Basic Seismological Characterization
for
Teton County, Wyoming
(Exclusive of Yellowstone National Park)

by

James C. Case, Rachel N. Toner, and Robert Kirkwood
Wyoming State Geological Survey
December 2002

BACKGROUND

Seismological characterizations of an area can range from an analysis of historic seismicity to a long-term probabilistic seismic hazard assessment. A complete characterization usually includes a summary of historic seismicity, an analysis of the Seismic Zone Map of the Uniform Building Code, deterministic analyses on active faults, "floating earthquake" analyses, and short- or long-term probabilistic seismic hazard analyses.

Presented below, for Teton County, Wyoming, are an analysis of historic seismicity, an analysis of the Uniform Building Code, deterministic analyses of nearby active faults, an analysis of the maximum credible "floating earthquake," and current short- and long-term probabilistic seismic hazard analyses.

Historic Seismicity in Teton County

The enclosed map of "Earthquake Epicenters and Suspected Active Faults with Surficial Expression in Wyoming" (Case and others, 1997) shows the historic distribution of earthquakes in Wyoming. Hundreds of magnitude 2.0 and greater earthquakes have been recorded in Teton County. The most significant earthquakes are discussed below.

1900s Earthquakes:
The first earthquake that was reported in Teton County occurred on October 6, 1906, approximately 2.5 miles northwest of Jackson (U.S.G.S. National Earthquake Information Center). No damage was reported from this intensity IV event.

1920s Earthquakes:
On March 24, 1923, an intensity V earthquake occurred approximately 13 miles northeast of Jackson. This earthquake was felt as far south as the Green River Basin. The Jackson Hole Courier (March 29, 1923) reported that several shocks were felt, with the largest rocking buildings all over the county. The paper reported that "Rocks weighing tons were shaken loose along the Tetons and in the hills about Grovont, and rolled into the valley. Many of the snow

slides which run about this time of year or a little later were started on their way by the Quake". A local resident reported that it felt like his home had been lifted up and shaken violently, and set down with a thump. No significant damage was reported.

On June 23, 1925, the lower Gros Ventre landslide north of Jackson activated, damming the Gros Ventre River. Nearby seismic activity on June 21 was reported by the Jackson Hole Courier (June 25, 1925) as being "quite severe." Voight (1978) described a report of local seismic activity on June 22, 1925, the night before the Gros Ventre River was dammed by the landslide. An intensity IV earthquake was also reported near Jackson on September 3, 1925. Most town residents felt the earthquake, which was centered approximately 3 miles northwest of Jackson. Objects were rattled, but no damage occurred (Blackwelder, 1926).

On March 31, 1928, an intensity IV earthquake occurred approximately 18 miles north of Jackson. Reports indicated that many residents in the area felt a trembling sensation. This was the strongest earthquake to date along the Gros Ventre River above Kelly. The earthquake was not felt at Moran (Heck and Bodle, 1930).

1930s Earthquakes:
Several earthquakes were recorded in Teton County in the 1930s. An intensity VI earthquake occurred on March 26, 1932, approximately 4 miles northeast of Jackson. The earthquake cracked plaster walls and foundations in several Jackson homes and businesses. The main shock was preceded by a few events along the Upper Gros Ventre River, and was followed by a number of intensity III and IV aftershocks. Because the event occurred at night, several residents ran from their homes without grabbing any clothing, and a few were thrown from their beds. The earthquakes were felt in Jackson, Kelly, Grovont, Wilson, Teton Pass, and the Snake River Canyon, but were not felt at Moran (Jackson Hole Courier, January 28, 1932).

On January 14, 1936, and intensity VI, magnitude 5.0 (estimated) earthquake occurred approximately 19 miles southwest of the south entrance to Yellowstone National Park. The earthquake, which was not felt in Jackson, cracked two brick chimneys and moved small objects. Residents of Moran reported beds rocking (Neumann, 1938).

In 1939, two earthquakes occurred approximately 3 miles northwest of Jackson. The first, an intensity III event, took place on October 22, 1939. The second, an intensity IV event, occurred on November 2, 1939. Neither earthquake caused damage.

1940s Earthquakes:
Four earthquakes occurred in the county in the 1940s. Two intensity III earthquakes were detected on October 22, 1940 and on November 2, 1940 (U.S.G.S. National Earthquake Information Center). Both were located approximately 3 miles northwest of Jackson, but neither caused damage.

The next earthquake in the county occurred on January 8, 1947. This intensity IV earthquake was located approximately 3.5 miles southeast of the south entrance to Yellowstone National Park. No damage was associated with this event.

On February 23, 1948, an intensity VI, magnitude 5.0 (estimated) earthquake was recorded approximately 13 miles west of Jackson. Some residents in the area reported that their houses rocked and swayed in an east-to-west direction. People also reported that dishes and windows rattled and pictures fell from walls. Some buildings in Jackson sustained cracked and twisted logs (Jackson Hole Courier, February 26, 1948).

1950s Earthquakes:
Only one earthquake was reported in Teton County in the 1950s. An intensity IV earthquake occurred on March 15, 1953, approximately 2 miles northeast of Alta. Many area residents reported that buildings creaked and loose objects rattled. In addition, thunderous sounds were heard before and during the earthquake (Murphy and Cloud, 1955).

1960s Earthquakes:
Teton County experienced several earthquakes in the 1960s. On October 6, 1962, an intensity IV earthquake occurred approximately 11 miles north of Jackson. The event lasted a few seconds and rattled dishes and windows (Casper Tribune-Herald and Star, October 7, 1962).

On October 12, 1963, a magnitude 3.9-4.0 earthquake occurred near the south border of the county, approximately 9 miles west-southwest of Hoback Junction. No damage was reported from this event. Two earthquakes were detected in December of 1963. The first magnitude 4.0 event occurred on December 8, 1963, approximately 26 miles southeast of Moran Junction. A few days later, on December 14, 1963, a magnitude 4.1 earthquake was reported approximately 19 miles southeast of Moran Junction. Neither of the December 1963 earthquakes caused damage or was felt.

A magnitude 3.8 earthquake occurred in Teton County on February 27, 1964. This event was centered approximately 23 miles southeast of Moran Junction. Again, this earthquake caused no damage and no one felt it. On May 1, 1964, a magnitude 4.0 earthquake was recorded approximately 17.5 miles south-southeast of Moran Junction. This event was followed by another earthquake on May 7, 1964. No specific magnitude or intensity has been associated with the May 7 earthquake, which was centered approximately 16.5 miles east-southeast of Hoback Junction. On June 24, 1964, another earthquake of no specific magnitude or intensity occurred approximately 4 miles southwest of Hoback Junction. None of the May or June 1964 earthquakes caused damage or were felt.

