire hydrants are also broken.

From a human-caused perspective, a worst case earthquake scenario could spawn any of the hazards discussed in this plan. A less intense seismic release could still disrupt power and communication systems, possibly leading to smaller scale energy shortages or cyber disruptions. Additionally, earthquakes may lead to energy outages. The major causes of outages during earthquakes are the failures of circuit breakers, transformer bushings and disconnect switches at the substations. Lack of power can affect pipelines supplying fuels and natural gas, as well as other products. Delivery of water can also be interrupted by an earthquake (U.S. Chamber of Commerce Foundation 2012).

Quickly and successfully eliminating waste and debris after an earthquake will lower the amount of resulting disease and contamination to the environment. The failure of dams, levees, and canals after an earthquake could cause a rapid and possibly catastrophic flood event.

Past Occurrence

The State of Idaho is one of the most active states in terms of the number of earthquakes experienced each year. Historical records demonstrate that earthquakes can occur throughout Idaho. Most earthquakes felt by Idaho residents have occurred within the Yellowstone Tectonic Parabola. Idaho experiences hundreds of earthquakes every year, but most are too small to feel. On average Idaho experiences shaking strong enough to damage chimneys every 10 years and a more significant event about every 20 years. Two of the largest historic earthquakes in the continental United States occurred in Idaho or within a few miles of the state border in 1983 and 1959. These events were magnitude 6.9 and 7.3, respectively, and caused fatalities and destruction to buildings, roads and other structures.

According to USGS, over 2,000 earthquakes greater than magnitude 1.0 have been recorded in the State of Idaho since 1994 (USGS 2017). According to NOAA-NCEI, there have been no recorded significant earthquakes with epicenters in Idaho (Moderate damage [approximately $1 million or more], 10 or more deaths, Magnitude 7.5 or greater, Modified Mercalli Intensity X or greater, or the earthquake generated a tsunami) (NOAA-NCEI 2017).

Many sources provided earthquake information regarding previous occurrences and losses associated with earthquake events throughout the State of Idaho. For the 2018 Plan update, earthquake events were summarized between January 1, 2010 and October 1, 2017. Table 3.6.O includes events discussed in the 2013 Plan through October 1, 2017 that have a magnitude 4 or higher. Figure 3.6.J maps these earthquakes with epicenters in Idaho. Earthquake documentation for Idaho is extensive, loss and impact information for many events could vary depending on the source. Therefore, Table 3.6.I may not include all events that have occurred in the State and the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP update.

Table 3.6.I. Earthquake Events in Idaho, 1872 – 2017

Date(s) of Event	Magnitude *	Location (recorded epicenter)	Counties Affected	Description
1872	7.4	Lake Chelan, WA	N/A	Largest quake in Washington State; felt strongly in North Idaho
1884	6	Bear Lake Valley	Bear Lake	Considerable damage to houses in Paris, ID
1905	6	SW Idaho or NE Nevada	Lincoln	Considerable damage at Shoshone, ID
1913	5	Adams County	Adams	Broke windows and dishes
1914	6	Utah-Idaho State line	Bear Lake	Intensity VII; between Ogden, UT and Montpelier, ID
1915	7.75	Pleasant Valley, NV	N/A	Considerable damage in SW Idaho, 100 miles from epicenter
1916	6	North of Boise	Ada	Boise residents rushed into the street, chimneys fell
1918	5	North Idaho	Bonner	Widely felt near Sandpoint
1925	6.6	SW Montana	N/A	Felt throughout Idaho
1926	4	North Idaho	Shoshone	Felt at Avery and Wallace
1927	5	Connor Creek	Valley	On Idaho-Oregon border, west of Cascade
1934	6.6	Hansel Valley, UT	N/A	Largest Utah event on record; 20 miles south of Idaho border; 2 fatalities

Date(s) of Event	Magnitude *	Location (recorded epicenter)	Counties Affected	Description
1935	6.25	Helena, MT	N/A	Extensive damage; multiple large events felt throughout Idaho; 4 fatalities
1936	6.4	Walla Walla, WA	N/A	Damaging earthquake; widely felt in Idaho
1942	5	Sandpoint area	Bonner	Cracked plaster; rock fell onto railroad tracks
1944	6	Central Idaho	N/A	Knocked people to ground in Custer County
1944	4	Lewiston area	Nez Perce	Widely felt in northern Idaho
1945	6	Central Idaho	Boise	Epicenter near Clayton; slight damage in Idaho City and Weiser
1947	6.25	Southwest Montana	N/A	Epicenter in Gravelly range, 10 miles north of Idaho border
1947	5	Central Idaho?	N/A	Several large cracks formed in a well-constructed brick building
August 18, 1959	7.3	Hebgen Lake, MT	Fremont	Major event, extensive fault scarps; 20 miles from Idaho; 29 fatalities. The Hebgen Lake earthquake (August 18, 1959) originated in Montana but was felt and caused considerable damage in Idaho. The Magnitude 7.3 event generated Intensity X shaking, killed 28 people as a result of an enormous landslide, formed "Quake Lake," and did $11 million damage to roads and timber. Many campers in the Yellowstone area were trapped for days (eventually rescued with the assistance of smoke jumpers and helicopters), and a fishing lodge dropped whole into a lake. There were six aftershocks of Magnitude 5.5 or greater within one day, and one of Magnitude 5.8 in 1964. The initial earthquake was felt in an area of over 450,000 square miles. In Idaho, Intensity VII was experienced in the areas of Big Springs, Island Park, and Henry's Lake. Big Springs increased its flow 15 percent and became rusty red colored, and wells in the Island Park area remained muddy for weeks. A man was knocked down at Edward's Lodge, and guests at Mack's Inn experienced hysteria. There was considerable damage to buildings in the Henry's Lake area. Trees swayed violently, breaking some roots, and cars jumped up and down. Chimneys fell, and a 7-foot-thick rock-and-concrete dock cracked.
1960	5	Soda Springs	Caribou	Foundations and plaster cracked
1962	5.7	Cache valley	Franklin	Heavily damaged older buildings
1963	5	Clayton	Custer	Plaster cracked and windows broken
1969	5	Ketchum	Blaine	Cement floors cracked
1975	6.1	NW Yellowstone	N/A	Widely felt in Yellowstone region
1975	6.1	Pocatello Valley	Oneida	Some 520 homes damaged in Ridgedale and Malad City
1977	4.5	Cascade	Valley	Drywall, foundations cracked; ceiling beams separated
1978	4	Flathead Lake, MT	N/A	Felt in NW Idaho
October 28, 1983	6.9	Borah Peak	Custer, Butte and Gooding	Major event, 21-mile surface scarp; 11 buildings destroyed, 2 fatalities The Borah Peak earthquake (October 28, 1983) was the largest ever recorded in Idaho, both in magnitude and in the amount of property damage, ($29.4M - in 2012 dollars). With a magnitude of 6.9, it was among the largest earthquakes to hit the State since the 1959 Hebgen Lake

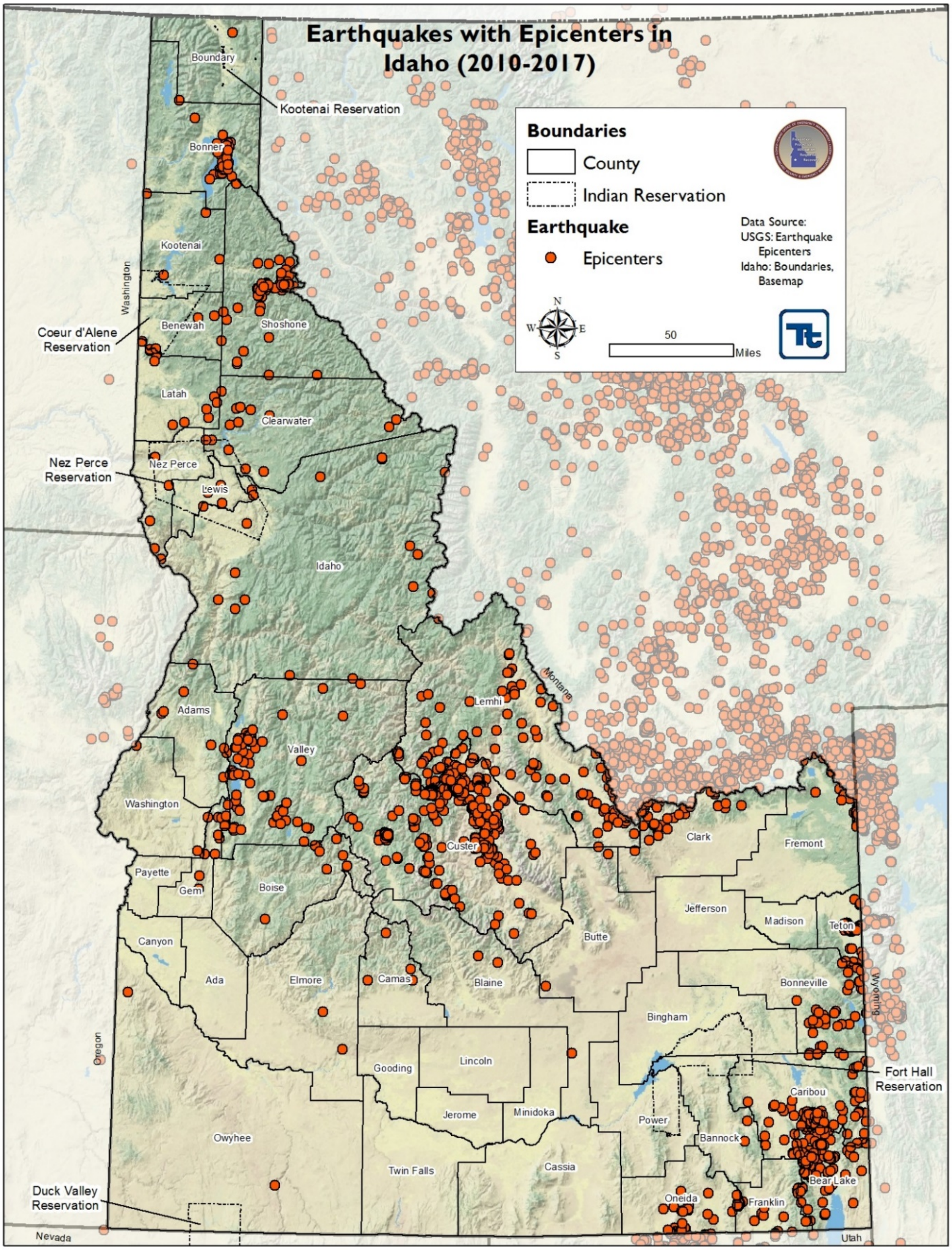
Date(s) of Event	Magnitude *	Location (recorded epicenter)	Counties Affected	Description
				event. The epicenter was in the Barton Flats area, approximately 10 miles northwest of Mackay and 30 miles southeast of Challis. There have been a number of California earthquakes larger than this: 1999 Hector Mine (7.1), 1992 Landers (7.3), 1992 Cape Mendocino (7.2), 1989 Loma Prieta (6.9), and 1980 Humboldt (7.2). The maximum observed intensity was IX (based on surface faulting), and the earthquake was felt in an area of over 330,000 square miles. Four aftershocks of Magnitude 5.5 or greater were recorded within 1 year, and numerous more have occurred to date. Table 3.6.G above shows the shaking in MM Intensity scale units. The event caused two deaths in Challis (both school age children) and several minor injuries. There was an estimated $12.5 million in damage in the Challis-Mackay area, affecting sewer and water systems, roads, other public facilities, and personal property. The facilities of an irrigation company and a fish hatchery also experienced extensive damage. Although damage occurred as far away as Boise, the most severe property damage occurred in the towns of Challis and Mackay. Eleven commercial buildings, 39 private houses, and one school sustained major damage, and 200 houses sustained minor to moderate damage. Most of the damaged commercial buildings were of masonry construction, including brick, concrete block, or stone. The majority of the residential chimneys were cracked or twisted, or collapsed. Significant ground displacement produced a 20-mile-long zone of fresh scarps and ground breakage in the Lost River Range. Displacement along the fault ranged from less than 1.5 feet to 9 feet. Other geologic effects included landslides and rock falls, flow changes in springs, and fluctuations in water levels. A temporary lake was formed by the rising water table south of Dickey, and widespread flooding occurred in the Warm Springs Creek area. The event resulted in State and Federal disaster declarations (designated DR-694). The declaration provided Public Assistance and Individual Assistance for Custer County, Individual Assistance for Butte County, and aid to schools in Butte and Gooding Counties
1984	5	Challis	Custer	Largest of many Borah Peak aftershocks
1988	4.1	Cooper Pass	Shoshone	Montana border NE of Mullan
1994	5.9	Draney Peak	Caribou	Remote area of Wyoming border; 1 injury from falling flower pot
1994	3.3	Avery area	Shoshone	Rare North Idaho event centered near Hoyt Mountain
1999	5.3	Lima, MT	N/A	In Red Rock valley, just north of Idaho border
2001	4	Spokane, WA	N/A	At least 75 felt events at shallow depth beneath the city
2005	5.6	Dillon, MT	N/A	Felt across Idaho
September –	4	Alpha Swarm	Valley	Between September and December 2005, thousands of small, very shallow earthquakes occurred near the

Date(s) of Event	Magnitude *	Location (recorded epicenter)	Counties Affected	Description
December 2005				community of Alpha in Valley County. These events, five with magnitudes as high as 4, were centered about 16 kilometers south of Cascade, in the vicinity of Clear Creek. The Idaho Geological Survey and BHS arranged for the deployment of a temporary seismic array to study the swarm. However, a seismologist from Boise State University reported a year later that, in his opinion, the swarm was incorrectly mapped due to "poor seismographic coverage." Although little damage was reported, many of the events were felt locally. Most of the Alpha swarm appears to have occurred along a previously unidentified fault that separates Long Valley to the north from Round Valley to the south. The latest of the five events may have been triggered by stress released from the other earthquakes. This event occurred several kilometers northwest of the others and was consistent with normal faulting on the Long Valley fault, one of the major Quaternary faults in Idaho.
2008	6.0	Wells, NV	N/A	The Wells, Nevada earthquake was felt in southern Idaho, and significant shaking was reported. On February 21, 2008, the northern Nevada town of Wells was struck by a 6.0 Magnitude earthquake resulting from a seismic event on a previously unmapped fault. Half of the non-residential buildings in Wells were damaged, and 10 of those sustained severe damage. The event appeared to occur almost instantaneously and caused nearly $9 million in damages. The community of Wells was severely disrupted for months and, due mostly to the lack of a presidential declaration and subsequent Federal aid, most of the heavily damaged buildings in the older part of town remain in ruins. The circumstances of this event could easily be replayed in many areas of Idaho.
2010	4.6	Randolph, UT	N/A	Shaking experienced in Idaho, Wyoming, and Utah
January and April 2010	4.8	Jackson Hole, WY	N/A	Shaking lasted ~10 seconds, toppled lamps in Jackson, shaking experienced in Idaho. In January and again in April 2010, a swarm of earthquakes occurred about 10 miles northwest of the Old Faithful area on the northwestern edge of the Yellowstone Caldera. Swarms have occurred in this area several times over the past 30 years; however, this swarm became the second largest ever recorded at Yellowstone –both longer (in time) and including more earthquakes than the December 2008-January 2009 swarm. As of September 2010, earthquake activity had returned to near background levels. To complicate matters, the plate beneath Yellowstone Lake ceased its tilting motion. Seismologists are uncertain as to whether or not this is a good thing. Damage from prehistoric caldera events was massive, and a similar event in this day and age would be cataclysmic. Because of recent Hollywood depictions of a Yellowstone super-volcano and despite the location of Yellowstone in neighboring Wyoming, a comment regarding geological and seismic potentials is warranted. Regarding a super-volcano

Date(s) of Event	Magnitude *	Location (recorded epicenter)	Counties Affected	Description
				event, the USGS states in its Open-File Report 2007-1071, "the probability of a forth large caldera-forming event at Yellowstone can be considered to be less than 1 in a million..." The relatively greater hazards are hydrothermal explosions of which 26 have occurred in the past 30 years.
April 10, 2014	4	11km NW of Challis, ID	Custer	No reference and/or no damage reported.
April 13, 2014	4.8	15km NNW of Challis, ID	Custer	No reference and/or no damage reported.
April 14, 2014	7.4	13km NW of Challis, ID	Custer	No reference and/or no damage reported.
January 13, 2015	5	9km E of Challis, ID	Custer	No reference and/or no damage reported.
April 25, 2015	3.3 to 4.2	Lake Pend Oreille SE of Sandpoint, ID	Bonner	A sequence of three M3-4 earthquakes occurred around Lake Pend Oreille southeast of Sandpoint, Idaho, on April 24th 2015. A sequence of three earthquakes, M4.1, M4.2, and M3.3, occurred and were followed by an elevated rate of seismicity. They were widely felt in much of northeastern Washington, northern Idaho, and northwestern Montana.
September 2, 2017	4 to 5.3	12-13km E of Soda Springs, ID	Caribou	No reference and/or no damage reported.
September 3, 2017	4 to 4.7	9-15km ESE of Soda Springs, ID	Caribou	No reference and/or no damage reported.
September 4, 2017	4.5	13km ESE Soda Springs, ID	Caribou	No reference and/or no damage reported.
September 5, 2017	4.1 to 4.3	12-17km ESE of Soda Springs, ID	Caribou	No reference and/or no damage reported.
September 6, 2017	4.1 to 4.6	10-15km ESE of Soda Springs, ID	Caribou	No reference and/or no damage reported.
September 7, 2017	4.1	17km ESE of Soda Springs, Idaho	Caribou	No reference and/or no damage reported.
September 9, 2017	4 to 4.1	18km ESE of Soda Springs, Idaho	Caribou	No reference and/or no damage reported.
September 10, 2017	4.1 to 5	12-18km ESE of Soda Springs, ID	Caribou	No reference and/or no damage reported.
September 11, 2017	4.1 to 4.7	17-18km SE of Soda Springs, ID	Caribou	No reference and/or no damage reported.
September 14, 2017	4	20km NNW of Montpelier, Idaho	Caribou	No reference and/or no damage reported.

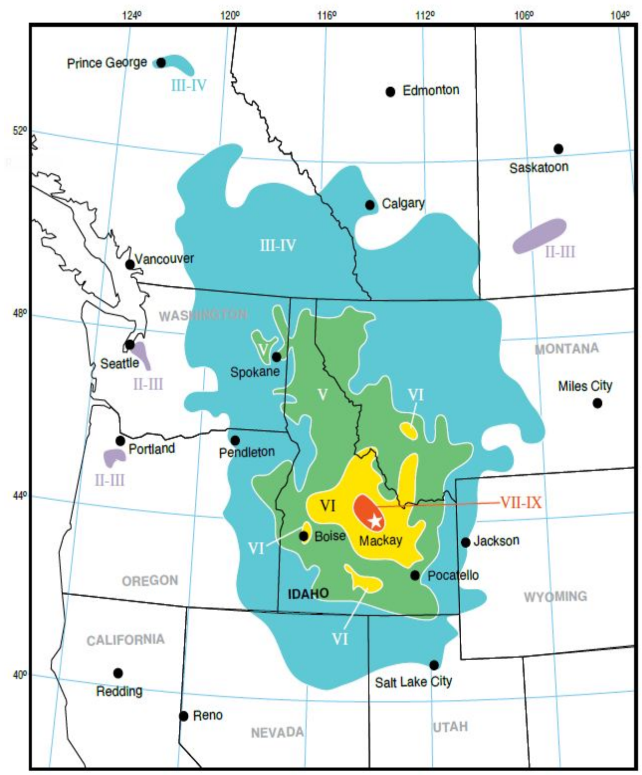
Sources: Idaho State HMP 2013; FEMA 2017; USGS 2017
** Magnitudes with deciles are approximate*
Note: For events that occurred between 2010 and 2017, only those with magnitude 4
E East, FEMA - Federal Emergency Management Agency, HMP - Hazard Mitigation Plan, ID – Idaho, K- Kilometers, N – North, N/A - Not available, S – South, USGS - U.S. Geological Survey, W – West.

Figure 3.6.J. Earthquakes with Epicenters in Idaho, 2010 to 2017

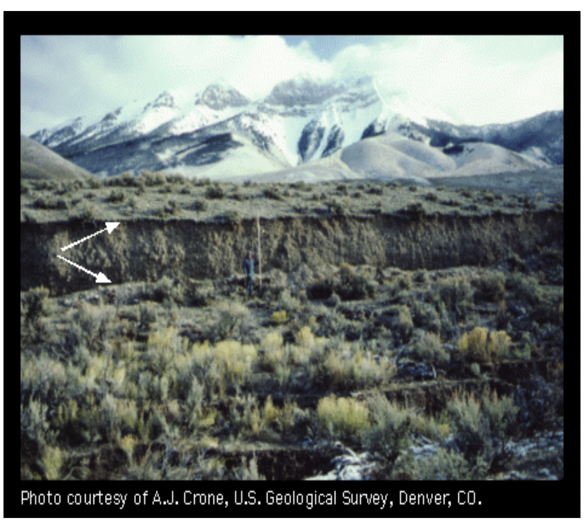


Hotspot-related seismic activity is typically confined to the Yellowstone region on the eastern border of the State. Dozens of small earthquakes (less than Magnitude 3.0) occur here each month, with larger events occurring about once a month. Fault-related seismic activity occurs throughout the State but is concentrated in the central mountains and in the southeast corner. From 2007-2010, earthquakes ranging from 2.0 – 3.8 have been felt annually in southeastern Idaho originating from north Utah along the Wasatch Fault zone. Idaho has a substantial number of known and suspected active faults. However, USGS uses only seven faults to compute the probabilistic seismic hazard maps for Idaho. Nonetheless, when identified, these faults can be useful for projecting future seismic activity. More recently, new mapping and information regarding the fault line and seismic activity in Eastern Washington (Spokane Fault line) shows an elevated threat in to Northern Idaho. The Sandpoint swarm of 2015 confirmed this, and has gained interest in the area from the geological community.

Hebgen Lake Earthquake / *Source: USGS*



Borah Peak Intensity / *Source: USGS*



Borah Peak Earthquake / *Source: USGS*

FEMA Disaster Declarations

Between 1954 and 2017, there was one FEMA major earthquake disaster (DR) declaration in Idaho. This declaration included Butte, Custer and Gooding Counties. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2017).

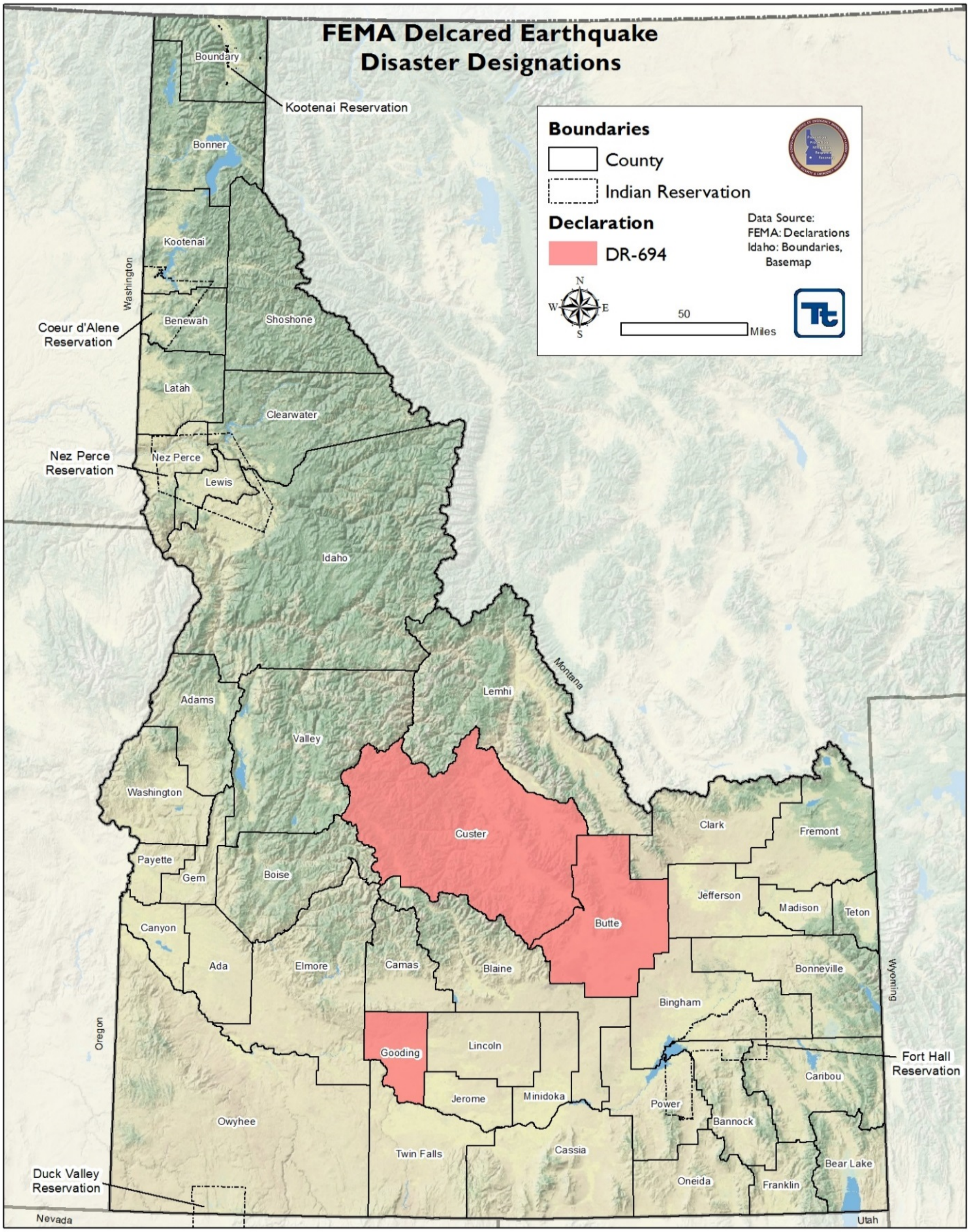
Based on all sources researched, known earthquake events that have affected Idaho and were declared a FEMA disaster are identified in Table 3.6.K. This table provides information on the disaster declarations for earthquakes, including date of event, state disaster declaration, federal disaster declaration and disaster number, and counties affected. Figure 3.6.L illustrates the number of FEMA-declared disasters by county.

Table 3.6.K. Earthquake-Related Disaster Declarations (1954 to 2017)

Year	Date	State	Federal	Counties Affected
1983	November 18, 1983	X	DR-694	Butte, Custer, and Gooding

Source: Idaho State HMP 2013; FEMA 2017
Note: The date is the declaration date for the event

Figure 3.6.L1. FEMA Disaster Declarations in Idaho



Future Occurrence

Thousands of earthquakes have been recorded in the State of Idaho. Currently, there are no realistic methods to predict earthquakes. According to the Idaho State seismologist, no studies, past or present, could create anything more than the general probabilities currently available. The past rate of occurrence is a modest predictor of future occurrence. One possible exception would be increased volcanic activity related to the Yellowstone hotspot. If that occurs, seismic activity would also be likely to increase. Nonetheless, the assessment of seismic risk is significantly impaired by 1) a lack of fault characterization data for Idaho's mapped faults, 2) limited NEHRP soil and liquefaction susceptibility maps, and 3) extremely limited seismic monitoring throughout Idaho.

For the purpose of this Plan update, the probability of future occurrences is defined by the number of events over a specified period of time. Between 1950 and 2017, there have been 3,314 earthquakes (of all magnitudes) with epicenters in Idaho. Based on this data, Idaho may experience an average of 50 earthquakes of any given magnitude each year. This average includes the many aftershocks that occur after large earthquakes. Please note that the number of small earthquakes (magnitude less than 3) is greatly under-reported in Idaho because of limited seismic monitoring.

Earthquake Catastrophes and Fatalities Projected to Rise in Populous 21st Century

MENLO PARK, Calif. —Predicted population increases in this century can be expected to translate into more earthquakes with very large death tolls and more people dying during earthquakes than ever before, according to a newly published study led by U.S. Geological Survey engineering geologist Thomas L. Holzer.

Holzer and his USGS coauthor James Savage studied earthquakes with death tolls of more than 50,000, which they define as catastrophic, and reported global death tolls from roughly 1500 A.D. to the present. Comparing those events to estimates of world population, they found that the number of catastrophic earthquakes has increased as population has grown. After statistically correlating the number of catastrophic earthquakes in each century with world population, they were able to use new (2011) 21st-century population projections by the United Nations to project that approximately 21 catastrophic earthquakes will occur in the 21st century, a tripling of the seven that occurred in the 20th century. They also predict that total deaths in the century could more than double to approximately 3.6 million people if world population grows to 10.1 billion by 2100 from 6.1 billion in 2000.

"This prediction need not be a prophesy: the National Earthquake Hazard Reduction Program (NEHRP) in the U.S. can be a model for how science can inform engineering designs that are adopted into life-saving building codes in earthquake-prone regions," said USGS Associate Director for Natural Hazards David Applegate. "I also cannot stress enough the value of educated citizens — those who understand the natural hazards of this planet and are empowered to take action to reduce their risk."

Four catastrophic earthquakes have already struck since the beginning of the 21st century, including the 2004 Sumatra-Andaman earthquake (and tsunami) and 2010 Haiti earthquake that each may have killed over 200,000 people. The study explains this increase in lethal earthquakes. It is not that we are having more earthquakes; it is that more people are living in seismically vulnerable buildings in the world's earthquake zones.

Holzer's study underscores the need to build residential and commercial structures that will not collapse and kill people during earthquake shaking.

"Without a significant increase in seismic retrofitting and seismic-resistant construction in earthquake hazard zones at a global scale, the number of catastrophic earthquakes and earthquake fatalities will continue to increase and our predictions are likely to be fulfilled," Holzer said.

Environmental Impacts

Earthquakes can lead to numerous, widespread, and devastating environmental impacts. These impacts may include but are not limited to:

- Induced flooding or landslides
- Poor water quality
- Damage to vegetation
- Breakage in sewage or toxic material containments

Secondary impacts can include train derailments, roadway damages, spillage of hazardous materials (HazMat), and utility interruption. Quickly and successfully eliminating waste and debris after an earthquake will lower the amount of resulting disease and contamination to the environment. The failure of dams, levees, and canals after an earthquake could cause a rapid and possibly catastrophic flood event.

The environmental impacts of earthquakes are highly dependent on the location of the quake. For example, in mountainous regions, earthquakes and aftershocks can cause landslides and land deformation and result in infrastructure damage. Microwave communication towers could be knocked out of alignment. In areas of human development, damaged infrastructure such as sewage systems and pipelines can result in large releases of harmful substances into the environment.

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes. The potential impacts of global climate change on earthquake probability are unknown. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the Earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. National Aeronautics and Space Administration (NASA) and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes.

Secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity because of the increased saturation. Dams storing increased volumes of water from changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts.

Development Trend Impacts

An understanding of population and development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine previous and potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate

The U.S. EPA's Integrated Climate and Land-Use Scenarios (ICLUS) project generated projected population and land use projections for the United States through 2100. The project examined multiple scenarios taking into account various population growth and economic development parameters that have been used as the baseline for the Intergovernmental Panel on Climate Change's (IPCC) Special Report on emissions Scenarios (SRES). Population change took into account assumptions regarding fertility, mortality, and immigration, which was then used to drive the land use projections. The SRES provides two development scenarios: economic development (A) and environmentally-driven development (B), where the A scenario will result in more sprawled development, and the B scenario will result in more compact developments close to the existing urban centers. Additionally, the model scenarios included parameters for global development (1) and regional development (2) (EPA, 2013). The model estimated projections for each decade from 2010 to 2100.

The ICLUS scenario 'A2' was selected to examine if changes in land use and housing density estimates from 2010 to 2020 are projected in the wildfire hazard area. The 2010 data was used as a baseline to determine if any changes in development by 2020 may result in increases or decreases in the hazard area. The resulting housing density and land use categories are defined as follows: Urban, which equates to 0.25 acres/unit; Suburban, which equates to 0.25 to 2 acres/unit; Exurban, which equates to 2 to 40 acres/unit; Rural, which equates to 40 acres/unit; Commercial and Industrial.

Table 3.6.M displays the estimated land-use area (square miles) located in the identified earthquake hazard and projected area for 2020 by jurisdiction. Changes to land-use and housing density may increase the number of vulnerable populations and developments to a hazard event. Earthquakes may occur anywhere in the State; therefore any growth in population and housing density will increase the State's risk to impacts from a seismic event.

The most significant changes in land-use are seen in the exurban and rural categories. Overall, 4.6 square miles of exurban area is projected to be developed into the earthquake hazard area by 2020, with the greatest additions in Caribou County. As for rural land, statewide there is a projected decline of approximately 6.4 square miles. This decline is the greatest in Caribou County, where a reduction of 2.3 square miles of rural land is projected; this coincides with the increase in higher housing densities, which will place a greater number of people in the hazard area. Some counties in the Northeast and Southeast, such as Jefferson, Teton, and Bonneville, have high growth rates and face significant seismic threat. In such areas, it can be predicted that an increased amount of housing stock and developed area will be at risk. However, seismic codes may mitigate the potential losses of life, injuries, and property damage.

Table 3.6.M. Projected Development Changes from 2010 to 2020 in the Earthquake Hazard Area (square miles)

Jurisdiction	Urban			Suburban			Exurban			Rural			Commercial/ Industrial		
	2010	2020	Change	2010	2020	Change	2010	2020	Change	2010	2020	Change	2010	2020	Change
Bannock County	0	0	0.0	0	0	0.0	0	0	0.0	37.7	37.7	0.0	0	0	0.0
Bear Lake County	0	0	0.0	1.6	1.6	0.0	11.8	12.3	0.5	477.9	477	-0.9	1.1	1.1	0.0
Bingham County	0	0	0.0	0	0	0.0	0	0	0.0	115.5	115.5	0.0	0	0	0.0
Blaine County	0	0	0.0	0.1	0.1	0.0	4.1	4.3	0.2	7.2	7	-0.2	0.1	0.1	0.0
Boise County	0	0	0.0	0	0	0.0	0.4	0.4	0.0	0	0	0.0	0	0	0.0
Bonneville County	0	0	0.0	0.1	0.1	0.0	0.6	0.7	0.1	132.9	132.7	-0.2	0	0	0.0
Butte County	0	0	0.0	0	0	0.0	0.1	0.1	0.0	39.6	39.6	0.0	0.3	0.3	0.0
Camas County	0	0	0.0	0	0	0.0	0	0	0.0	0.2	0.2	0.0	0	0	0.0
Caribou County	0.1	0.1	0.0	1.2	1.2	0.0	4.7	6.3	1.6	700.1	697.8	-2.3	0.4	0.4	0.0
Clark County	0	0	0.0	0	0	0.0	0.2	0.4	0.2	91.7	91.6	-0.1	0.1	0.1	0.0
Custer County	0	0	0.0	1	1	0.0	19.5	19.7	0.2	254.1	253.9	-0.2	2.5	2.5	0.0
Franklin County	0	0	0.0	1.3	1.3	0.0	23.7	23.8	0.1	400.5	400.4	-0.1	0	0	0.0
Fremont County	0	0	0.0	1.1	1.1	0.0	8.5	8.5	0.0	28.5	28.5	0.0	0	0	0.0
Lemhi County	0	0	0.0	0.2	0.2	0.0	2	2	0.0	202.7	202.7	0.0	0.7	0.7	0.0
Oneida County	0	0	0.0	0.7	0.7	0.0	4.8	5.7	0.9	280.9	279.9	-1.0	0	0	0.0
Teton County	0	0	0.0	0.7	0.7	0.0	20.5	21.4	0.9	53.3	52.2	-1.3	0	0	0.0
Valley County	0	0	0.0	0	0	0.0	0	0	0.0	2.1	2.1	0.0	0	0	0.0
Idaho Total	**0.1**	**0.1**	**0.0**	**7.9**	**8**	**0.1**	**101**	**105.6**	**4.6**	**2,825.20**	**2,818.80**	**-6.4**	**5.1**	**5.1**	**0.0**

Source: EPA 2013, USGS 2014
Notes: Projected development includes changes in housing density and land use

Seismic building codes increase building integrity and help ensure the future safety of communities. These codes are designed to protect lives, but not to ensure that buildings are undamaged or usable after an earthquake. Seismic codes are intended to protect people inside buildings by preventing collapse and allowing safe evacuation. Structures built according to the current code should be undamaged in minor earthquakes, resist moderate earthquakes without significant structural damage, and resist severe earthquakes without collapse. In Idaho, seismic codes made substantial improvements in construction as early as the mid-1970s. Buildings constructed prior to this time may be seismically unsafe. However, buildings constructed in the 1980s would not be as seismically safe as buildings constructed under today's seismic codes. To keep up with the latest progressions in seismic design, building codes are revised every three years to incorporate new data findings and knowledge.