No other earthquakes were recorded in Teton County until December 20, 1967, when an earthquake of no specific magnitude or intensity occurred approximately 6 miles southeast of Moran Junction. It was not felt and did not cause damage.

The last earthquake to occur in Teton County in the 1960s took place on November 15, 1968. This magnitude 3.9 earthquake was recorded approximately 19 miles southeast of Moran Junction. No one reported feeling the earthquake.

1970s Earthquakes:
Twenty-one earthquakes were recorded in Teton County in the 1970s. Most of the earthquakes that occurred during this decade were not felt and did not cause any damage. On November 12,

1970, a magnitude 3.9 earthquake was detected in the northern portion of the county. This event was centered approximately 14 miles southeast of the south entrance to Yellowstone National Park. No one felt this earthquake.

An earthquake of no specific magnitude or intensity occurred in the same area on June 23, 1971. Again, no one reported feeling this event.

Three more earthquakes of no specific magnitude or intensity were recorded on March 24, 25, and 29, 1973. These March 1973 events were centered approximately 17, 20, and 23 miles northeast of Moran Junction, respectively. None of these earthquakes were felt.

On September 23, 1974, an earthquake was detected by the U.S.G.S. in western Teton County. No one reported feeling this magnitude 3.0 event, although it was centered approximately 0.5 mile northeast of Alta. On October 18, 1974, a magnitude 3.6, intensity IV earthquake was recorded approximately 4 miles southeast of the south entrance to Yellowstone National Park. No damage was associated with this event. Another non-damaging earthquake occurred on December 22, 1974. This magnitude 3.3 event was located approximately 10.5 miles southeast of the south entrance to Yellowstone National Park.

Four earthquakes occurred in Teton County in 1975. The first was recorded on January 23, 1975, approximately 12.5 miles east of the Yellowstone National Park south entrance. This magnitude 2.5 event was not felt and did not cause any damage. Magnitude 3.3 earthquakes occurred in the county on June 17, 1975, and on July 17, 1975. The June 17 event was located approximately 12 miles southwest of Jackson, while the July 17 event was centered approximately 9 miles east-southeast of Moran Junction. Neither of these earthquakes was felt. The last earthquake to occur in the county in 1975 took place on August 14, 1975. The epicenter of this non-damaging, magnitude 3.0 earthquake was approximately 11.5 miles east-southeast of Moran Junction.

In March of 1976, a series of earthquakes occurred in southern Teton County. The University of Utah Seismograph Stations detected a magnitude 2.0 earthquake on March 11, 1976. No one reported feeling this earthquake that was centered approximately 12.5 miles west-northwest of Hoback Junction. On March 14, 1976, a magnitude 3.7 earthquake was recorded approximately 5 miles south-southeast of Hoback Junction. This event was followed by a magnitude 3.9 earthquake on March 17, 1976. This earthquake was centered approximately 6 miles south-southeast of Hoback Junction. On March 21, 1976, a magnitude 2.9 earthquake and a magnitude 2.8 earthquake occurred approximately 5 miles southeast of Hoback Junction. These events were followed by a magnitude 2.7 earthquake on March 27, 1976. This earthquake was centered approximately 10 miles east-southeast of the south entrance to Yellowstone National Park. No one reported feeling any of the March 1976 earthquakes, and no damage was associated with them. A magnitude 3.1 earthquake was detected in Teton County on May 8, 1976, approximately 17.5 miles east of Kelly. Again, no one reported feeling this earthquake.

On July 22, 1977, a magnitude 3.0 earthquake occurred approximately 16 miles east-northeast of Jackson. No one reported feeling this earthquake.

Teton County did not experience another earthquake until March 10, 1978. On this date, a magnitude 3.2 earthquake occurred approximately 17 miles east-southeast of Moran Junction. No one reported feeling this event.

On July 3, 1979, a magnitude 3.2, intensity IV earthquake occurred approximately 5 miles southeast of Jackson. Jackson residents reported that dishes rattled and that pictures on walls moved. Horses at the Teton County Fairgrounds were also noticeably disturbed (Casper Star-Tribune, July 4, 1979).

1980s Earthquakes:
A number of earthquakes occurred in Teton County in the 1980s, but few caused any significant damage. The first earthquake in this decade was recorded on January 5, 1980. This non-damaging, magnitude 2.8 event was centered in the east-central portion of the county, approximately 22 miles east of Moran Junction. On May 31, 1980, a magnitude 2.5 earthquake occurred approximately 10.5 miles southeast of the south entrance to Yellowstone National Park. No one reported feeling this event.

The first earthquake that was felt in the 1980s occurred on May 6, 1981. The epicenter of the magnitude 3.7, intensity IV earthquake was located approximately 7 miles southeast of Jackson. A local disc jockey reported that "window frames changed position briefly, and the turntable and the seat of my pants came up and down at the same time". A local secretary said her desk moved during the event (Casper Star-Tribune, May 7, 1981). A magnitude 3.0 earthquake occurred a few days later on May 12, 1981. It was centered approximately 10 miles southeast of Moran Junction, but no one reported feeling it.

On November 2, 1983, a magnitude 3.5, intensity IV earthquake was recorded approximately 10 miles west-southwest of Jackson. Although the event was felt, no damage occurred. Another non-damaging earthquake occurred a week later on November 9, 1983. This magnitude 3.6, intensity III earthquake was centered approximately 17.5 miles east-southeast of Moran Junction. The U.S.G.S. National Earthquake Information Center reported that this event was felt. The next earthquake to occur in Teton County took place on December 20, 1983, approximately 10 miles south of Jackson. This magnitude 4.5, intensity IV earthquake was felt from Jackson to the Palisades Reservoir in Idaho. In Jackson, there were reports of Christmas trees falling over and dishes breaking (Laramie Daily Boomerang, December 21, 1983). A number of aftershocks followed the December 20, 1983 event. The largest aftershock was a magnitude 3.4 earthquake that occurred on December 22, 1983.

On January 5, 1984, a magnitude 3.0 aftershock occurred in the same area. A magnitude 2.6 earthquake was detected on January 17, 1984, approximately 11 miles east of the south entrance to Yellowstone National Park. No one reported feeling this event. A magnitude 2.8 earthquake was detected on March 23, 1984, approximately 3 miles northwest of Hoback Junction. Area residents reported feeling it as an intensity II event. An earthquake was detected on November 2, 1984, approximately 6 miles northwest of Jackson. People did report feeling the earthquake, which was a magnitude 3.1, intensity III event.