Map 2.F. in Chapter 2 (State Profile) displays the projected population growth by 2026.

Vulnerability Assessment and Loss Estimation

Statewide Analysis

The majority of the State's population is concentrated in areas of high seismic risk, either along faults that define the margins of mountain ranges or in seismically active mountainous areas. Moreover, seismic hazard assessments in Idaho are made more complicated because most of Idaho's earthquakes are not associated with known faults. As such, lifelines (e.g., utilities and transportation routes) and critical facilities (e.g., dams, government, military, and research installations) are at risk in varying degrees that are not easily classified, due mainly to inadequate seismic monitoring. It is important to note the difference between hazard and risk in this plan. To use an example, the eastern Idaho town of Driggs is in a high seismic hazard zone as shown by the USGS 2008 Probabilistic Seismic Hazard map. This is due to its proximity to major active faults and the amount of recorded seismicity near it. Boise, on the other hand, has a lower seismic hazard as shown on the same map. It is farther from major high-slip rate faults and lacks much recorded seismicity. However, Boise may have a higher risk from earthquakes because it has a much higher population and more structures and critical infrastructure than does Driggs.

Critical Infrastructure and State Facility Impacts

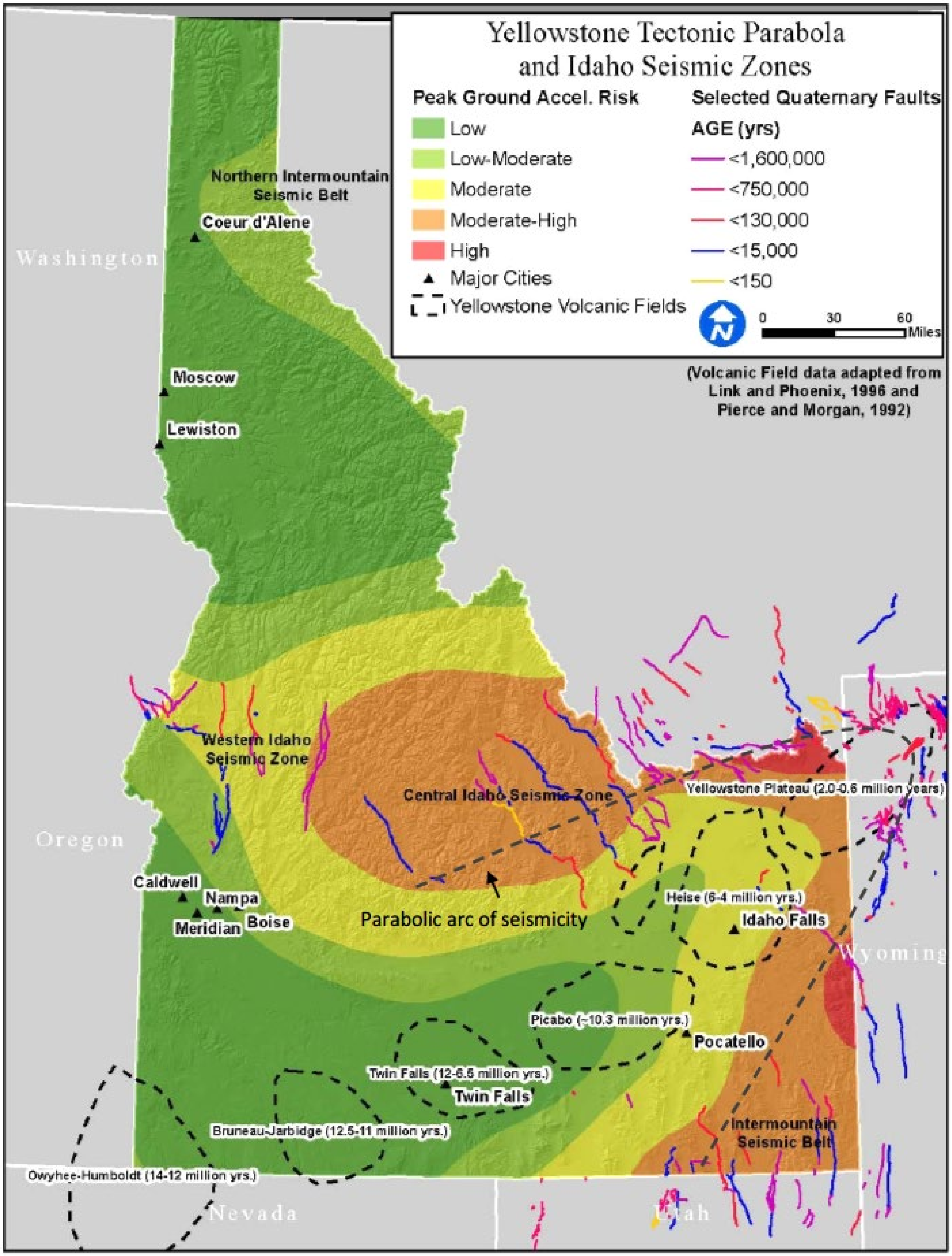
A statewide earthquake analysis was conducted based on best available data for the State of Idaho. This section discusses statewide vulnerability of areas susceptible to earthquakes and potential losses to state assets and critical facilities.

Data

The USGS has produced Probabilistic Seismic Hazard Maps, a series of maps and GIS datasets that define the seismic hazard of earthquakes. The advantages of using these maps are: 1) maps are produced using a carefully documented protocol with best available scientific information; 2) maps are produced for the entire USA, permitting valid comparisons between political jurisdictions; 3) maps are incorporated into the International Building Code (IBC) and International Residential Code (IRC); and 4) maps updated every six years.

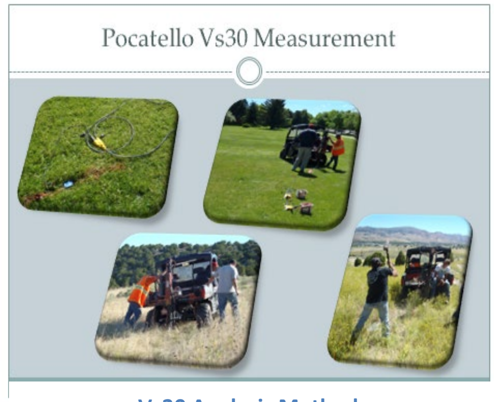
The 2015 Idaho Multi-Risk Portfolio (IMHRP) utilized the 2014 USGS National Seismic Hazard Map for Peak Ground Acceleration for its assessment. This dataset denotes areas that may be equal to or exceed 2% annually over a 50 year period for its assessment. For the IMHRP, the PGA zones are divided into five categories: Low, Low-Moderate, Moderate, Moderate-High, and High, which are shown on Figure 3.6.N. Assets located within the Moderate-High and High hazard area are deemed potentially vulnerable for the purposes of the 2018 State HMP risk assessment.

Figure 3.6.N. Statewide Earthquake Risk



Source: IMHRP, 2015

Geologic mapping and specialized geotechnical and geophysical studies can identify regions that are susceptible to enhanced shaking or liquefaction. These studies produce maps that are used by engineers and architects to reduce damage to structures from earthquakes, and help emergency managers improve the accuracy of earthquake disaster computer simulations. The Idaho OEM funded the Idaho Geological Survey (IGS) to prepare such maps in several parts of Idaho, including Idaho Falls-Rexburg, metro Boise, Teton County, Pocatello, and Wood River Area. The maps and the data used to make them are available in digital format for free download at the website of the Idaho Geological Survey (http://www.idahogeology.org/). Two types of maps have been produced: NERHP Site Class Maps and Liquefaction Susceptibility Maps.



Vs30 Analysis Methods

NERHP Site Class Mapping

In 1997, the National Earthquake Hazards Reduction Program (NEHRP) established procedures for placing building sites into classes based upon the geotechnical properties of near-surface materials. For each NEHRP site class, coefficients adjust expected earthquake motions for local ground conditions. Earthquake ground motion parameters are generated by USGS for all parts of the United States and are available as national seismic hazard maps (http://earthquake.usgs.gov/hazards/products/). NEHRP site classes are not shown on national seismic hazard maps (NSHM) because local conditions are frequently too variable to accurately depict at the NSHM scale, or because the required geotechnical information is unavailable. Both NEHRP site classes and USGS national seismic hazard maps are incorporated into the International Building Code and International Residential Code. NEHRP site classes range from A-F, from lowest to highest expected ground motion and potential damage. Several methods were used to classify earth materials in order to prepare the maps. In Idaho Falls-Rexburg and metro Boise, geotechnical properties of near-surface materials measured during construction projects were compiled and correlated with geologic map units. In Teton County, Pocatello, and the Sun Valley area, measurements of shallow shear-wave velocities (Vs30) were made. Both methods yield useful results but Vs30 data are preferred because they permit direct calculation of NEHRP site classes. Methods used in Pocatello are typical of Vs30 surveys. After obtaining permission from landowners, a 40 kg (88 lb) weight was dropped repeatedly on the ground to generate shallow seismic waves. Geophones connected to a 100 m (330 ft) long cable recorded the waves and transmitted them to a laptop computer for processing and computation of Vs30. The surveys do not damage property or vegetation. Vs30 was determined at 51 sites within Pocatello city limits, correlated with type and thickness of surficial geologic deposits in Pocatello, and used to produce a NEHRP site class map.

Table 3.6.O. NEHRP Soil Classifications

Soil Classification	Description
A	Hard Rock
B	Rock
C	Very dense soil and soft rock
D	Stiff soils
E	Soft soils

Source: FEMA 2013

Liquefaction Susceptibility Mapping

In order to determine the hazard posed to an area by liquefaction, two types of data are collected. First, geological and agricultural soil maps are used to outline areas underlain by bedrock or firm, consolidated deposits where liquefaction cannot occur. The maps, along with water well drilling logs, are further studied to identify regions with evidence for sandy, cohesionless materials. Such deposits can experience liquefaction during a strong earthquake if saturated. Second, data from water wells and agricultural soil maps are collected to identify areas subject to saturation by high water tables. It is fairly common in Idaho for saturation to occur at least seasonally as a result of spring run-off or irrigation practices. The two types of data are combined to produce maps showing High, Medium, or Low liquefaction hazards. High hazard areas possess both sandy, cohesionless materials and evidence for at least seasonal saturation. Medium hazard areas contain sandy, cohesionless materials but water tables are greater than 12 m (39 ft.) below the ground surface. Low hazard areas are underlain by bedrock or cohesive materials that cannot liquidize.

Summary of Mapping Results

In all areas mapped, the most common NEHRP site class is C (very dense soil and soft rock) with smaller regions of site class D (stiff soil) and even smaller areas of site class E (soft soil). Class D and E sites are generally located in or adjacent to wetlands along rivers. The liquefaction susceptibility hazard is classified as generally low in most populated regions. For example, Idaho Falls and substantial portions of the metro Boise area are largely built on well-drained, gravelly soils or areas of shallow bedrock. However, some developed regions of the Rexburg area and Teton County have potentially cohesionless deposits and high water tables. A notable finding is that the IGS mapping generally indicated reduced hazard risk when compared with the automated method used by USGS to estimate NERHP site class from topography. This is because low relief land surfaces may be assigned relatively high hazard (site class D) by the USGS because they are assumed to contain thick unconsolidated deposits. While true in many places elsewhere in the United States, in Idaho such land surfaces are often underlain by shallow volcanic rocks.

Methodology

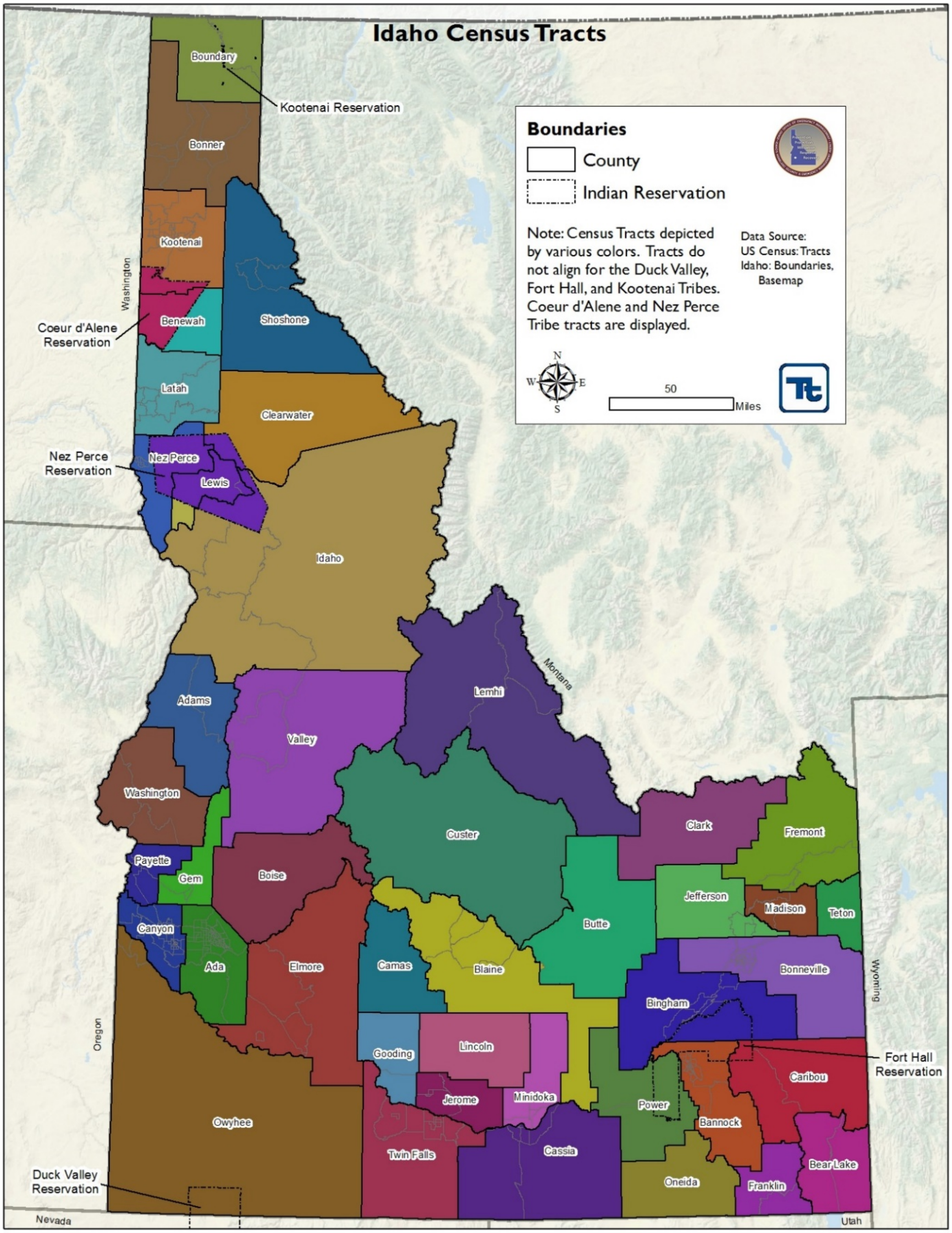
A Level 2 assessment was conducted in HAZUS-MH 4.0 for four different scenarios based on input from Idaho OEM. Three ShakeMap Scenarios were selected to assess vulnerability in three major urban areas and one historic event to assess the vulnerability utilizing the updated state asset and critical facility inventory:

- USGS ShakeMap: Eastern Bear Lake M7.3 (Pocatello)
- USGS ShakeMap: Lemhi M7.0 (Idaho Falls)
- USGS ShakeMap: Squaw Creek M7.0 (Boise)
- Historic Borah Peak event M6.9

The USGS ShakeMap data represents the potential for a future earthquake with a specified location, magnitude, and additional geologic information. Data for PGA, PGV, spectral response at 0.3 seconds and spectral response at 1.0 second are incorporated into Hazus-MH to run an earthquake model for the specified hypothetical event. Hazus-MH also has information regarding the observed geologic conditions for a multitude of historic earthquake events. The event data can be loaded to assess a hypothetical earthquake event similar to a historic one. The four scenarios estimated potential impacts to the default population and general building stock in Hazus-MH 4.0 and the updated user-defined State and critical facilities.

HAZUS-MH 4.0 generates results at the Census-tract level. Census tracts align with the county boundaries; however, the Census Tracts do not align with the Kootenai Tribe, Duck Valley, and Fort Hall Tribes boundaries. Therefore, loss estimates from HAZUS-MH will be incorporated into the results for the counties which encompass them. The Owyhee County boundary includes the Duck Valley Tribe; Bannock County, Bingham County, Caribou County, and Power County include the Fort Hall Tribe; and Boundary includes the Kootenai Tribe. Results in subsequent tables are presented for the U.S. Census tracts, with the associated jurisdictions listed for each tract. Figure 3.6.P shows spatial relationships between U.S. Census tracts and county and Tribal boundaries.

Figure 3.6.P. Idaho Census Tracts



Major highways, railways, and power/communication transmission lines are state assets with the potential to be impacted by a seismic event. State facilities that were constructed prior to the mid-1970, which have not yet been seismically retrofitted, are the most vulnerable; even those facilities constructed under building codes that reflected increased attention to seismicity may still be vulnerable to earthquakes. This is due to the fact that data and scientific analysis relating to earthquakes are continually being improved and enhanced. Therefore a structure built to 1980's construction codes would have increased vulnerability as compared to a similar structure built today.

To assess the State's exposure to the earthquake hazard, the 2014 USGS National Seismic Hazard Map for Peak Ground Acceleration was utilized. Tables 3.6.Q and 3.6.R summarize the number of State owned and leased buildings located in the high and moderate-high PGA risk zones by county and State agency, respectively.