On May 25, 1985, a magnitude 2.6-2.8 earthquake was recorded approximately 4 miles northwest of Moran Junction. This event was not felt.

Beginning in June of 1986, the U.S. Bureau of Reclamation began operation of the Jackson Hole Seismic Network. Hundreds to thousands of earthquakes have been detected since 1986. Only the earthquakes that were jointly detected by the U.S. Geological Survey and the University of Utah Seismograph Stations are described in detail in this report. A yearly summary of the number of earthquakes detected by the U.S. Bureau of Reclamation will be noted.

In 1986, no earthquakes of magnitude 3.0 or greater were recorded in Teton County. The U.S. Bureau of Reclamation did detect approximately 14 additional earthquakes ranging in magnitude between 2.0 and 2.8 in or in the near vicinity of Teton County.

On February 20, 1987, two earthquakes occurred in Teton County, approximately 11 miles southeast of Moran Junction. No damage was reported from these magnitude 3.1 and 3.2 events (U.S. Bureau of Reclamation). Another magnitude 3.1 earthquake was recorded by the U.S. Bureau of Reclamation on June 4, 1987. It was centered approximately 9 miles southwest of the south entrance to Yellowstone National Park. No one reported any damage from this earthquake. The U.S. Bureau of Reclamation detected approximately 396 additional earthquakes ranging in magnitude from 0.2 to 2.8 in or in the near vicinity of Teton County in 1987.

Teton County did not experience another earthquake until August 24, 1988, when two earthquakes occurred approximately 3.5 miles northeast of Jackson. Area residents reported feeling the first earthquake, which was a magnitude 2.8 event, but no one reported feeling the second, magnitude 2.4 earthquake. The U.S.G.S. National Earthquake Information Center detected two earthquakes in southern Teton County on October 21, 1988. The first, a magnitude 3.6 earthquake, was centered approximately 16.5 miles east-southeast of Hoback Junction. The second earthquake was a magnitude 3.5 event, located approximately 19 miles east-northeast of Hoback Junction. Neither earthquake was felt. A magnitude 3.6 earthquake on December 4, 1988, was centered approximately 22 miles east of Jackson. No one felt this earthquake. In 1988, the U.S. Bureau of Reclamation detected approximately 41 additional earthquakes ranging in magnitude between 2.0 and 2.9 in or in the near vicinity of Teton County.

On May 12, 1989, a magnitude 2.6 earthquake occurred approximately 1.5 miles east-northeast of Jackson. No one reported feeling this earthquake. It was followed closely by a magnitude 3.1 earthquake approximately 5 miles southeast of Jackson. The U.S.G.S. National Earthquake Information Center reported that the earthquake was felt as an intensity III event in Jackson, but no damage occurred. On June 24, 1989, two earthquakes were felt strongly at Jackson. They both were centered approximately 2 miles north of Jackson. The first earthquake, which occurred at 3:25 a.m., had a magnitude of 3.8. The second earthquake, which occurred one hour later, had a magnitude of 3.7. People reported windows rattling, but no damage was associated with these earthquakes (Casper Star-Tribune, June 25, 1989). Two more earthquakes were detected by the U.S.G.S. National Earthquake Information Center later that same day. Both were magnitude 3.0, but neither was felt. On July 26, 1989, the U.S. Bureau of Reclamation recorded a magnitude 3.1 earthquake approximately 22 miles southeast of Kelly. No damage was reported from this event. In 1989, the U.S. Bureau of Reclamation detected approximately 49

additional earthquakes ranging in magnitude between 2.0 and 2.9 in or in the near vicinity of Teton County.

1990s Earthquakes:
The first earthquake to be detected in Teton County in the 1990s occurred on March 4, 1990. This magnitude 4.1 earthquake was centered approximately 6 miles south of Jackson. Jackson area residents felt the earthquake as an intensity IV event, but no damage was reported (Casper Star-Tribune, March 6, 1990). On March 14, 1990, a magnitude 3.4 earthquake was detected by the U.S. Bureau of Reclamation near the Teton County-Sublette County border. No damage was reported from this event that was centered approximately 10 miles southeast of Hoback Junction. Two earthquakes occurred in the county in October of 1990. The first took place on October 2, 1990, when a magnitude 3.6 earthquake was recorded approximately 16 miles east-northeast of Jackson. The second event was a magnitude 3.0 earthquake that occurred on October 26, 1990. Its epicenter was located approximately 17 miles east-southeast of Moran Junction. No one reported feeling either of these October 1990 earthquakes. In 1990, the U.S. Bureau of Reclamation detected approximately 17 additional earthquakes ranging in magnitude between 2.0 and 2.5 in or in the near vicinity of Teton County.

On August 14, 1991, a magnitude 3.0 earthquake was recorded approximately 4.5 miles northeast of Hoback Junction. This earthquake was not felt. A magnitude 3.2 earthquake that occurred on September 29, 1991, approximately 26 miles east of Jackson, was also not felt. The U.S. Bureau of Reclamation recorded a magnitude 3.1 earthquake in Teton County on December 19, 1991. No damage was reported from this event, which was located approximately 9 miles southeast of Kelly. In 1991, the U.S. Bureau of Reclamation detected approximately 41 additional earthquakes ranging in magnitude between 2.0 and 2.7 in or in the near vicinity of Teton County.

The area near Mount Leidy experienced a magnitude 3.7 earthquake on September 24, 1992. No one felt this earthquake that was located approximately 25 miles northeast of Jackson. In 1992, the U.S. Bureau of Reclamation detected approximately 35 additional earthquakes ranging in magnitude between 2.0 and 2.9 in or in the near vicinity of Teton County.

The first earthquake to occur in Teton County in 1993 took place on February 27, 1993. The epicenter of this magnitude 3.0 earthquake was located approximately 5 miles northeast of Hoback Junction (U.S. Bureau of Reclamation). No damage was associated with this earthquake. On April 1, 1993, a magnitude 3.1 event was centered approximately 21.5 miles southeast of Moran Junction. No one felt this earthquake. The U.S. Bureau of Reclamation recorded a magnitude 3.0 earthquake on May 15, 1993, in western Teton County, approximately 4 miles south-southeast of Alta. No damage occurred from this event. On November 26, 1993, a magnitude 3.8 earthquake occurred approximately 29 miles east-northeast of Jackson. Again, this event was not felt. A magnitude 4.7 earthquake, intensity V earthquake occurred on December 28, 1993, approximately 34 miles east of Jackson. The earthquake was felt in Jackson, Dubois, Hudson, Lander, and Rock Springs. Most reports indicated that the earthquake felt like a heavy truck passing by. A ranch near the epicenter reported swinging lights, but no damage. In 1993, the U.S. Bureau of Reclamation detected approximately 44 additional earthquakes ranging in magnitude between 2.0 and 2.8 in or in the near vicinity of Teton County.

On February 3, 1994, a magnitude 2.7 and magnitude 2.6 earthquakes were detected in southwestern Teton County, approximately 15 miles southwest of Jackson. No one reported feeling these earthquakes. The U.S.G.S. National Earthquake Information Center detected a magnitude 2.9 earthquake on July 31, 1994, approximately 6 miles south of the south entrance to Yellowstone National Park. According to the U.S.G.S., people did report feeling the earthquake as an intensity III event. Four other earthquakes occurred in the county in 1994, but none were felt and no damage was reported. These include a magnitude 3.0 earthquake on May 19, 1994, that was located approximately 10 miles southeast of Moran Junction, a magnitude 3.0 earthquake on September 7, 1994, that was centered approximately 20 miles southeast of Moran Junction and magnitude 2.2 and 3.1 earthquakes on December 4, 1994, approximately 5 miles southwest of the south entrance to Yellowstone National Park. In 1994, the U.S. Bureau of Reclamation detected approximately 82 additional earthquakes ranging in magnitude between 2.0 and 2.9 in or in the near vicinity of Teton County.

On January 27, 1995, an earthquake was recorded approximately 20 miles east-northeast of Jackson. No one reported feeling this magnitude 3.5 event. On August 27, 1995, three earthquakes occurred in the vicinity of Joy Park and Enos Lake in northeastern Teton County. The first event had a magnitude of 4.5, and was felt at Flagg Ranch, south of Yellowstone National Park, as well as at Fishing Bridge and Grant Village within the Park. At Flagg Ranch, there were reports of buildings vibrating and dishes rattling. At Grant Village, the event was felt for 10-15 seconds, and a few items fell off the shelves at the Hamilton Store. The magnitude 4.5 earthquake was quickly followed by a magnitude 2.6 earthquake that caused no damage. Within two hours, another non-damaging, magnitude 3.8 earthquake also occurred. In 1995, the U.S. Bureau of Reclamation detected approximately 64 additional earthquakes ranging in magnitude between 2.0 and 2.9 in or in the near vicinity of Teton County.

On January 29, 1996, a magnitude 3.2-3.7 earthquake occurred in the vicinity of Lower Slide Lake, approximately 16 miles northeast of Jackson. No damage was associated with the earthquake. As mentioned previously, there were reports of seismic activity in the same area in 1925. On May 10, 1996, a magnitude 3.1 earthquake occurred approximately 3 miles southeast of Jackson (U.S. Bureau of Reclamation). No damage was associated with this earthquake. A magnitude 3.7 earthquake was recorded on June 22, 1996, approximately 29 miles southeast of Moran Junction. No one felt this event. On July 5, 1996, a magnitude 3.1 earthquake occurred approximately 23 miles east-northeast of Jackson. A magnitude 3.2 earthquake was also detected 12 miles east-northeast of Jackson on July 5, 1996. Again, no one felt these earthquakes. The U.S. Bureau of Reclamation recorded a magnitude 3.0 earthquake on September 23, 1996. No damage was reported from this event, which was centered approximately 25 miles southeast of Kelly. In 1996, the U.S. Bureau of Reclamation detected approximately 65 additional earthquakes ranging in magnitude between 2.0 and 2.8 in or in the near vicinity of Teton County.

The largest earthquake to occur in Teton County in 1997 took place on September 13, 1997. This magnitude 2.8 event was centered approximately 5 miles east-southeast of Jackson, but no one reported feeling it. In 1997, the U.S. Bureau of Reclamation detected approximately 46

additional earthquakes ranging in magnitude between 2.0 and 2.5 in or in the near vicinity of Teton County.

A series of earthquakes occurred in the county during the spring of 1998. On June 14, 1998, a swarm of earthquakes with magnitudes greater than 2.0 began to occur approximately 3.5 miles southeast of Hoback Junction near Camp Davis. Approximately 14 earthquakes with magnitudes ranging from 2.0 to 3.3 preceded a magnitude 4.7 earthquake that occurred in this area on June 20, 1998. No damage was reported from the magnitude 4.7 event, but it was distinctly felt at Hoback Junction and was felt by many residents of Jackson. Through June 22, 1998, approximately 14 aftershocks with magnitudes greater than 2.0 occurred in the area. On July 11, 1998, a magnitude 3.0 earthquake was detected approximately 6.5 miles east of Jenny Lake. Again, this event was not felt. Two earthquakes occurred on August 23, 1998, approximately 5 miles north-northeast of Alta. No one felt the first earthquake, which was a magnitude 3.2 event. People in this area did, however, feel the magnitude 4.2 earthquake that quickly followed. This same area experienced several more earthquakes in 1998, including magnitude 3.8 earthquakes on August 26, 1998 and September 17, 1998; a magnitude 3.3 earthquake on September 26, 1998; and magnitude 3.2 events on October 18, 1998 and November 1, 1998. None of these earthquakes were felt and no damage was associated with any of them. In 1998, the U.S. Bureau of Reclamation detected approximately 123 additional earthquakes ranging in magnitude between 2.0 and 2.9 in or in the near vicinity of Teton County.

On January 15, 1999, a magnitude 3.4 earthquake was recorded approximately 3 miles northeast of Alta. A few days later, on January 20, 1999, a magnitude 3.2 earthquake occurred in the same area. No one reported feeling either of these earthquakes. Another earthquake occurred in the Alta area on April 10, 1999. Area residents did report feeling this magnitude 3.8 event. Three more earthquakes were recorded in Teton County in 1999, but none of them were felt and no damage was reported from any of them. On April 19, 1999, a magnitude 2.8 earthquake occurred approximately 3 miles southeast of Hoback Junction. A magnitude 3.6 event was detected on June 29, 1999, approximately 4 miles northeast of Alta. The last earthquake to occur in the county in 1999 took place on November 16, 1999. This magnitude 3.1 event was centered approximately 19 miles east-northeast of Hoback Junction. In 1999, the U.S. Bureau of Reclamation detected approximately 75 additional earthquakes ranging in magnitude between 2.0 and 2.9 in or in the near vicinity of Teton County.