The spatial analysis indicate that Fremont County has the greatest number of State buildings in the defined hazard area, and the Department of Parks and Recreation is the State agency with the greatest number located in the hazard area. Fremont County has 73 ($12.2 million) State owned and leased buildings located in the earthquake hazard area, which represents 38.2% of the county's total number of State buildings. Overall, 3.4% of the State's owned and leased buildings are located in the high and moderate high seismic zones, which is approximately $21.5 million.

Table 3.6.S summarizes the total number of critical facilities located in the hazard area by County and Tribal Nation. At the county level, both Custer County and Franklin County have 100% of their critical facilities located in the earthquake hazard area. Additionally, Bear Lake County, Caribou County, and Oneida County have over 90% of their critical facilities located in the hazard area.

Table 3.6.Q. Number of State-Owned and Leased Buildings Located in the High and Moderate-High PGA Seismic Risk Zones by Jurisdiction

	State-Owned Buildings		State-Leased Buildings		Total	
Jurisdiction	Number in the Earthquake Hazard Area	Value in the Earthquake Hazard Area	Number in the Earthquake Hazard Area	Value in the Earthquake Hazard Area	Total Number of Buildings	Total Value
Ada County	0	$0	0	$0	589	$2,989,418,989
Adams County	0	$0	0	$0	3	$1,783,594
Bannock County	0	$0	0	$0	156	$1,103,616,221
Bear Lake County	5	$735,496	0	$0	5	$735,496
Benewah County	0	$0	0	$0	1	$2,749,464
Bingham County	0	$0	0	$0	90	$77,767,107
Blaine County	0	$0	0	$0	22	$5,902,697
Boise County	0	$0	0	$0	17	$2,887,850
Bonner County	0	$0	0	$0	64	$15,374,769
Bonneville County	2	$62,130	0	$0	55	$128,187,998
Boundary County	0	$0	0	$0	10	$2,921,183
Butte County	0	$0	0	$0	0	$0

Jurisdiction	State-Owned Buildings		State-Leased Buildings		Total	
	Number in the Earthquake Hazard Area	Value in the Earthquake Hazard Area	Number in the Earthquake Hazard Area	Value in the Earthquake Hazard Area	Total Number of Buildings	Total Value
Camas County	0	$0	0	$0	0	$0
Canyon County	0	$0	0	$0	217	$150,244,776
Caribou County	15	$2,277,825	0	$0	15	$2,277,825
Cassia County	0	$0	0	$0	28	$3,167,401
Clark County	1	$7,880	0	$0	2	$71,311
Clearwater County	0	$0	0	$0	6	$258,189
Coeur D'Alene Tribe	0	$0	0	$0	21	$8,410,014
Custer County	19	$2,331,691	0	$0	19	$2,331,691
Duck Valley Tribe	0	$0	0	$0	0	$0
Elmore County	0	$0	0	$0	33	$8,637,861
Fort Hall Tribe	0	$0	0	$0	1	$4,546,934
Franklin County	7	$2,244,517	0	$0	7	$2,244,517
Fremont County	73	$12,232,698	0	$0	191	$59,931,586
Gem County	0	$0	0	$0	8	$1,846,444
Gooding County	0	$0	0	$0	88	$49,454,311
Idaho County	0	$0	0	$0	27	$21,047,034
Jefferson County	0	$0	0	$0	50	$19,079,527
Jerome County	0	$0	0	$0	18	$13,471,464
Kootenai County	0	$0	0	$0	71	$83,386,890
Kootenai Tribe	0	$0	0	$0	0	$0
Latah County	0	$0	0	$0	390	$1,497,479,249
Lemhi County	2	$156,994	0	$0	48	$11,258,674
Lewis County	0	$0	0	$0	0	$0
Lincoln County	0	$0	0	$0	20	$11,258,939
Madison County	0	$0	0	$0	4	$3,514,980
Minidoka County	0	$0	0	$0	9	$6,314,545
Nez Perce County	0	$0	0	$0	135	$305,323,161
Nez Perce Tribe	0	$0	0	$0	62	$26,895,878
Oneida County	2	$832,428	0	$0	2	$832,428
Owyhee County	0	$0	0	$0	12	$2,639,778
Payette County	0	$0	0	$0	7	$3,405,151
Power County	0	$0	0	$0	33	$4,323,726
Shoshone County	0	$0	0	$0	8	$2,604,226
Teton County	2	$669,927	0	$0	27	$8,821,471
Twin Falls County	0	$0	0	$0	63	$86,924,836
Valley County	0	$0	0	$0	58	$9,575,027
Washington County	0	$0	0	$0	21	$2,024,672
Idaho Total	**128**	**$21,551,586**	**0**	**$0**	**2,713**	**$6,744,949,885**

Source: USGS 2014, Risk Management Technical Records

Table 3.6.R. Number of State-Owned and Leased Buildings Located in the High and Moderate-High PGA Seismic Risk Zones by Jurisdiction

	State-Owned Buildings		State-Leased Buildings		Total	
Agency	Number in the Earthquake Hazard Area	Value in the Earthquake Hazard Area	Number in the Earthquake Hazard Area	Value in the Earthquake Hazard Area	Total Number of Buildings	Total Value
Administration - Department Of	0	$0	0	$0	16	$545,649,861
Blind Commission	0	$0	0	$0	1	$12,931,760
Board Of Pharmacy	0	$0	0	$0	1	$550,280
Boise State University	0	$0	0	$0	216	$1,478,845,528
Boise Veteran's Home	0	$0	0	$0	3	$35,009,037
Commission On The Arts	0	$0	0	$0	1	$178,978
Correctional Industries	0	$0	0	$0	4	$12,070,521
Dairy Products Commission	0	$0	0	$0	1	$2,302,604
Deaf And Blind School	0	$0	0	$0	17	$35,062,732
Department Of Agriculture	0	$0	0	$0	8	$19,838,429
Department Of Corrections	0	$0	0	$0	111	$566,639,088
Department Of Fish And Game	49	$5,859,835	0	$0	503	$106,038,567
Department Of Juvenile Corrections	0	$0	0	$0	196	$58,581,570
Department Of Labor	0	$0	0	$0	9	$46,110,479
Department Of Lands	0	$0	0	$0	115	$56,967,411
Department Of Parks And Recreation	60	$10,839,028	0	$0	242	$50,186,766
Department Of Transportation	9	$1,033,702	0	$0	228	$160,342,438
Department Of Transportation-Aeronautics	0	$0	0	$0	3	$2,559,109
Department Of Water Resources	0	$0	0	$0	1	$160,000
Dept Of Health & Welfare, Region I	0	$0	0	$0	1	$612,067
Dept Of Health & Welfare, Region II	0	$0	0	$0	1	$1,842,609
Dept. Of Health & Welfare, Region V	0	$0	0	$0	2	$3,859,869
Dept. Of Health & Welfare, Region VI	0	$0	0	$0	3	$7,875,177
Eastern Idaho Technical College	0	$0	0	$0	8	$76,544,215
Historical Society	4	$287,300	0	$0	52	$61,850,665
Idaho Barley Commission	0	$0	0	$0	1	$10,506
Idaho Crop Improvement Association	0	$0	0	$0	5	$1,875,876
Idaho State University	1	$202,154	0	$0	118	$1,071,183,355
Idaho Wheat Commission	0	$0	0	$0	1	$888,285

Agency	State-Owned Buildings		State-Leased Buildings		Total	
	Number in the Earthquake Hazard Area	Value in the Earthquake Hazard Area	Number in the Earthquake Hazard Area	Value in the Earthquake Hazard Area	Total Number of Buildings	Total Value
IDHW - Bureau Of Laboratories	0	$0	0	$0	1	$19,366,868
IDHW - State Hospital North	0	$0	0	$0	14	$19,793,423
IDHW - State Hospital South	0	$0	0	$0	14	$50,573,434
IDHW - Welfare Medicaid Operations	0	$0	0	$0	1	$113,141
IDHW Southwest Idaho Treatment Center	0	$0	0	$0	31	$65,257,596
ISP - Idaho State Police	0	$0	0	$0	15	$74,050,639
Lava Hot Springs Foundation	0	$0	0	$0	10	$14,994,779
Lewis-Clark State College	0	$0	0	$0	41	$228,497,894
Lewiston Veteran's Home	0	$0	0	$0	2	$12,096,807
Lottery Commission	0	$0	0	$0	2	$14,665
Military Division	3	$1,957,217	0	$0	70	$70,015,196
Pocatello Veteran's Home	0	$0	0	$0	4	$13,558,252
Public Employees Retirement System	0	$0	0	$0	2	$12,602,747
Public Health District 1 (Panhandle)	0	$0	0	$0	7	$17,949,011
Public Health District 2 (North Central)	0	$0	0	$0	5	$10,948,557
Public Health District 3 (Southwest)	0	$0	0	$0	5	$9,551,538
Public Health District 4 (Central)	0	$0	0	$0	3	$10,807,899
Public Health District 5 (South Central)	0	$0	0	$0	5	$8,898,081
Public Health District 6 (South Eastern)	1	$710,301	0	$0	3	$8,479,572
Public Health District 7 (Eastern)	1	$662,047	0	$0	9	$10,187,921
State Insurance Fund	0	$0	0	$0	2	$21,023,875
State Liquor Division	0	$0	0	$0	1	$14,451,435
University Of Idaho	0	$0	0	$0	590	$1,631,136,168
Veterans State Cemetery	0	$0	0	$0	8	$4,012,608
Total	**128**	**$21,551,586**	**0**	**$0**	**2,713**	**$6,744,949,885**

Source: USGS 2014, Risk Management Technical Records

Table 3.6.S. Number of County Critical Facilities Located in the High and Moderate-High PGA Seismic Risk Zones by Jurisdiction

Jurisdiction	Total Number of Critical Facilities	Number of Critical Facilities in the Earthquake Area	Percent (%) of Total
Ada County	1,078	0	0.0%
Adams County	96	0	0.0%
Bannock County	513	1	<1%
Bear Lake County	152	151	99.3%
Benewah County	67	0	0.0%
Bingham County	334	4	1.2%
Blaine County	320	17	5.3%
Boise County	157	8	5.1%
Bonner County	466	0	0.0%
Bonneville County	493	27	5.5%
Boundary County	206	0	0.0%
Butte County	80	3	3.8%
Camas County	41	0	0.0%
Canyon County	961	0	0.0%
Caribou County	220	208	94.5%
Cassia County	272	0	0.0%
Clark County	66	8	12.1%
Clearwater County	114	0	0.0%
Coeur D'Alene Tribe	126	0	0.0%
Custer County	122	122	100.0%
Duck Valley Tribe	1	0	0.0%
Elmore County	374	0	0.0%
Fort Hall Tribe	34	0	0.0%
Franklin County	207	207	100.0%
Fremont County	228	57	25.0%
Gem County	204	0	0.0%
Gooding County	216	0	0.0%
Idaho County	197	0	0.0%
Jefferson County	187	0	0.0%
Jerome County	236	0	0.0%
Kootenai County	758	0	0.0%
Kootenai Tribe	0	0	0.0%
Latah County	366	0	0.0%
Lemhi County	182	33	18.1%
Lewis County	0	0	0.0%
Lincoln County	129	0	0.0%
Madison County	173	0	0.0%
Minidoka County	196	0	0.0%
Nez Perce County	116	0	0.0%
Nez Perce Tribe	335	0	0.0%
Oneida County	111	108	97.3%

Jurisdiction	Total Number of Critical Facilities	Number of Critical Facilities in the Earthquake Area	Percent (%) of Total
Owyhee County	252	0	0.0%
Payette County	267	0	0.0%
Power County	161	0	0.0%
Shoshone County	210	0	0.0%
Teton County	111	65	58.6%
Twin Falls County	761	0	0.0%
Valley County	314	2	<1%
Washington County	241	0	0.0%
Idaho Total	**12,451**	**1,021**	**8.2%**

Source: USGS 2014, ICRMP, HSIP, IOEM, IDWR

Table 3.6.T below lists the miles of canals that are Located in the earthquake hazard area by Jurisdiction. Since the soil of the canals will be saturated, they may be subject to liquefaction, which could compromise the integrity and quality of the canals. All canals in Custer County and Franklin County are located in the earthquake hazard area. Ada County has the greatest percentage of canals located in the soft NEHRP soils and very high liquefaction susceptibility zones. Ada County also has the greatest total length of canals located in the soft NEHRP soils (20.4 mi), while Canyon County has the greatest total length of canals in the liquefaction hazard area (87.4 mi).

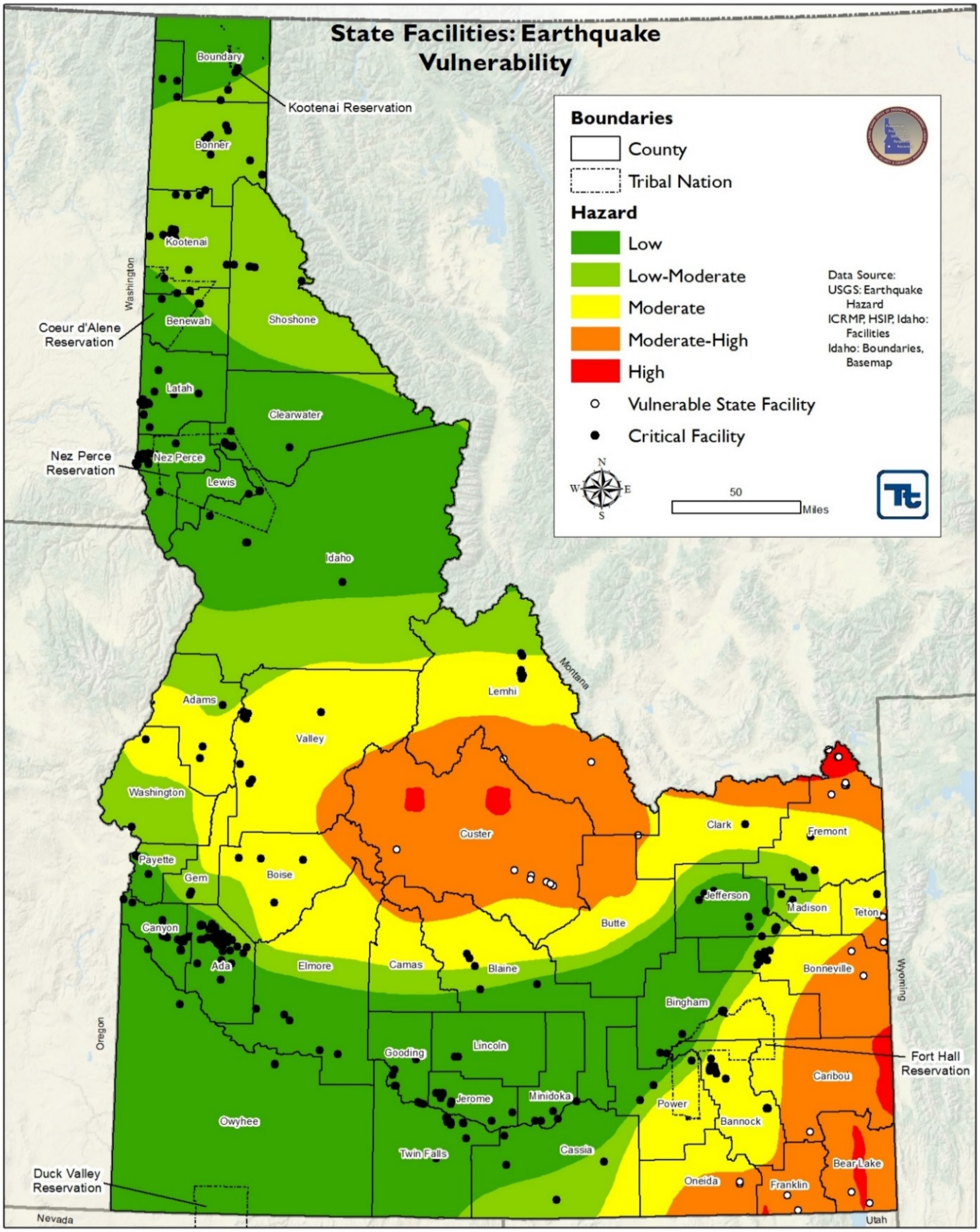
Table 3.6.T. Canals Located in the High and Moderate-High PGA Seismic Risk Zones, Soft NEHRP Soils (Class E), Very High Liquefaction Susceptibility Zones by Jurisdiction

Jurisdiction	Total Canal Length (mi)	PGA Risk Exposed Length (mi)	Percent (%) of Total	NEHRP Exposed Length (mi)	Percent (%) of Total	Liquefaction Exposed Length (mi)	Percent (%) of Total
Ada County	422.0	0.0	0.0%	20.4	4.8%	53.6	12.7%
Adams County	28.7	0.0	0.0%	0.0	0.0%	0.0	0.0%
Bannock County	92.6	13.3	14.3%	0.0	0.0%	0.0	0.0%
Bear Lake County	198.7	195.6	98.4%	0.0	0.0%	0.0	0.0%
Benewah County	0.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Bingham County	455.6	0.0	0.0%	3.6	<1%	23.8	5.2%
Blaine County	114.5	0.0	0.0%	0.0	0.0%	0.0	0.0%
Boise County	10.6	0.0	0.0%	0.0	0.0%	0.0	0.0%
Bonner County	1.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Bonneville County	385.4	6.1	1.6%	12.5	3.2%	19.3	5.0%
Boundary County	72.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Butte County	166.9	40.8	24.4%	0.0	0.0%	0.0	0.0%
Camas County	4.9	0.0	0.0%	0.0	0.0%	0.0	0.0%
Canyon County	855.0	0.0	0.0%	19.4	2.3%	87.4	10.2%
Caribou County	168.2	142.9	85.0%	0.0	0.0%	0.0	0.0%
Cassia County	625.1	0.0	0.0%	0.0	0.0%	0.0	0.0%