2000s Earthquakes:
Five earthquakes occurred in Teton County in 2000. On February 3, 2000, a magnitude 3.0 earthquake was detected approximately 18 miles east-northeast of Moran Junction. No one reported feeling this event. Another magnitude 3.0 earthquake occurred on April 9, 2000. Area residents did report feeling this earthquake, which was centered approximately 6 miles west-southwest of Jackson. On April 20, 2000, a magnitude 2.7 earthquake and a magnitude 2.3 earthquake were detected in far southern Teton County. No one reported feeling these earthquakes, which were centered approximately 6 miles south-southeast of Hoback Junction. A magnitude 3.9 earthquake occurred on October 3, 2000, approximately 18 miles southeast of Moran Junction. No one felt this event. In 2000, the U.S. Bureau of Reclamation detected approximately 30 additional earthquakes ranging in magnitude between 2.0 and 2.6 in or in the near vicinity of Teton County.

Several earthquakes occurred in Teton County in 2001. On February 3, 2001, a magnitude 2.5 earthquake was detected approximately 8 miles southeast of the south entrance to Yellowstone National Park. No one felt the earthquake. The U.S. Bureau of Reclamation recorded a magnitude 3.1 earthquake on February 19, 2001, in the southeastern portion of the county. No damage resulted from this event, which was centered approximately 30 miles southeast of Kelly. A magnitude 3.3 earthquake occurred approximately 5 miles southwest of Hoback Junction on June 14, 2001. No damage was reported. The U.S. Bureau of Reclamation detected another earthquake on August 22, 2001, approximately 20.5 miles east of Jackson. No damage was associated with this magnitude 3.1 event. On September 27, 2001, an earthquake was recorded near the Fremont County-Teton County-Sublette County borders, approximately 36 miles east of Jackson. Area residents reported feeling this magnitude 4.3 event. On November 15, 2001, a magnitude 2.9 earthquake and a magnitude 2.8 earthquake were recorded approximately 11 miles south of Moran Junction. Neither event was felt. In 2001, the U.S. Bureau of Reclamation detected approximately 69 additional earthquakes ranging in magnitude between 2.0 and 2.9 in or in the near vicinity of Teton County.

Several earthquakes were also recorded in Teton County in 2002. An increase in seismic activity was noted in the Kelly, Wyoming area in 2002. From January 1, 2002 to April 15, 2002, 31 small earthquakes occurred approximately 1.5-3 miles south of Kelly. These events can be classified as a small swarm. Earthquake swarms are common in northwestern and western Wyoming. Most have not been precursors to larger events. On January 2, 2002, a magnitude 3.1 earthquake occurred approximately 26 miles east of Jackson. No one reported feeling this event. On January 29, 2002, an earthquake was detected approximately 11 miles northeast of Jackson. According to the U.S.G.S. National Earthquake Information Center, residents in this area did report feeling this magnitude 3.7 earthquake. A magnitude 2.9 earthquake occurred 11 miles northeast of Jackson on March 5, 2002. This event was not felt. A magnitude 2.8 earthquake occurred in eastern Teton County on April 24, 2002. No one reported feeling this earthquake, which was centered approximately 14.5 miles east-northeast of Moran Junction. The U.S. Bureau of Reclamation recorded a magnitude 3.1 earthquake in Teton County on May 12, 2002. No damage resulted from this earthquake, which was centered approximately 4 miles southeast of Kelly. On June 30, 2002, the U.S. Bureau of Reclamation recorded a magnitude 3.0 earthquake approximately 13.5 miles east-northeast of Jackson. No damage was reported. Another magnitude 3.1 earthquake was detected by the U.S. Bureau of Reclamation on July 25, 2002. No damage was associated with this event, which was centered approximately 3 miles southeast of Kelly. On November 8 and 9, 2002, two earthquakes occurred approximately 17.5 miles southeast of Kelly. No damage resulted from these magnitude 3.1 earthquakes. A magnitude 3.2 earthquake was recorded in northern Teton County on November 20, 2002. This non-damaging event was centered approximately 7 miles southeast of the south entrance to Yellowstone National Park. This same area experienced two more earthquakes in November 2002. The U.S. Bureau of Reclamation recorded a magnitude 3.1 earthquake on November 22, 2002, and most recently, a magnitude 3.2 earthquake on November 24, 2002. No damage was associated with any of the November 2002 earthquakes. In 2002, the U.S. Bureau of Reclamation has detected approximately 156 additional earthquakes ranging in magnitude between 1.5 and 2.9 in or in the near vicinity of Teton County.

Regional Historic Seismicity

Teton County is in close proximity to Yellowstone National Park, one of the most volcanically and seismically active regions in the United States. Many known active faults are exposed in the Yellowstone area and thousands of earthquakes have been recorded inside the Park boundaries since the late 1800s. The largest earthquake recorded in this region occurred on August 17, 1959. This magnitude 7.5, intensity X event occurred just outside of Yellowstone National Park, near Hebgen Lake in Montana. The event triggered a landslide that dammed the Madison River and created Earthquake Lake. Twenty-eight people lost their lives; most of them were buried in the campground located directly beneath the landslide. Numerous aftershocks, some as large as magnitude 6.5, occurred within or near Yellowstone National Park. This earthquake is a model for what can occur along the Teton fault in Teton County. The largest earthquake that occurred inside Yellowstone National Park boundaries was on June 30, 1975. This magnitude 6.4, intensity VII event caused landslides and large cracks in the ground.

Several earthquakes have also occurred in the counties near Teton County, beginning in the 1960s. On June 25, 1963, a magnitude 4.2 earthquake occurred in western Park County, approximately 27.5 miles northeast of Moran Junction. No one felt this earthquake. A magnitude 4.3 earthquake was recorded in eastern Idaho on October 11, 1963. No one reported feeling this event, which was located approximately 18 miles southwest of Jackson. A magnitude 4.4 earthquake occurred on October 8, 1966, in northern Lincoln County. This non-damaging earthquake was centered approximately 16 miles southwest of Hoback Junction. This same area experienced a magnitude 3.7 earthquake on October 27, 1966. No one reported feeling the October 1966 earthquakes. The last earthquake to occur in the region in the 1960s took place on February 25, 1969. This non-damaging, magnitude 3.6 event was centered in eastern Idaho, approximately 6 miles north-northwest of Alta.

Four earthquakes were recorded near Teton County in the 1970s. The first occurred on September 21, 1970, in northern Lincoln County near the Elbow Campground, approximately 9 miles south-southwest of Hoback Junction. The Jackson Hole Guide (September 24, 1970) reported that residents from Jackson through the Hoback Canyon to Bondurant felt this magnitude 4.4 earthquake. Some residents from Jackson thought that the event was a sonic boom. At Camp Davis, a resident reported a figurine knocked off a television set and a "vibrating" staircase. Eleven miles south of Jackson, a resident reported rattling windows and a shaking bed. Near Bondurant, in Sublette County, a resident reported that windows rattled and her whole house shook. A magnitude 3.6 earthquake was recorded in southern Yellowstone National Park on April 24, 1974, approximately 9 miles east-northeast of the south entrance to the Park. No one reported feeling this earthquake and no damage was reported. On December 27, 1975, a magnitude 3.1 earthquake occurred in northern Lincoln County. Its epicenter was located approximately 12 miles south-southwest of Hoback Junction. No damage was reported from this earthquake.

On January 28, 1980, a magnitude 2.8 earthquake occurred in western Fremont County. No one felt this event, which was centered approximately 25 miles east of Moran Junction. Local residents did feel the earthquake that occurred on February 8, 1983. This magnitude 4.4, intensity V earthquake was located in eastern Idaho, approximately 24 miles southwest of

Jackson. No damage was reported. On November 2, 1983, a magnitude 3.5 earthquake was recorded in northern Sublette County, approximately 41 miles east-northeast of Hoback Junction. This event was not felt. In August and September of 1985, four earthquakes occurred in northern Lincoln County, three of which were felt in Jackson. The first, a magnitude 4.8, intensity V event on August 21, 1985, was lightly felt in Jackson. A local business reported that "it felt like something hit the side of the building" (Casper Star-Tribune, August 22, 1985). The second earthquake, a magnitude 4.3, intensity IV event, occurred on August 22, 1985, but was not felt in Jackson. The third, a magnitude 4.3, intensity V event on August 30, 1985, was felt in Jackson, but caused no damage (Laramie Daily Boomerang, August 31, 1985). The last earthquake occurred on September 6, 1985. This magnitude 4.6, intensity V event was felt as an intensity IV earthquake in Wilson. An earthquake-induced landslide temporarily closed a portion of U.S. Highway 89 in the Snake River Canyon (Casper Star-Tribune, September 8, 1985). Two earthquakes occurred in Lincoln County on November 17, 1986, approximately 12 miles south-southwest of Hoback Junction. The first was a magnitude 3.9 event, which was felt by residents in the area. The second, a magnitude 3.7 earthquake, was not felt.

Several earthquakes occurred near Teton County in the 1990s. A magnitude 3.5 event was detected in northern Lincoln County on April 9, 1990. The earthquake, which was located approximately 13 miles south-southeast of Hoback Junction, did not cause any damage. On April 19, 1990, a magnitude 3.3 earthquake was recorded in eastern Idaho, approximately 22 miles west-southwest of Hoback Junction. Residents in the area reported feeling this earthquake as an intensity IV event. The next earthquake that caused any concern occurred on April 3, 1992. The magnitude 4.0, intensity IV earthquake was located in eastern Idaho, approximately 4 miles north-northwest of Alta. Although it was felt as an intensity III event at Moose and Wilson, it did not cause any damage (Casper Star-Tribune, April 4, 1992). On August 22, 1993, approximately 34 miles southeast of Moran Junction, a magnitude 3.1 earthquake occurred in eastern Fremont County. No one reported feeling this event. Another 3.1 earthquake was detected in northern Lincoln County on October 10, 1993. No one felt this earthquake, which was centered approximately 12 miles west-southwest of Hoback Junction. On November 7, 1996, a magnitude 3.8 earthquake was detected in eastern Lincoln County, approximately 4 miles southwest of Alta. Residents in the area reported feeling this earthquake. A magnitude 2.8 earthquake was detected in eastern Idaho on June 28, 1999. No one reported feeling this event, which was centered approximately 7.5 miles north-northwest of Alta.

On April 21, 2001, a magnitude 5.4 earthquake occurred in eastern Idaho, approximately 42 miles southwest of Hoback Junction. It was felt as far away as Logan, Ogden, and Salt Lake City, Utah. In Wyoming, it was felt as an intensity V earthquake at Etna, an intensity IV earthquake at Thayne, and an intensity III earthquake at Afton, Jackson, and Wilson. On October 21, 2002, a magnitude 3.2 earthquake was detected approximately 3 miles northeast of Alpine or 16.5 miles southwest of Hoback Junction (U.S. Bureau of Reclamation). This event was followed closely by a magnitude 4.4 earthquake and a magnitude 4.2 earthquake (U.S. Bureau of Reclamation) centered in approximately the same area. Residents in the area reported feeling both of these earthquakes. No damage was reported from either event. On October 23, 2002, a magnitude 3.4 earthquake was reported approximately 4.5 miles north-northeast of Alpine. No one reported feeling this most recent earthquake.

Uniform Building Code

The Uniform Building Code (UBC) is a document prepared by the International Conference of Building Officials. Its stated intent is to "provide minimum standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of all buildings and structures within this jurisdiction and certain equipment specifically regulated herein."

The UBC contains information and guidance on designing buildings and structures to withstand seismic events. With safety in mind, the UBC provides Seismic Zone Maps to help identify which design factors are critical to specific areas of the country. In addition, depending upon the type of building, there is also an "importance factor". The "importance factor" can, in effect, raise the standards that are applied to a building.

The current UBC Seismic Zone Map (Figure 1) (1997) has five seismic zones, ranging from Zone 0 to Zone 4, as can be seen on the enclosed map. The seismic zones are in part defined by the probability of having a certain level of ground shaking (horizontal acceleration) in 50 years. The criteria used for defining boundaries on the Seismic Zone Map were established by the Seismology Committee of the Structural Engineers Association of California (Building Standards, September-October, 1986). The criteria they developed are as follows:

Zone	Effective Peak Acceleration, % gravity (g)
4	30% and greater
3	20% to less than 30%
2	10% to less than 20%
1	5% to less than 10%
0	less than 5%

The committee assumed that there was a 90% probability that the above values would not be exceeded in 50 years, or a 100% probability that the values would be exceeded in 475 to 500 years.