Clark County	66.9	41.2	61.7%	0.0	0.0%	0.0	0.0%
Clearwater County	0.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Coeur D'Alene Tribe	5.3	0.0	0.0%	0.0	0.0%	0.0	0.0%
Custer County	115.9	115.9	100.0%	0.0	0.0%	0.0	0.0%
Duck Valley Tribe	21.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Elmore County	197.2	0.0	0.0%	0.0	0.0%	0.0	0.0%
Fort Hall Tribe	201.7	0.0	0.0%	0.1	<1%	3.6	1.8%
Franklin County	214.2	214.2	100.0%	0.0	0.0%	0.0	0.0%
Fremont County	366.2	20.7	5.6%	0.0	0.0%	0.0	0.0%
Gem County	117.2	0.0	0.0%	0.0	0.0%	0.0	0.0%
Gooding County	383.1	0.0	0.0%	0.0	0.0%	0.0	0.0%
Idaho County	22.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Jefferson County	401.0	0.0	0.0%	12.4	3.1%	6.0	1.5%
Jerome County	431.5	0.0	0.0%	0.0	0.0%	0.0	0.0%
Kootenai County	26.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Kootenai Tribe	6.8	0.0	0.0%	0.0	0.0%	0.0	0.0%
Latah County	0.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Lemhi County	111.2	74.6	67.1%	0.0	0.0%	0.0	0.0%
Lewis County	0.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Lincoln County	220.8	0.0	0.0%	0.0	0.0%	0.0	0.0%
Madison County	165.8	0.0	0.0%	0.4	<1%	7.7	4.6%
Minidoka County	252.6	0.0	0.0%	0.0	0.0%	0.0	0.0%
Nez Perce County	1.6	0.0	0.0%	0.0	0.0%	0.0	0.0%
Nez Perce Tribe	10.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Oneida County	39.8	39.2	98.6%	0.0	0.0%	0.0	0.0%
Owyhee County	349.6	0.0	0.0%	8.7	2.5%	0.3	0.1%
Payette County	230.2	0.0	0.0%	2.3	1.0%	0.0	0.0%
Power County	57.7	0.0	0.0%	0.0	0.0%	0.0	0.0%
Shoshone County	0.0	0.0	0.0%	0.0	0.0%	0.0	0.0%
Teton County	82.3	45.1	54.8%	0.0	0.0%	0.0	0.0%
Twin Falls County	500.4	0.0	0.0%	0.0	0.0%	0.0	0.0%
Valley County	59.4	0.0	0.0%	0.0	0.0%	0.0	0.0%
Washington County	55.5	0.0	0.0%	0.0	0.0%	0.0	0.0%
Idaho Total	**8,315.6**	**949.6**	**11.4%**	**79.7**	**1.0%**	**201.6**	**2.4%**

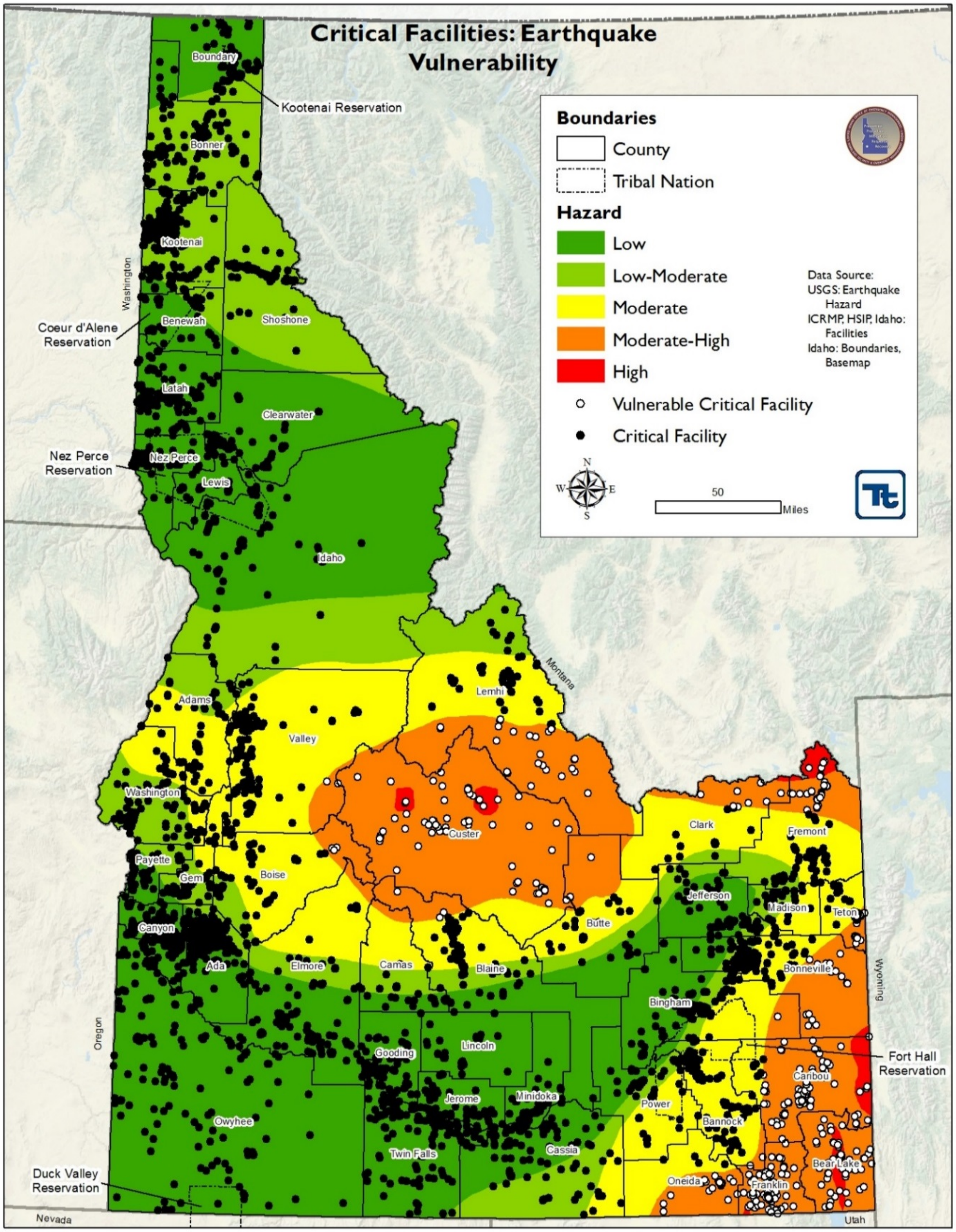
Source: IOEM, USGS 2014

Figure 3.6.U. State Facilities: Earthquake Vulnerability



Note: State facility = State owned- or State-leased building. A vulnerable facility is a facility located in the identified hazard area.

Figure 3.6.V. Critical Facilities: Earthquake Vulnerability



Note: State facility = State owned- or State-leased building.
A vulnerable facility is a facility located in the identified hazard area.

Hazard Mitigation Vulnerability Assessments

This section discusses the vulnerability of jurisdictions to areas susceptible to earthquakes. It provides a summary of vulnerability and potential losses to population and buildings by jurisdiction and discusses the jurisdictions most threatened by the earthquake hazard. The exposure analysis was conducted using the USGS Probabilistic Seismic Hazard data (high and moderate-high seismic risk zones) and the 2010 U.S. Census Block population data and default general building stock data, which is presented in the dasymetric census block data from HAZUS-MH 4.0. Blocks with their centroid in the hazard area were deemed exposed and potentially vulnerable to the hazard.

Population

Table 3.6.W lists the population located in the identified earthquake hazard area. Both Bear Lake County and Franklin County have 100% of their population located in the moderate-high and high seismic zones. Overall, the State has 44,611 people, or 2.8% of its population located in the hazard area.

The entire population of Idaho is potentially vulnerable to seismic risk; however, populations considered most vulnerable include the elderly (persons over the age of 65) and individuals living below the U.S. Census poverty threshold. These socially vulnerable populations are most susceptible based on a number of factors including their physical and financial ability to react or respond during a hazard, the location and construction quality of their housing, and the ability to be self-sustaining for prolonged periods of time after an incident because of limited ability to stockpile supplies. Custer County has the greatest proportion of its total population comprised of socially vulnerable populations located in the hazard area. As noted, Bear Lake and Franklin Counties are located in the earthquake hazard area in their entirety; therefore 100% of their total socially vulnerable populations exposed to this hazard. Refer to Chapter 2 (State Profile) which summarizes the State's demographics by jurisdiction.

Table 3.6.W. 2010 U.S. Census Population Located in the High and Moderate-High PGA Seismic Risk Zones by Jurisdiction

Jurisdiction	Total Population	Population Located in the Earthquake Hazard Area	Percent (%) of Total Population	Population Over 65 Located in the Earthquake Hazard Area	Percent (%) of Total Population	Low Income Population Located in the Earthquake Hazard Area	Percent (%) of Total Population
Ada County	392,365	0	0.0%	0	0.0%	0	0.0%
Adams County	3,976	0	0.0%	0	0.0%	0	0.0%
Bannock County	80,722	64	<1%	12	0.0%	3	0.0%
Bear Lake County	5,986	5,986	100.0%	1,104	18.4%	482	8.1%
Benewah County	4,743	0	0.0%	0	0.0%	0	0.0%
Bingham County	42,775	0	0.0%	0	0.0%	0	0.0%
Blaine County	21,376	442	2.1%	73	<1%	12	<1%
Boise County	7,028	37	<1%	22	<1%	5	<1%
Bonner County	40,877	0	0.0%	0	0.0%	0	0.0%
Bonneville County	104,234	792	<1%	177	<1%	104	<1%

Boundary County	10,858	0	0.0%	0	0.0%	0	0.0%
Butte County	2,891	250	8.6%	35	1.2%	15	<1%
Camas County	1,117	0	0.0%	0	0.0%	0	0.0%
Canyon County	188,923	0	0.0%	0	0.0%	0	0.0%
Caribou County	6,963	6,782	97.4%	1,069	15.4%	369	5.3%
Cassia County	22,952	0	0.0%	0	0.0%	0	0.0%
Clark County	982	15	1.5%	3	<1%	2	<1%
Clearwater County	3,038	0	0.0%	0	0.0%	0	0.0%
Coeur D'Alene Tribe	6,765	0	0.0%	0	0.0%	0	0.0%
Custer County	4,368	4,329	99.1%	816	18.7%	506	11.6%
Duck Valley Tribe	356	0	0.0%	0	0.0%	0	0.0%
Elmore County	27,038	0	0.0%	0	0.0%	0	0.0%
Fort Hall Tribe	5,769	0	0.0%	0	0.0%	0	0.0%
Franklin County	12,786	12,786	100.0%	1,643	12.8%	704	5.5%
Fremont County	13,242	1,043	7.9%	290	2.2%	71	<1%
Gem County	16,719	0	0.0%	0	0.0%	0	0.0%
Gooding County	15,464	0	0.0%	0	0.0%	0	0.0%
Idaho County	11,936	0	0.0%	0	0.0%	0	0.0%
Jefferson County	26,140	0	0.0%	0	0.0%	0	0.0%
Jerome County	22,374	0	0.0%	0	0.0%	0	0.0%
Kootenai County	136,271	0	0.0%	0	0.0%	0	0.0%
Kootenai Tribe	114	0	0.0%	0	0.0%	0	0.0%
Latah County	37,244	0	0.0%	0	0.0%	0	0.0%
Lemhi County	7,936	891	11.2%	212	2.7%	138	1.7%
Lewis County	36	0	0.0%	0	0.0%	0	0.0%
Lincoln County	5,208	0	0.0%	0	0.0%	0	0.0%
Madison County	37,536	0	0.0%	0	0.0%	0	0.0%
Minidoka County	20,069	0	0.0%	0	0.0%	0	0.0%
Nez Perce County	34,664	0	0.0%	0	0.0%	0	0.0%
Nez Perce Tribe	18,440	0	0.0%	0	0.0%	0	0.0%
Oneida County	4,286	3,889	90.7%	673	15.7%	329	7.7%
Owyhee County	11,170	0	0.0%	0	0.0%	0	0.0%
Payette County	22,623	0	0.0%	0	0.0%	0	0.0%
Power County	6,997	0	0.0%	0	0.0%	0	0.0%
Shoshone County	12,765	0	0.0%	0	0.0%	0	0.0%
Teton County	10,170	7,305	71.8%	424	4.2%	266	2.6%
Twin Falls County	77,230	0	0.0%	0	0.0%	0	0.0%

Valley County	9,862	0	0.0%	0	0.0%	0	0.0%
Washington County	10,198	0	0.0%	0	0.0%	0	0.0%
Idaho Total	**1,567,582**	**44,611**	**2.8%**	**6,553**	**<1%**	**3,006**	**<1%**

Source: US Census 2010, USGS 2014

Residents may be displaced or may require temporary to long-term sheltering because of an earthquake event. The number of people requiring shelter is generally less than the number displaced, as some displaced persons use hotels or stay with family or friends following a disaster event. Impacts on persons and households in the planning area were estimated for the four earthquake scenarios through the Level 2 HAZUS-MH analysis; results of these analyses are summarized in Table 3.6.X.

HAZUS-MH 4.0 estimates the number of people that may potentially be injured and/or killed by an earthquake depending on the time of day the event occurs. These estimates are provided for three times of day (2:00 a.m., 2:00 p.m. and 5:00 p.m.), representing the periods of the day that different sectors of the community are at their peak. The 2:00 am estimate considers the residential occupancy at its maximum; the 2:00 p.m. estimate considers the educational, commercial, and industrial sector at their maximum; and the 5:00 p.m. estimate represents peak commuter time. Table 3.6.Y and Table 3.6.Z summarize the injuries and casualties estimated for four earthquake scenarios.

Table 3.6.X. Estimated Shelter Requirements

Jurisdiction	Eastern Bear Lake		Lemhi		Squaw Creek		Borah Peak	
	Displaced Households	Short-Term Sheltering Needs	Displaced Households	Short-Term Sheltering Needs	Displaced Households	Short-Term Sheltering Needs	Displaced Households	Short-Term Sheltering Needs
Ada County	0	0	0	0	8	4	0	0
Adams County	0	0	0	0	0	0	0	0
Bannock County	0	0	0	0	0	0	0	0
Bear Lake County	6	4	0	0	0	0	0	0
Benewah County	0	0	0	0	0	0	0	0
Bingham County	0	0	0	0	0	0	0	0
Blaine County	0	0	0	0	0	0	21	12
Boise County	0	0	0	0	0	0	0	0
Bonner County	0	0	0	0	0	0	0	0
Bonneville County	0	0	0	0	0	0	0	0
Boundary County	0	0	0	0	0	0	0	0
Butte County	0	0	1	1	1	1	0	0
Camas County	0	0	0	0	0	0	0	0
Canyon County	0	0	0	0	2	2	0	0

Jurisdiction	Eastern Bear Lake		Lemhi		Squaw Creek		Borah Peak	
	Displaced Households	Short-Term Sheltering Needs	Displaced Households	Short-Term Sheltering Needs	Displaced Households	Short-Term Sheltering Needs	Displaced Households	Short-Term Sheltering Needs
Caribou County	0	0	0	0	0	0	0	0
Cassia County	0	0	0	0	0	0	0	0
Clark County	0	0	0	0	0	0	0	0
Clearwater County	0	0	0	0	0	0	0	0
Coeur D’Alene Tribe	0	0	0	0	0	0	0	0
Custer County	0	0	0	0	0	0	1	0
Elmore County	0	0	0	0	0	0	0	0
Franklin County	0	0	0	0	0	0	0	0
Fremont County	0	0	0	0	0	0	0	0
Gem County	0	0	0	0	18	11	0	0
Gooding County	0	0	0	0	0	0	0	0
Idaho County	0	0	0	0	0	0	0	0
Jefferson County	0	0	0	0	0	0	0	0
Jerome County	0	0	0	0	0	0	0	0
Kootenai County	0	0	0	0	0	0	0	0
Latah County	0	0	0	0	0	0	0	0
Lemhi County	0	0	0	0	0	0	0	0
Lewis County	0	0	0	0	0	0	0	0
Lincoln County	0	0	0	0	0	0	0	0
Madison County	0	0	0	0	0	0	0	0
Minidoka County	0	0	0	0	0	0	0	0
Nez Perce County	0	0	0	0	0	0	0	0
Nez Perce Tribe	0	0	0	0	0	0	0	0
Oneida County	0	0	0	0	0	0	0	0
Owyhee County	0	0	0	0	0	0	0	0
Payette County	0	0	0	0	0	0	0	0
Power County	0	0	0	0	0	0	0	0
Shoshone County	0	0	0	0	0	0	0	0
Teton County	0	0	0	0	0	0	0	0
Twin Falls County	0	0	0	0	0	0	0	0
Valley County	0	0	0	0	0	0	0	0

Jurisdiction	Eastern Bear Lake		Lemhi		Squaw Creek		Borah Peak	
	Displaced Households	Short-Term Sheltering Needs	Displaced Households	Short-Term Sheltering Needs	Displaced Households	Short-Term Sheltering Needs	Displaced Households	Short-Term Sheltering Needs
Washington County	0	0	0	0	0	0	0	0
Idaho Total	**6**	**4**	**1**	**1**	**29**	**18**	**23**	**13**

Source: HAZUS-MH v4.0

Table 3.6.Y. Estimated Injuries and Casualties for Eastern Bear Lake and Lemhi ShakeMap Scenarios

Level of Severity	Eastern Bear Lake			Lemhi		
	2:00 AM	2:00 PM	5:00 PM	2:00 AM	2:00 PM	5:00 PM
Injuries	5	7	5	3	2	2
Hospitalization	1	1	1	0	0	0
Casualties	0	0	0	0	0	0

Source: HAZUS-MH v4.0

Table 3.6.Z. Estimated Injuries and Casualties for Squaw Creek ShakeMap and Borah Peak Scenarios

Level of Severity	Squaw Creek			Borah Peak		
	2:00 AM	2:00 PM	5:00 PM	2:00 AM	2:00 PM	5:00 PM
Injuries	42	57	40	7	10	8
Hospitalization	3	7	4	1	2	1
Casualties	0	1	1	0	0	0

Source: HAZUS-MH v4.0

General Building Stock

Similar to the analyses presented earlier, the general building stock data was overlaid with the earthquake hazard area to assess vulnerability. Table 3.6.AA lists the number of buildings and total replacement cost by jurisdiction located in the hazard area. Overall, both Bear Lake County and Franklin County have their entire building stock inventory located in the earthquake hazard area.