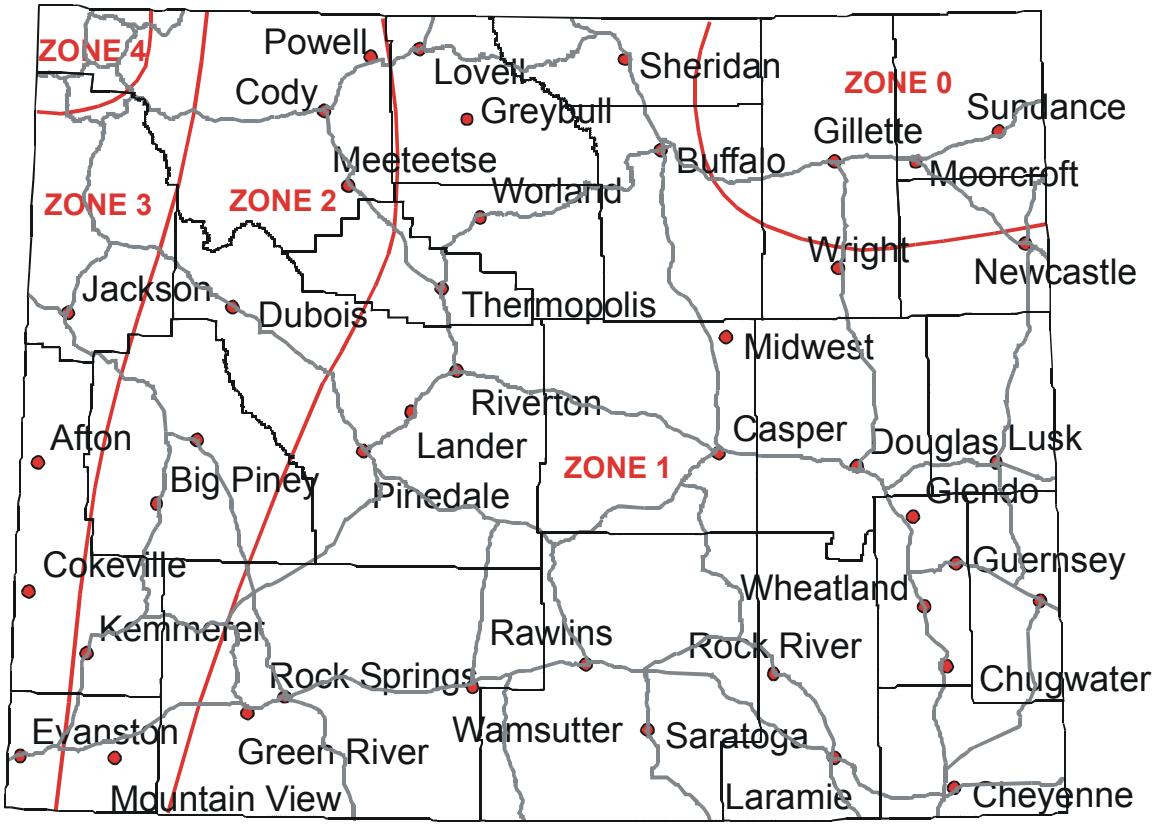

Figure 1. UBC Seismic Zone Map.

Teton County is primarily in Seismic Zone 3 of the UBC, although eastern portions of the county are in Seismic Zone 2. Since effective peak accelerations (90% chance of non-exceedance in 50 years) can range from 10%g-30%g in these two zones, and there has been some significant historic seismicity in the county, it may be reasonable to assume that an average peak acceleration of 25%g could be applied to the design of a non-critical facility located in the county if only the UBC were used. Such acceleration, however, is significantly less than would be suggested through the new International Building Code (IBC).

Recently, the UBC has been replaced by the International Building Code (IBC). The IBC is based upon probabilistic analyses, which are described in a following section. Teton County still uses the UBC, however, as do most Wyoming counties as of December 2002.

Deterministic Analysis of Regional Active Faults with a Surficial Expression

Several active fault systems are present in Teton County. The Teton fault system is a series of northeast-southwest-trending normal faults located on the eastern edge of the Teton Range near Jackson, Wyoming. While Quaternary/Holocene-aged fault scarps have been identified along the entire length of the fault (Smith et al., 1990a, Wong et al., 2000), much is still unresolved about the Teton fault system. Previous investigations have divided it into northern, central, and southern segments (Smith et al., 1990a; Susong et al., 1987). Other researchers prefer an unsegmented model of the Teton fault (Ostenaa et al., 1988, Byrd et al., 1994). In addition, questions still exist as to whether or not the Beula-Hering Lakes faults in Yellowstone National Park are a northern extension of the Teton fault (Wong et al., 2000). Based upon unsegmented surface rupture lengths (48 miles/77 km including Beula-Hering Lakes faults; 40miles/64km not including Beula-Hering Lakes faults), Wong and others (2000) estimate that the Teton fault is capable of generating a magnitude 6.9 to 7.5 earthquake. This agrees with other analyses, in which a maximum credible earthquake of magnitude 7.5 and a recurrence interval of 800-3600 years were suggested for the Teton fault (Doser and Smith, 1983; Gilbert et al., 1983). A trench on the Teton fault indicated that the fault most recently activated between 4800-7000 years ago (Smith et al., 1993). As a result, Case (1997a) suggests that the Teton fault may be overdue for a magnitude 7.5 earthquake. If a magnitude 7.5 earthquake did occur on the Teton fault, it could potentially generate peak horizontal accelerations of approximately 20%g -21%g at Alta, approximately 20%g at Hoback Junction, approximately 39%g at Jackson, approximately 80%g at Jackson Lake Dam and Jenny Lake, approximately 36%g at Kelly, approximately 62%g at Moose, approximately 23%g at Moran Junction, and greater than 80%g at Wilson (Campbell, 1987). These accelerations are roughly equivalent to intensity IX earthquakes at Jackson Lake Dam, Jenny Lake and Wilson, intensity VIII earthquakes at Jackson, Kelly, and Moose, intensity VII earthquakes at Alta, Hoback Junction, and Moran Junction. Jackson Lake Dam, Jenny Lake and Wilson could sustain heavy damage. Heavy to moderate damage could occur at Jackson, Kelly, and Moose, and moderate to heavy damage could occur at Alta, Hoback Junction, and Moran Junction.

The Baldy Mountain fault system is a series of short faults located approximately 21 miles (33 km) east of the Teton fault. Investigators at the U.S.G.S. identified areas where the faults offset Quaternary-aged glacial moraines. No maximum magnitude earthquake has been specifically postulated for the Baldy Mountain fault system. It is generally accepted that a magnitude 6.5

earthquake is required to produce ground surface rupture. While evidence of ground surface rupturing has been identified on the Baldy Mountain fault system, the ground surface rupture length is not consistent with a magnitude 6.5 event. In the interest of public safety, however, this report will model the Baldy Mountain fault system as being capable of generating a magnitude 6.5 earthquake with a recurrence interval of approximately 13,000-25,000 years (Machette et al., 2001; Pierce and Morgan, 1992). A magnitude 6.5 earthquake on this fault system could, in turn, generate peak horizontal accelerations of approximately 3.6%g at Alta, approximately 3.3%g at Hoback Junction, approximately 4.5%g at Jackson, approximately 13%g at Jackson Lake Dam, approximately 8.2%g at Jenny Lake, approximately 7.4%g at Kelly, approximately 7.0%g at Moose, approximately 20%g at Moran Junction, and approximately 3.8 %g at Wilson (Campbell, 1987). These accelerations are roughly equivalent to an intensity VII earthquake at Moran Junction, an intensity VI earthquake at Jackson Lake Dam, intensity V earthquakes at Jackson, Jenny Lake, Kelly, and Moose, and intensity IV earthquakes at Alta, Hoback Junction, and Wilson. Moderate damage could occur at Moran Junction, light damage could occur at Jackson Lake Dam, and very light damage could occur at Jackson, Jenny Lake, Kelly, and Moose. No damage should occur at Alta, Hoback Junction, or Wilson.