Table 3.6.AA. Estimated General Building Stock Located in the High and Moderate-High PGA Seismic Risk Zones by Jurisdiction

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value	Number of Buildings Located in the Earthquake Hazard Area	Percent (%) of Total Buildings	Value Located in the Earthquake Hazard Area	Percent (%) of Total Value
Ada County	94,345	$67,917,280,000	0	0.0%	$0	0.0%
Adams County	2,824	$768,231,000	0	0.0%	$0	0.0%
Bannock County	16,672	$12,223,383,000	42	<1%	$11,278,000	<1%
Bear Lake County	3,911	$1,196,118,000	3,911	100.0%	$1,196,118,000	100.0%
Benewah County	2,456	$698,652,000	0	0.0%	$0	0.0%
Bingham County	6,206	$5,405,079,000	8	<1%	$2,223,000	<1%
Blaine County	12,602	$5,476,705,000	477	3.8%	$302,088,000	5.5%
Boise County	5,475	$1,497,585,000	54	1.0%	$16,790,000	1.1%
Bonner County	24,133	$7,701,597,000	0	0.0%	$0	0.0%
Bonneville County	21,966	$18,775,427,000	842	3.8%	$245,932,000	1.3%
Boundary County	5,112	$1,556,926,000	0	0.0%	$0	0.0%
Butte County	1,127	$452,406,000	79	7.0%	$29,355,000	6.5%
Camas County	762	$247,126,000	0	0.0%	$0	0.0%
Canyon County	25,059	$24,048,014,000	0	0.0%	$0	0.0%
Caribou County	2,880	$1,176,048,000	2,771	96.2%	$1,143,940,000	97.3%
Cassia County	1,389	$3,061,608,000	0	0.0%	$0	0.0%
Clark County	419	$124,419,000	52	12.4%	$10,258,000	8.2%
Clearwater County	2,028	$625,216,000	0	0.0%	$0	0.0%
Coeur D'Alene Tribe	3,651	$1,379,028,000	0	0.0%	$0	0.0%
Custer County	2,603	$987,374,000	2,570	98.7%	$980,148,000	99.3%
Duck Valley Tribe	52	$15,524,000	0	0.0%	$0	0.0%
Elmore County	954	$3,778,122,000	0	0.0%	$0	0.0%
Fort Hall Tribe	250	$596,710,000	0	0.0%	$0	0.0%
Franklin County	4,943	$1,742,513,000	4,943	100.0%	$1,742,513,000	100.0%
Fremont County	8,810	$2,807,781,000	3,879	44.0%	$1,300,502,000	46.3%
Gem County	7,294	$2,308,168,000	0	0.0%	$0	0.0%
Gooding County	907	$1,934,143,000	0	0.0%	$0	0.0%
Idaho County	4,252	$2,057,570,000	0	0.0%	$0	0.0%
Jefferson County	2,127	$3,163,139,000	0	0.0%	$0	0.0%
Jerome County	1,461	$2,620,168,000	0	0.0%	$0	0.0%
Kootenai County	50,322	$22,058,607,000	0	0.0%	$0	0.0%
Kootenai Tribe	50	$13,200,000	0	0.0%	$0	0.0%
Latah County	12,216	$5,264,747,000	0	0.0%	$0	0.0%
Lemhi County	4,833	$1,429,223,000	697	14.4%	$164,914,000	11.5%

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value	Number of Buildings Located in the Earthquake Hazard Area	Percent (%) of Total Buildings	Value Located in the Earthquake Hazard Area	Percent (%) of Total Value
Lewis County	34	$11,318,000	0	0.0%	$0	0.0%
Lincoln County	156	$629,652,000	0	0.0%	$0	0.0%
Madison County	4,371	$3,682,487,000	0	0.0%	$0	0.0%
Minidoka County	2,141	$2,594,005,000	0	0.0%	$0	0.0%
Nez Perce County	14,271	$6,382,936,000	0	0.0%	$0	0.0%
Nez Perce Tribe	8,389	$2,580,646,000	0	0.0%	$0	0.0%
Oneida County	1,995	$684,026,000	1,854	92.9%	$616,246,000	90.1%
Owyhee County	1,140	$1,258,911,000	0	0.0%	$0	0.0%
Payette County	8,108	$2,900,679,000	0	0.0%	$0	0.0%
Power County	80	$1,011,694,000	0	0.0%	$0	0.0%
Shoshone County	7,056	$2,248,057,000	0	0.0%	$0	0.0%
Teton County	5,156	$1,793,082,000	3,692	71.6%	$1,321,802,000	73.7%
Twin Falls County	17,970	$11,430,233,000	0	0.0%	$0	0.0%
Valley County	11,335	$3,764,632,000	0	0.0%	$0	0.0%
Washington County	4,642	$1,615,788,000	0	0.0%	$0	0.0%
Idaho Total	**420,935**	**247,695,983,000**	**25,871**	**6.1%**	**$9,084,107,000**	**3.7%**

Source: HAZUS-MH v4.0, USGS, 2014

HAZUS-MH estimates the direct building losses to repair or replace the damage caused to the building. According to NYCEM, a building's construction determines how well it can withstand the force of an earthquake. The NYCEM report indicates that unreinforced masonry buildings are most at risk during an earthquake because the walls are prone to collapse outward, whereas steel and wood buildings absorb more of the earthquake's energy. Additional attributes that contribute to a building's capability to withstand an earthquake's force include its age, number of stories, and quality of construction. HAZUS-MH considers building construction and the age of buildings as part of the analysis. Because the default general building stock was used for this HAZUS-MH analysis, the default building ages and building types already incorporated into the inventory were used. Table 3.6.BB summarizes the estimated potential losses to the statewide building inventory per earthquake scenario per jurisdiction. Figures 3.6.CC through 3.6.FF below display the potential losses per square mile for each of the four earthquake scenarios.

Table 3.6.BB. Earthquake Estimated Potential Losses to Buildings (Structure and Contents) HAZUS-MH Scenarios

Jurisdiction	Eastern Bear Lake	Lemhi	Squaw Creek	Borah Peak
Ada County	$0	$0	$155,391,022	$0
Adams County	$0	$0	$146,529	$0
Bannock County	$984,889	$258,146	$258,146	$58,831

Jurisdiction	Eastern Bear Lake	Lemhi	Squaw Creek	Borah Peak
Bear Lake County	$30,099,296	$0	$0	$0
Benewah County	$0	$0	$0	$0
Bingham County	$458,174	$1,243,562	$1,243,562	$183,986
Blaine County	$1,807,171	$90,349	$1,204	$32,940,871
Boise County	$0	$0	$1,496,942	$0
Bonner County	$0	$0	$0	$0
Bonneville County	$1,249,595	$3,827,090	$3,827,090	$247,630
Boundary County	$0	$0	$0	$0
Butte County	$229	$5,276,292	$5,276,292	$379,355
Camas County	$11,535	$324	$288	$84,273
Canyon County	$0	$0	$46,634,332	$0
Caribou County	$1,841,691	$687	$687	$0
Cassia County	$987	$4,680	$4,680	$330,303
Clark County	$0	$36,148	$36,148	$8,446
Clearwater County	$0	$0	$0	$0
Coeur D’Alene Tribe	$0	$0	$0	$0
Custer County	$0	$1,633,912	$0	$4,495,047
Elmore County	$1,645	$169	$132,005	$39,593
Franklin County	$2,379,896	$1,533,770	$1,533,770	$0
Fremont County	$15,410	$96,668	$96,668	$0
Gem County	$0	$0	$56,333,014	$0
Gooding County	$20,961	$521	$594	$260,913
Idaho County	$0	$0	$274	$0
Jefferson County	$64,509	$1,555,456	$1,555,456	$68,929
Jerome County	$35,060	$227	$0	$402,740
Kootenai County	$0	$0	$0	$0
Latah County	$0	$0	$0	$0
Lemhi County	$18,530	$1,754,866	$17,862	$687,563
Lewis County	$0	$0	$0	$0
Lincoln County	$0	$7,504	$0	$349,732
Madison County	$43,902	$276,294	$276,294	$0
Minidoka County	$11,550	$59,835	$59,835	$529,898
Nez Perce County	$0	$0	$0	$0
Nez Perce Tribe	$0	$0	$0	$0
Oneida County	$14,566	$0	$0	$0
Owyhee County	$0	$0	$358,330	$0
Payette County	$0	$0	$7,633,168	$0

Jurisdiction	Eastern Bear Lake	Lemhi	Squaw Creek	Borah Peak
Power County	$27,447	$31,942	$31,942	$117,883
Shoshone County	$0	$0	$0	$0
Teton County	$6,694	$2,478	$2,478	$0
Twin Falls County	$61,052	$0	$0	$986,110
Valley County	$815	$1,253	$288,830	$41,018
Washington County	$0	$0	$1,584,855	$0
Idaho Total	**$39,155,601**	**$17,692,172**	**$284,222,298**	**$42,213,118**

Source: HAZUS-MH v4.0
Notes: Building losses include structural and non-structural damage estimates.

Figure 3.6.CC. Potential Losses for the Eastern Bear Lake Scenario

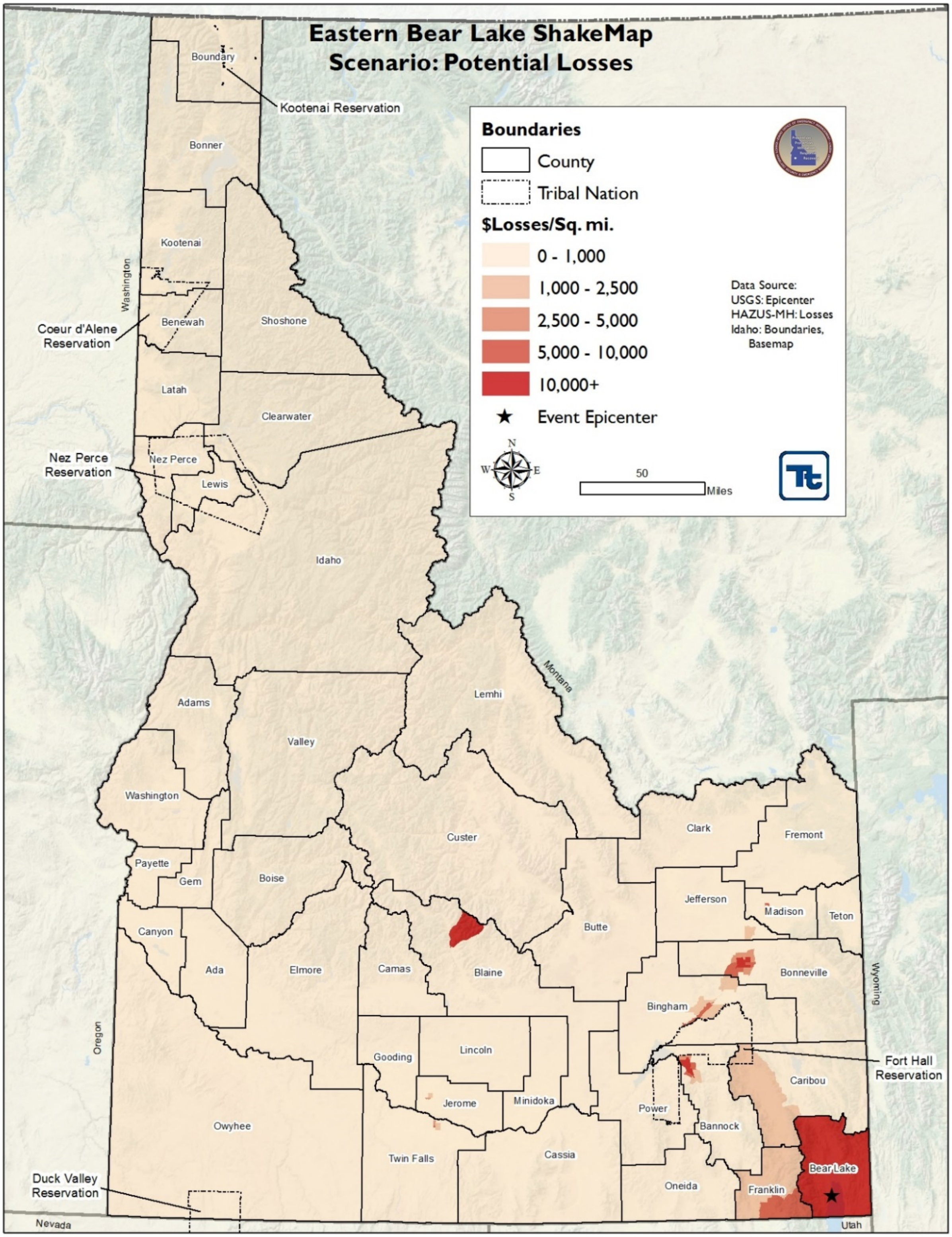


Figure 3.6.DD. Potential Losses for the Lemhi Scenario

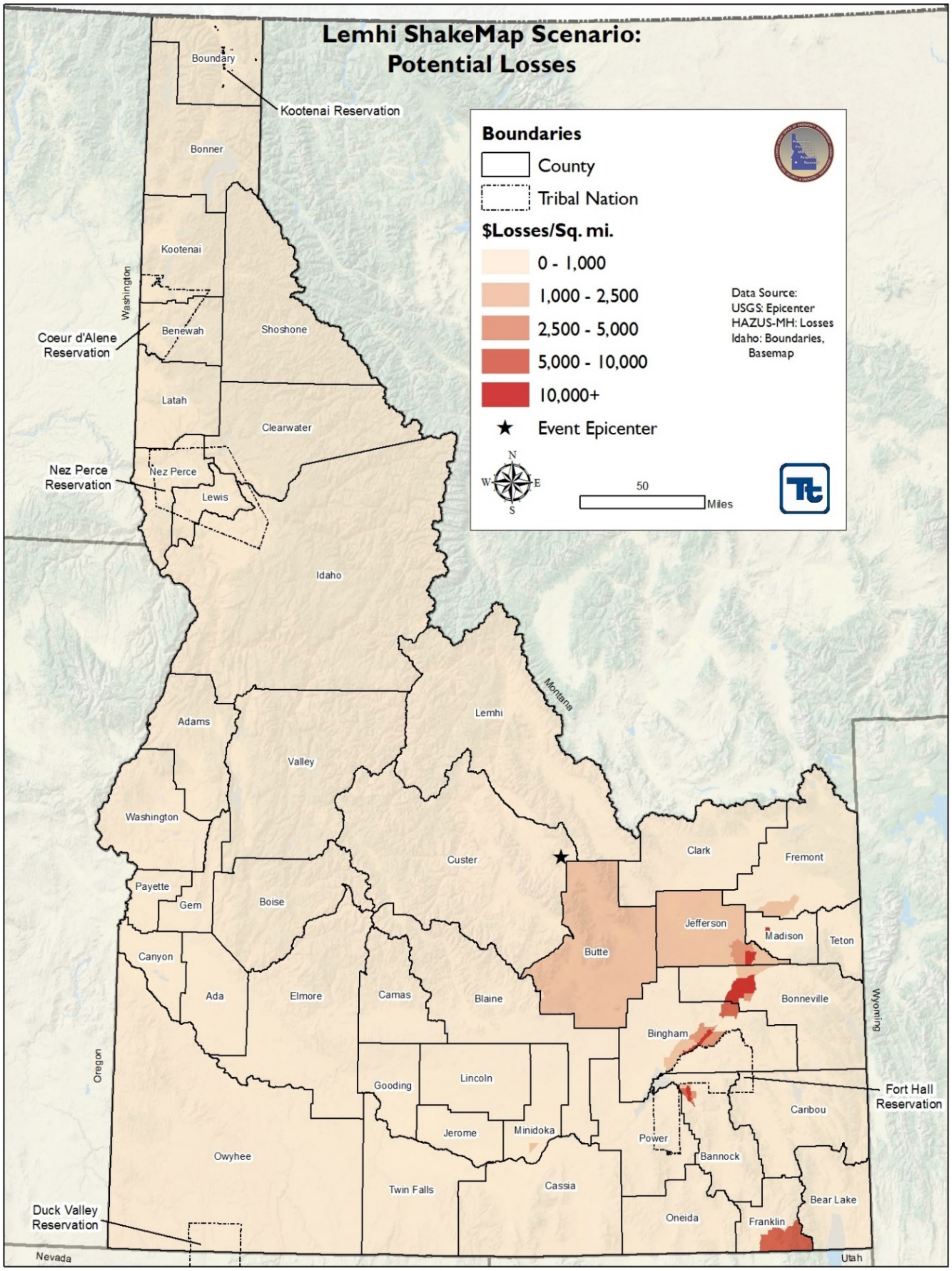


Figure 3.6.EE. Potential Losses for the Squaw Creek Scenario

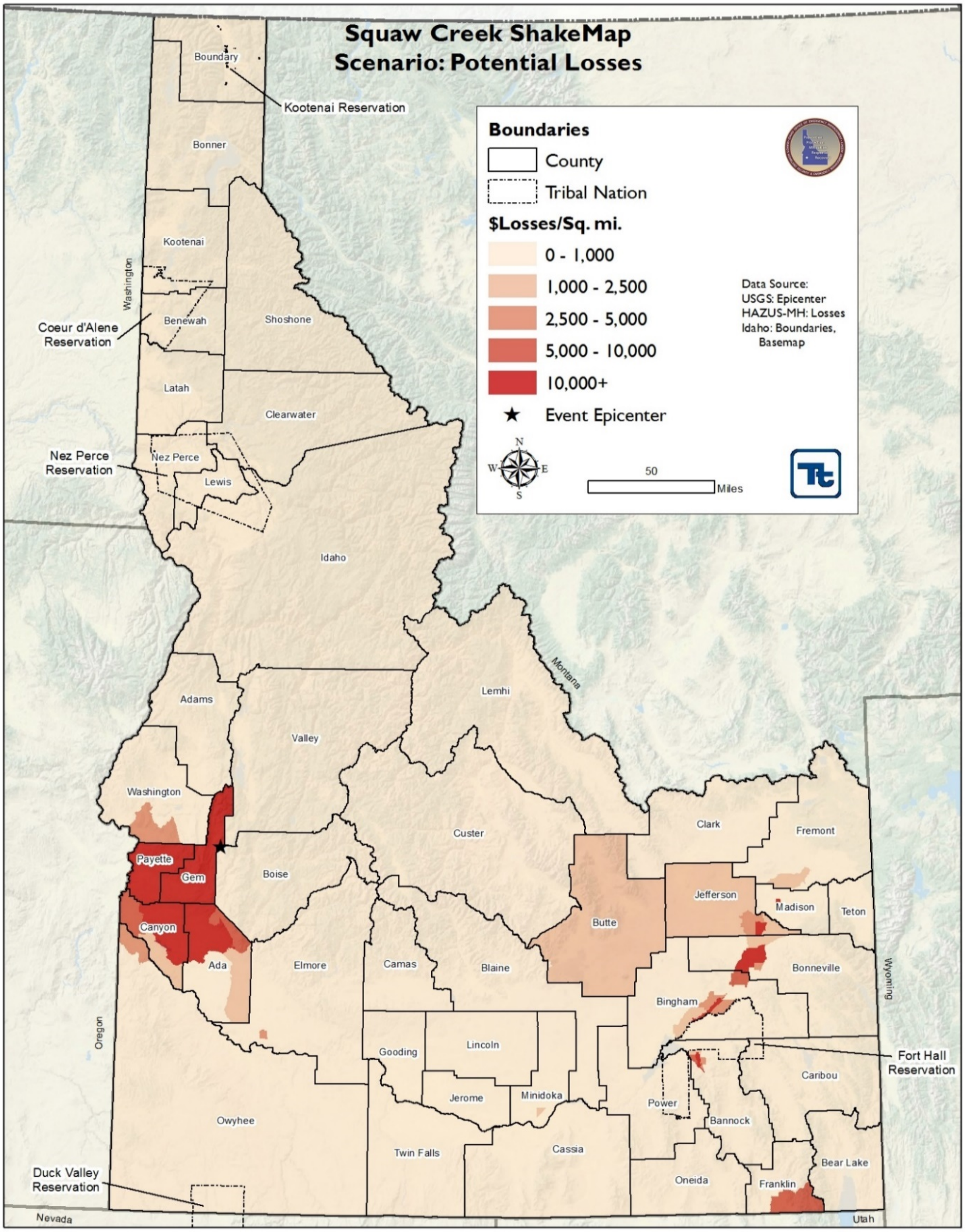
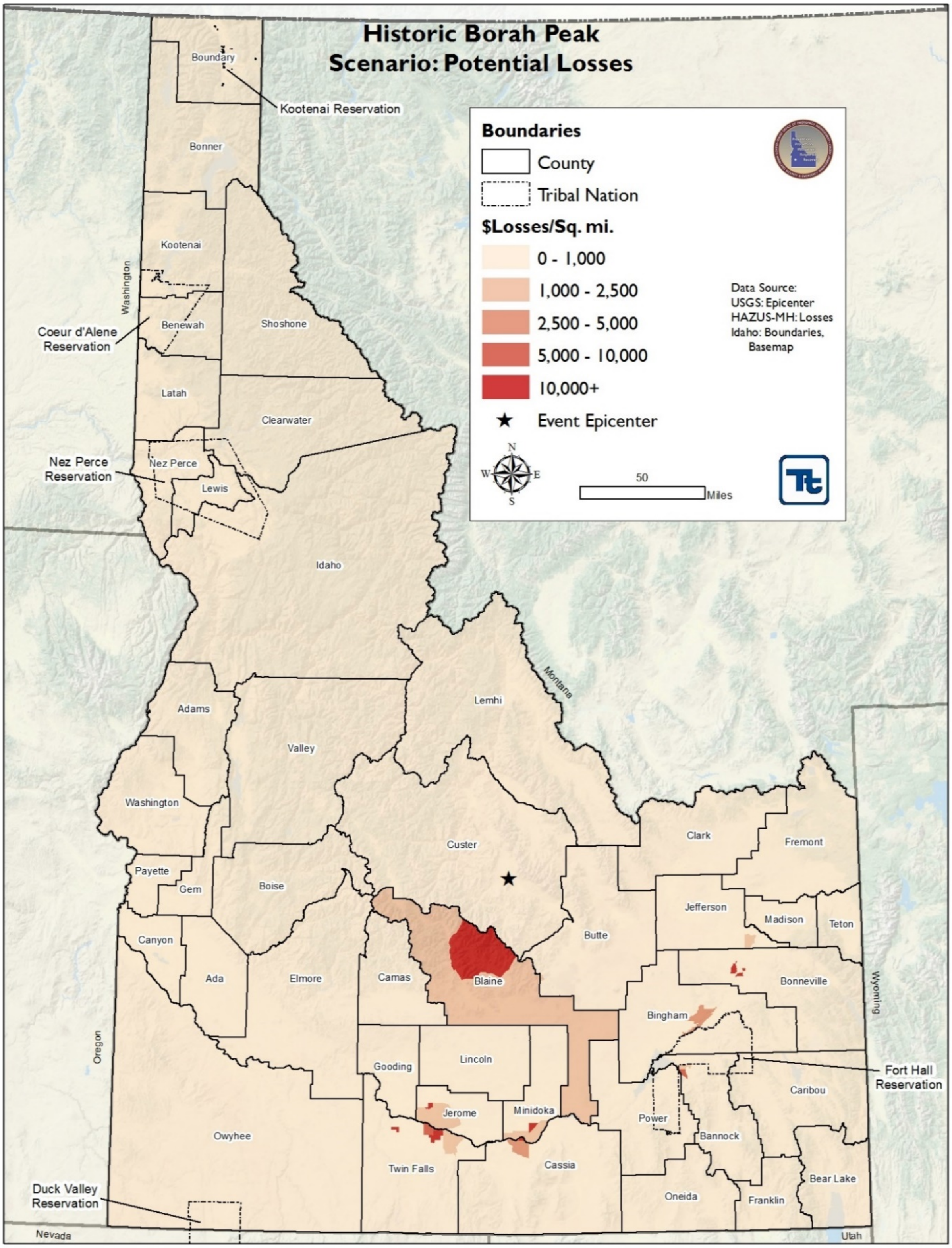


Figure 3.6.FF. Potential Losses for the Historic Borah Peak Scenario



Earthquakes have the potential to impact economies at both the local and regional scale. Losses can include structural and non-structural damage to buildings, loss of business function, damage to inventory, relocation costs, wage loss, and rental loss caused by the repair and replacement of buildings. Roads that cross earthquake-prone soils have the potential to be significantly damaged during an earthquake event, potentially impacting commodity flows. Access to major roads is crucial to life and safety after a disaster event, as well as to response and recovery operations. Further, water and sewer infrastructure would likely suffer considerable damage in the event of an earthquake.

Lifeline related losses include the direct repair cost to transportation and utility systems; losses are reported in terms of the probability of reaching or exceeding a specified level of damage when subjected to a given level of ground motion. Additionally, economic loss includes business interruption losses associated with the inability to operate a business because of damage sustained during an earthquake, as well as temporary living expenses for those displaced. These losses are presented in Table 3.6.GG.

Table 3.6.GG. Estimated Potential Economic Losses for Idaho (Millions of Dollars)

	Eastern Bear Lake	Lemhi	Squaw Creek	Borah Peak
Income Losses				
Wage	2.3	0.6	8.4	1.7
Capital-Related	1.7	0.5	6.5	1.5
Rental	1.5	0.4	7.6	1.9
Relocation	3.7	1.0	16.8	4.2
Subtotal	**9.2**	**2.5**	**39.3**	**9.2**
Capital Stock Losses				
Structural	5.7	2.2	34.7	7.0
Non-Structural	24.3	11.0	180.3	27.6
Content	9.2	4.5	69.3	7.6
Inventory	0.2	0.2	1.6	0.1
Subtotal	**39.3**	**17.8**	**285.9**	**42.4**
Total	**48.5**	**20.3**	**325.1**	**51.6**

Source: HAZUS-MH v4.0

The HAZUS-MH earthquake model also estimates volume of debris that may be generated as a result of an earthquake event to enable the study region to prepare and rapidly and efficiently manage debris removal and disposal. Debris estimates are divided into two categories: (1) reinforced concrete and steel that require special equipment to break up before transport, and (2) brick, wood, and other debris that can be loaded directly onto trucks with bulldozers (FEMA 2015).

Table 3.6.HH summarizes the estimated debris generated by the four earthquake scenarios in HAZUS-MH 4.0.

Table 3.6.HH. Estimated Debris Generated by HAZUS-MH for each Earthquake Scenario

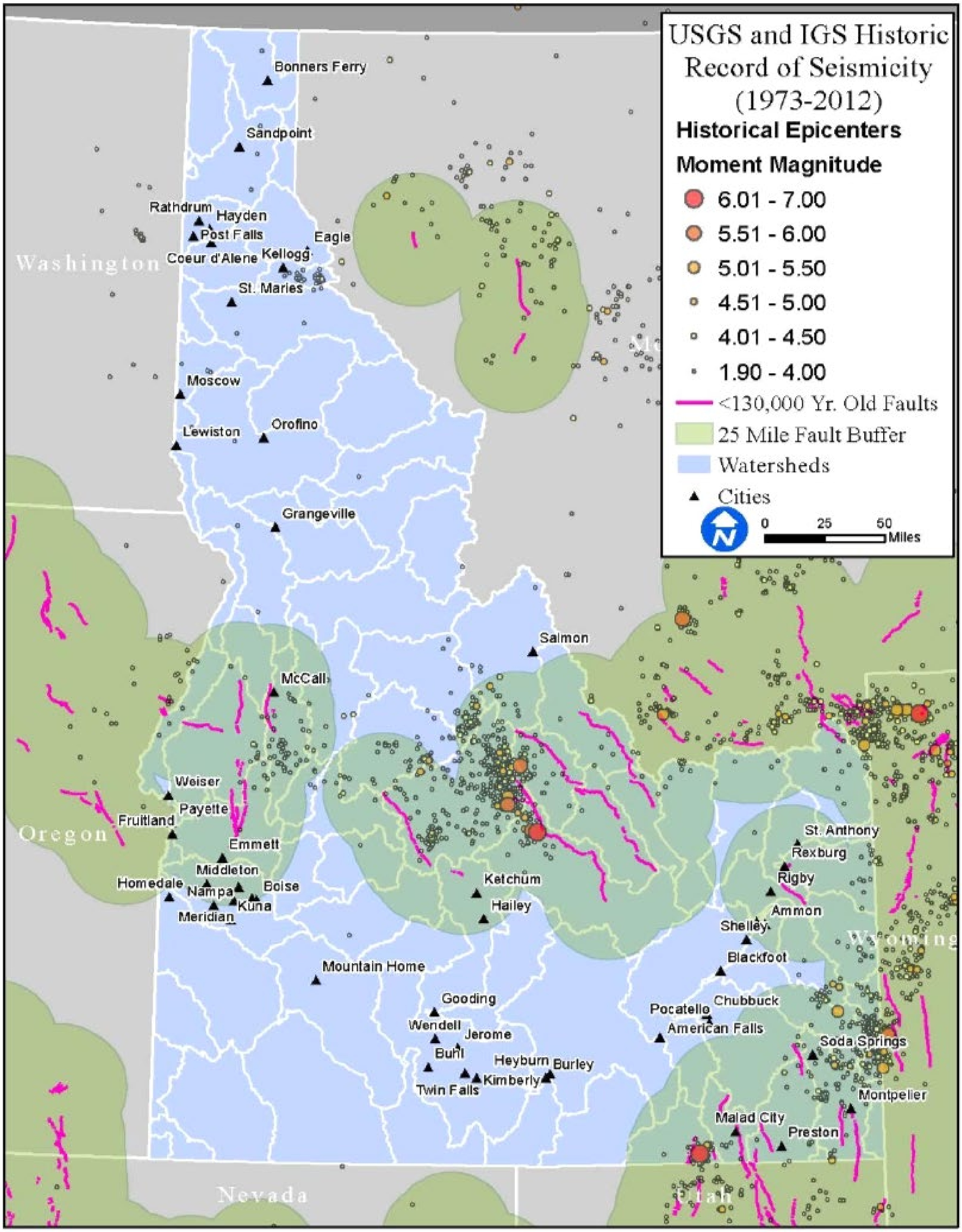
Scenario	Debris Type	
	Brick/Wood (tons)	Concrete/ Steel (tons)
Eastern Bear Lake	4,967	6,677
Lemhi	2,081	1,478
Squaw Creek	29,416	25,553
Borah Peak	5,384	6,164

Source: HAZUS-MH 4.0

Vulnerability Summary

The IMHRP evaluated the State's earthquake risk by calculating a risk score on a watershed basis utilizing Ground Acceleration Map and USGS Quaternary Fault data. Figure 3.6.II (below) summarizes the Peak Ground Acceleration Risk and selected Quaternary Faults throughout the State.

Figure 3.6.II. Quaternary Faults and Historic Epicenters



Source: IMHRP, 2015

Table 3.6.JJ summarizes the 'high' earthquake risk-ranked watersheds in descending total risk order in accordance with the IMHRP risk ranking methodology. In an effort to align the IMHRP and State HMP risk analyses, the counties and Tribal Nations that intersect the high-ranked watersheds are listed in Table 3.6.KK below.

Table 3.6.JJ. Watersheds with a 'High' Earthquake Risk Rank

HUC-8 Watershed	Earthquake Risk Rank	HUC-8 Watershed	Earthquake Risk Rank
Blackfoot	1	Lower Bear-Malad	14
Teton	2	Weiser	15
Middle Bear	3	Upper Salmon	16
Portneuf	4	Willow	17
Idaho Falls	5	Big Lost	18
Bear Lake	6	Middle Snake-Payette	19
Lower Henrys	7	Lemhi	20
Payette	8	Beaver-Camas	21
North Fork Payette	9	Brownlee Reservoir	22
Big Wood	10	Middle Salmon-Panther	23
American Falls	11	Lake Walcott	24
Lower Boise	12	Little Salmon	25
Upper Henrys	13		

Source: IMHRP, 2015

Table 3.6.KK. Counties/Tribal Nations Located in the Top 5 High Earthquake Risk Ranked Watersheds

Jurisdiction	HUC-8 Watershed	Flood Risk Rank	Jurisdiction	HUC-8 Watershed	Flood Risk Rank
Bannock County	Portneuf	4	Fort Hall Tribe	Blackfoot	1
Bannock County	Middle Bear	3	Fort Hall Tribe	Portneuf	4
Bear Lake County	Blackfoot	1	Franklin County	Portneuf	4
Bear Lake County	Middle Bear	3	Franklin County	Middle Bear	3
Bingham County	Blackfoot	1	Fremont County	Teton	2
Bingham County	Portneuf	4	Jefferson County	Idaho Falls	5
Bonneville County	Idaho Falls	5	Madison County	Idaho Falls	5
Bonneville County	Blackfoot	1	Madison County	Teton	2
Bonneville County	Teton	2	Oneida County	Portneuf	4
Caribou County	Blackfoot	1	Oneida County	Middle Bear	3
Caribou County	Portneuf	4	Power County	Portneuf	4
Caribou County	Middle Bear	3	Teton County	Teton	2

As demonstrated by the 2018 SHMP Hazus analysis, the counties with the greatest exposure to their population, building, and critical facilities are: Bear Lake County, Caribou County, Franklin County, and Oneida County. These counties are located in the southeast region of the State. As noted above, the Blackfoot, Teton and Middle Bear are the top 3 most at risk watersheds according to the 2015 IMHRP. Of these three watersheds, Blackfoot and Middle Bear intersect the county boundaries of Bear Lake, Caribou, and Franklin. Oneida County is bordered by Middle Bear and Portneuf watersheds, while the Lower Bear-Malad watershed is located within the county.

Overall, of the four modeled earthquake scenarios, the Squaw Creek event causes the greatest impact on the State. Estimated potential building losses are approximately 5 times higher than any of the other scenarios. The event's epicenter is located near the northwest region of Boise County which is approximately 36 miles north of the city of Boise; the most populated city in the State. Ada County, Canyon County, and Gem County are estimated to experience the greatest potential losses as a result of this event. The Payette, North Fork Payette, and Lower Boise watersheds are located in this region, and were also identified as some of the most at risk watersheds in the 2015 IMHRP. In addition to causing damages to buildings and assets in these counties and surrounding areas, damages are also estimated for the eastern portion of the State as well.

The IMHRP identified the following counties as seismic priority counties: Ada County, Bannock County, Canyon County, Caribou County, Franklin County, Oneida County, and Teton County. According to the population projections from ICLUS, these seven Counties are projected to experience population growth which will expose more people to the earthquake hazard.

Consequence Analysis Evaluation

Another way vulnerability was assessed was by conducting a consequence scenario that analyzed a hypothetical hazard event. The Seismic Technical Working Group (TWG) met on March 8, 2018 to analyze an earthquake scenario involving a 6.9 Mw event in Pocatello. The event discussed occurred in the fall months, at 8:00 AM in the morning.

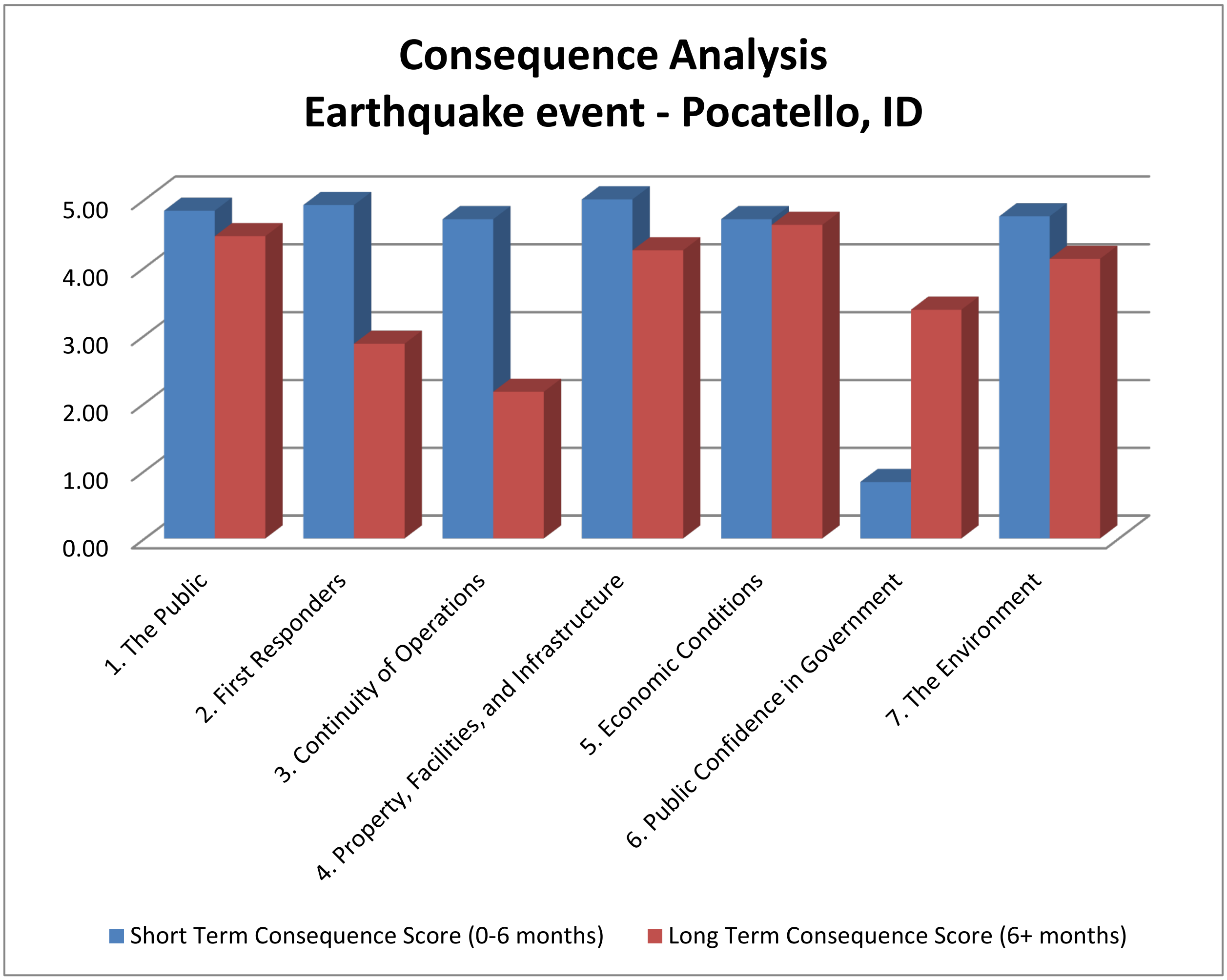
The Seismic TWG walked through this group exercise, where they scored, from 0 (no consequences) to 5 (most severe consequences]), the short-term (0-6 month) and long-term (6+ months) consequences of the scenario as it pertained to the following systems:

- The public
- First responders
- Continuity of operations
- Property, facilities, and infrastructure
- Economic conditions
- Public confidence in government
- The environment

Scenario

Fall: 6.9 Mw earthquake event in Pocatello, at 8:00 AM during the fall months.

Results



The chart above presents the results of the exercise. Looking at the short-term consequences of this 6.9 Mw event, exercise participants felt that the most severe consequences would be felt by the public, first responders, the built environment, and the economy. The group felt that the public's confidence in the government would be barely impacted in the early day/months after the disaster would occur. From a long-term standpoint, a definite shift is seen on the consequences to the various systems discussed. The TWG felt that equally moderate consequences would be felt by a majority of the systems, with the impacts to continuity of operations and the environment fairing a little better. Overall, it was determined that the short-term impacts of a large seismic event would be greater than the long-term effects.

Some observations of the group to note included:

- The fact that this hypothetical event occurred in the winter would have more severe consequences since there would be issues with shelter.
- Fire and earthquake have a high probability of dual occurrence.
- The bureaucracy that would follow the Federal assistance could negatively affect the public's confidence in the government in the long-term.
- Time of day of this scenario has greatest impact on human life since families are separated and many adults are working in large office buildings that could collapse or are in transit and risk being hit by downed powerlines.
- Possible long term contamination if hazardous material gets into watersheds.

Mitigation Rationale

While few local plans prioritize earthquake as a major hazard, the significant economic impact of an earthquake makes mitigation a priority. The 6.9-magnitude scenario in Idaho Falls, for example, resulted in $1.5 billion in damages, which would be truly catastrophic. A considerable number of public and private commercial buildings are pre-code structures, constructed of both reinforced and unreinforced masonry. Much of Idaho's housing stock in suburban and rural communities was built prior to the 1970s, before building codes were in force. Additionally, rural Idaho communities do not have the resources to respond to widespread damage that might be caused by a catastrophic earthquake. Earthquakes are one of the State's least predictable and most poorly understood hazards.

General Mitigation Approaches

Information/Outreach and Public Education

Much mitigation work (such as home retrofitting and non-structural falling hazard reduction) is dependent on the actions of property owners and residents. Hazard awareness and education programs must lay the groundwork of knowledge that leads to this work.

As available, IOEM funds cooperative projects with the Idaho Geological Survey (IGS). These projects have included summer field workshops for Idaho's earth science teachers, the development of NEHRP soil classification and liquefaction susceptibility maps, and the development of public education materials on geologic hazards. This outreach has been funded using a variety of grant programs, including the Earthquake Hazard Reduction Grant, Emergency Management Performance Grant, and Pre-disaster Mitigation Planning funds. Earth science teacher workshops have been held from 1993 – 2013 annually, facilitated by the IGS. The focus of the workshops was on the science of natural hazards, hazard mitigation strategies, disaster preparedness for schools, and the enhancement of science teaching resulting in improved study of seismic safety in schools, and the next generation of decision makers in Idaho growing up better educated to seismic risks and other natural hazards. Other public outreach has been the booklet mentioned above, "Putting Down Roots in Earthquake Country." It was published using mitigation grant monies by IOEM, with considerable input and valuable advice from the IGS, and was widely distributed in eastern Idaho. The booklet was especially well received by educators in many parts of the State and will continue to be distributed at every opportunity, through every possible venue. Public outreach and education will continue as funds are available.

Infrastructure

New public facilities and other infrastructure must be built to earthquake-resistant standards. The large stock of buildings constructed before 1992 is more problematic. Changes in occupancy, such as occurs when old buildings are converted to restaurants, shops, and apartments, provide opportunities for seismic retrofits. Extensive work is expensive, though, and hard to justify to building owners. Lifelines and critical facilities should not be concentrated in high-risk areas. Mitigation projects will be identified in separate categories, as follows: Public infrastructure; State/county facilities; and Private infrastructure.

Data Collection & Analysis

IGS will be working in the future towards updating and then maintaining a state fault database. As the USGS takes a step back from their formal large role in fault mapping, the State will step up and seek funding to complete and maintain it.

NEHRP EQ Fault Database Update:

The Idaho Geological Survey (IGS) updated the state's active fault database in 2021 through NEHRP funding. Previous mapping lacked sufficient detail for seismic hazard assessment. The update reconciled multiple sources of existing mapping, refined the location of fault traces with high-resolution imagery, and incorporated new geologic and paleoseismologic research. The database prioritized active faults, revised linework, analyzed data, and provided missing references. IGS makes faults mapping available to the public as an interactive webmap and as a geographic information system (GIS) database with an instructional webinar. The database allows multiple users to assess data on seismic hazards to mitigate risks. Engineers evaluate sources and perform probabilistic seismic hazard assessments. The U.S. Geological Survey (USGS) maintains a national database which relies on state updates and benefits directly from this effort. The SHMP earthquake chapter will include the best available

What is the largest earthquake Idaho has ever had and where was it, and how soon can you predict an earthquake?

Scott Dorval, Channel 6 Chief Meteorologist, answered this question posed by a Liberty Elementary school student. You can track where earthquakes are occurring at Idaho 6 on Your Side. Typically, there are many tiny earthquakes going on in the mountains. The 1983 Borah Peak Earthquake measured 6.9 and was the strongest to occur in Idaho. It caused some major damage in Mackay and Challis and was felt in Boise. During a quake, two plates that are being held together because of friction, suddenly overcome that friction with one plate popping up higher than the other. The earthquake left a scarp line shown here displacing the ground up to seven feet. "There were reports of some people out hunting nearby and the ground started to shake and the pickup was literally bouncing off the ground like you would see in a cartoon. One person reported even seeing what you call a zipper when you see a line shooting right across the ground here. Finally the ground dropped just below the pickup truck and then the truck fell down on top of it." Borah Peak rose nearly 7 feet in elevation. (Dorval, 2013) fault data. A recent robust sequence of earthquakes near Soda Springs, ID has drawn attention to the seismic hazard in southeastern Idaho. IGS is working in collaboration with the Utah Geological Survey to apply for USGS Earthquake Hazard Program funds to map and investigate the Wasatch, Cache Valley, and Bear Lake faults.

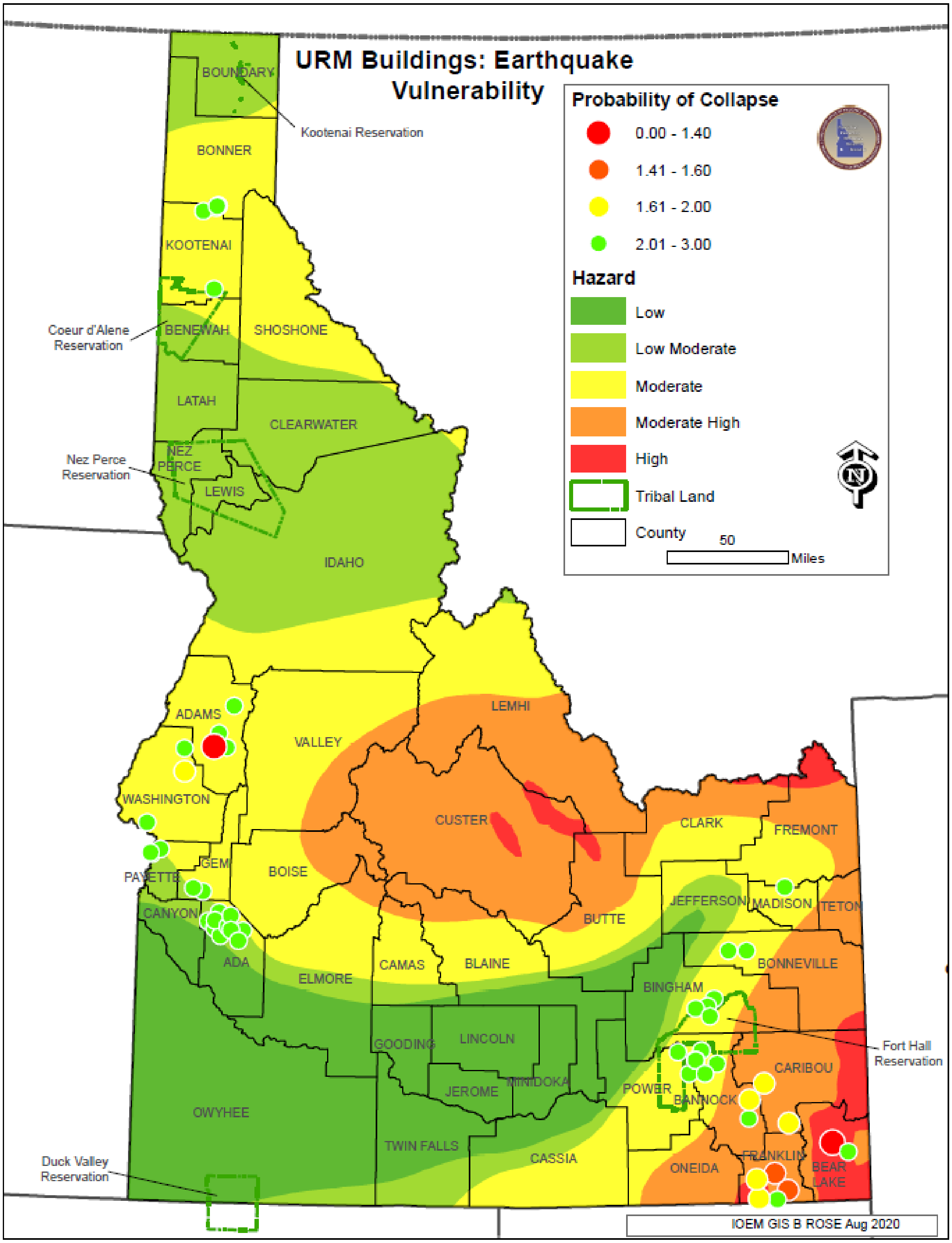
NEHRP Un-reinforced Masonry Assessment:
The Idaho Office of Emergency Management (IOEM) was awarded NEHRP grant funding to assess state and school buildings, create an inventory of Unreinforced Masonry (URM) facilities, and identify vulnerable structures. The grant Period of Performance was 08-01-2019 to 07-31-2020. FEMA P-154 Rapid Visual Screening of Buildings for Potential Seismic Hazards, ACT-20, and Rover training was provided May 29-30, 2019 to inspectors in anticipation of this project. The courses taught students to identify, inventory, and score buildings according to their risk of collapse from an earthquake.

The Seismic Technical Working Group held a kickoff meeting to review requirements, project application, task assignments, and timelines. The Idaho Department of Administration provided an updated inventory of state facilities. A Division of Building Safety (DBS) inspector took the inventory of state facilities and confirmed assessment against their inventory of state facilities which are inspected annually. The DBS Industrial Safety Program has an updated school facilities list for each of their regional inspectors. Annually DBS does a safety inspection of each state and school building during which the DBS Inspector performs an annually safety inspection of each building. This inspection requires the inspector to visually inspect all occupied spaces within the building and then to enter unoccupied or limited access spaces like attics, maintenance rooms/spaces and sometimes crawl spaces. The inspector will complete their annual inspection by doing a thorough walk around the outside perimeter of the building and on some buildings, an assessment of the roof is included. As part of the annual inspections, the inspectors were able to use Rapid Visual Screening as they toured the buildings to highlight areas or specific buildings of concern. This process was conducted through the 2019/2020 school year and concluded on June of 2020. Out of the hundreds of facilities inspected, 226 were determined to be un-reinforced masonry structures.

A contracted structural engineering firm added missing data needed for assessments such as year built, prioritized 226 URM DBS inspector reports by seismic hazard area, and entered high to moderate ranked building data into ROVER software. The contractor drafted the For Official Use Only (FOUO) report and presented to the Seismic Technical Working Group for review and edits. “This report used the methodology from FEMA P-154 and ROVER v2.2.2 to evaluate the buildings and asses their risk. The method uses a combination of field work, structural building knowledge, and calculated probabilities to come up with a final score. A higher score indicates a higher reliability in the event of an earthquake.” (Idaho Rapid Visual Screenings of State and School Un-reinforced Masonry Facilities page 3, McClendon Engineering, Inc.)

Report results identified the most vulnerable school buildings and state facilities as displayed in Figure 3.6.12. A table of the all the URM buildings is found in the FOUO report Appendix 2. The final FOUO report was distributed to the Department of Administration and school contacts.

Figure 3.6.I2. Un-reinforced Masonry Vulnerability



Earthquake Clearinghouse Plan

An earthquake Clearinghouse is crucial for supporting and organizing post-earthquake reconnaissance efforts, maximizing information sharing and availability, and better utilizing the talents of those present immediately after a damaging earthquake. Reconnaissance teams comprised of engineers, academics, and scientists typically flock to a damaged area to investigate earthquake impacts. These teams make rapid, general damage surveys of the affected area, document initial important observations from the particular earthquake, and assesses the need for follow-up areas of research. Observations and findings from these teams support emergency response and recovery activities in the short term and improve the understanding of natural hazards and how to mitigate their impacts in the long term.

Geologic Hazards Video

The Idaho Geological Survey (IGS) and IOEM worked on a project to educate teachers and the public on the geologic hazards in Idaho. The project was orginally planned for a three-day field workshop, but due to COVID_19 distancing regulations, the project evolved into an online educational video. IOEM contracted a videographer with experience filming seismic projects, and IGS developed and delivered the script. The result is a geological field trip of the Borah Peak area with an Idaho Geological Survey seismologist. The video is online at YouTube, 1983 Borah Peak Earthquake Virtual Fieldtrip - Idaho Geological Survey, https://www.youtube.com/watch?v=OYtvM1JCGho. It was shared to multiple stakeholders and was available for ShakeOut 2020. IOEM Public Information Officer reports the video reached 107 Unique Account views from social media, and the video itself has 280 views.

Regulatory

Enacting building codes, dam design requirements, and other regulatory measures is necessary to ensure that structures have earthquake-resistant construction. Areas of known extreme hazard, such as fill soils and known faults, can be designated and zoned for open space or similar non-vulnerable uses. IOEM adopts the Western States Seismic Policy Council (WSSPC) Policy Recommendation 07-4 wherein WSSPC not only endorses adoption and enforcement of International Existing Building Code, the International Building Code, and the International Residential Code, but also discourages modification and amendments that weaken these codes. The State Legislative session of 2018 formally adopted the most recent International Building Codes (IBC 2015), allowing for the local jurisdictions to adopt as well.

Further IOEM adopts the additional policy of encouraging including of NEHRP provisions which include purpose, education, incentives, lifelines, and public and private sectors. The State could also provide incentives (e.g., tax relief) for proper owners to retrofit their homes and other properties. Earthquake insurance is typically very expensive, and coverage is generally not required by lending institutions.

In addition, IOEM adopts WSSPC Policy Recommendation 06-1: Developing Earthquake Risk-Reduction Strategies stated here:

WSSPC strongly encourages the development of long-term, comprehensive statewide and community - level earthquake risk-reduction strategies as part of an all-hazards plan to reduce injury, loss of life, property damage, and economic disruption from earthquakes.

WSSPC believes comprehensive statewide and local plans and strategies should include the following elements:

- Assessment of all seismic hazards to quantify and define the risk to communities;
- Implementation of land-use and development policies to reduce exposure to earthquake hazards;
- Adoption of enforcement of the International Building Codes for the seismic design, inspection, and construction of new buildings and structures;

- Adoption of International Existing Building Code for the maintenance and retrofit of seismically "at risk" structures;
- Development and implementation of retrofit, redevelopment, grant and abatement programs to help strengthen existing structures, where necessary;
- Support of [ongoing] public-education efforts and public/private partnerships to raise awareness of seismically induced threats and build constituent support for earthquake hazard reduction programs.

It would be a useful mitigation strategy in the future to have a consolidated listing at the state agency level of all local jurisdiction ordinances pertaining to earthquake planning for a statewide analysis and understanding of the effectiveness of such policies.