The last active fault system in Teton County is the Togwotee Lodge fault system. This series of faults lie in the eastern part of the county, approximately 9 miles (15 km) west of Togwotee Pass. The U.S.G.S. found evidence that Quaternary-aged glacial deposits have been offset along the fault traces, with a recurrence interval of approximately 16,000-23,000 years (Marchette et al, 2001). As with the Baldy Mountain fault system, the Togwotee Lodge faults have a shorter ground surface rupture length than would be produced by a magnitude 6.5 earthquake. The presence of any ruptured ground surface along these faults, however, suggests that they may be capable of producing at least a magnitude 6.5 earthquake. A magnitude 6.5 earthquake on the Togwotee Lodge fault system could generate peak horizontal accelerations of approximately 2.8%g at Alta and Hoback Junction, approximately 3.5%g at Jackson, approximately 8.4%g at Jackson Lake Dam, approximately 5.4%g at Jenny Lake, approximately 6.2%g at Kelly, approximately 5.2%g at Moose, approximately 10.1%g at Moran Junction, and approximately 3.1%g at Wilson (Campbell, 1987). These accelerations are roughly equivalent to an intensity VI earthquake at Moran Junction, intensity V earthquakes at Jackson Lake Dam, Jenny Lake, Kelly, and Moose, and intensity IV earthquakes at Alta, Hoback Junction, Jackson, and Wilson. Light damage could occur at Moran Junction, and very light damage could occur at Jackson Lake Dam, Jenny Lake, Kelly, and Moose. No damage should occur at Alta, Hoback Junction, Jackson, or Wilson.

Active fault systems present in the southern portion of Yellowstone National Park may also affect Teton County. Love and Christiansen (1985) describe the Buffalo Fork fault as beginning on the western side of the South Arm of Yellowstone Lake and continuing south to Gravel Mountain in Teton National Forest. This normal fault that reactivated a reverse fault surface offsets the Quaternary Lava Creek Tuff near Channel Mountain (U.S.G.S., 1972). Based upon a maximum surface rupture length of 32 miles (51 km), a maximum credible earthquake of magnitude 7.1 has been postulated for this fault (Wong et al., 2000). No definite recurrence interval has been determined for the Buffalo Fork fault. The U.S.G.S. suggests a long recurrence interval of approximately 10,000 to 100,000 years (Marchette et al., 2001), since at least one event has occurred on the fault since the glaciers receded from the area. A magnitude 7.1

earthquake on the Buffalo Fork fault could potentially generate peak horizontal accelerations of approximately 4.7%g at Alta, approximately 3.6%g at Hoback Junction, approximately 4.8%g at Jackson, approximately 13.5%g at Jackson Lake Dam, approximately 8.4%g at Jenny Lake, approximately 7.8%g at Kelly, approximately 7.2%g at Moose, approximately 17%g at Moran Junction, and approximately 4.3%g at Wilson (Campbell, 1987). These accelerations are roughly equivalent to intensity VI earthquakes at Jackson Lake Dam and Moran Junction, intensity V earthquakes at Alta, Jackson, Jenny Lake, Kelly, Moose, and Wilson, and intensity IV earthquakes at Hoback Junction. Light damage could occur at Jackson Lake Dam and Moran Junction, and Alta, Jackson, Jenny Lake, Kelly, Moose, and Wilson could sustain very light damage. No damage should occur at Hoback Junction.

The Beula-Hering Lakes faults are present east of Hering Lake and extend south into Teton County. They may even be an extension of the Teton fault system (Case, 1997a; Love, 1961; Love et al., 1992; Wong et al., 2000). For this analysis, however, they will be considered as a separate fault system. (See the first paragraph of this section for information related to including the Beula-Hering Lakes faults as part of the Teton fault) The Quaternary-aged Huckleberry Ridge Tuff and Lewis Canyon Rhyolite are displaced by the Beula-Hering Lakes faults. Based upon a maximum surface rupture length of 8 miles (13 km), Wong and others (2000) estimated that a maximum magnitude 6.7 earthquake could result from this fault system. A long recurrence interval is probable, as the most recent event is dated to less than 630,000 years before present (offset of the Lava Creek Tuff), but the 70,000 year old Pitchstone Plateau rhyolite flow is not disturbed by these faults (U.S.G.S., 1972; Marchette et al., 2001). A magnitude 6.7 earthquake on the Beula-Hering Lakes faults could generate peak horizontal accelerations of approximately 6%g at Alta, approximately 2.3%g at Hoback Junction, approximately 3.2%g at Jackson, approximately 11%g at Jackson Lake Dam, approximately 7.5%g at Jenny Lake, approximately 4.8%g at Kelly, approximately 5.2%g at Moose, approximately 9%g at Moran Junction, and approximately 3.3%g at Wilson (Campbell, 1987). These accelerations are roughly equivalent to an intensity VI earthquake at Jackson Lake Dam, intensity V earthquakes at Alta, Jenny Lake, Kelly, Moose, and Moran Junction, and intensity IV earthquakes at Hoback Junction, Jackson, and Wilson. Light damage could occur at Jackson Lake Dam. Alta, Jenny Lake, Kelly, Moose, and Moran Junction could sustain very light damage, but no damage should occur at Hoback Junction, Jackson, and Wilson**.**

The Mount Sheridan-Heart River fault system extends from the Heart Lake Geyer Basin southwest of Yellowstone Lake to near Bobcat Ridge in the Bridger-Teton National Forest. Quaternary-aged movement has been identified along these north-south-trending faults, as they offset the Huckleberry Ridge Tuff in several locations. Based upon a maximum surface rupture length of nearly 26 miles (41 km), a maximum magnitude 7.0 earthquake has been suggested for this fault system (Wong et al., 2000). The U.S.G.S. estimated that because this fault system has a high slip rate (1-5mm/yr), the recurrence interval for the Mount Sheridan-Heart River fault is less than 5,000 years. The age of the most recent events are not known, as no dating has been done on this fault system. A magnitude 7.0 earthquake on the Mount Sheridan-Heart River fault could generate peak horizontal accelerations of approximately 6%g at Alta, approximately 3.2%g at Hoback Junction, approximately 4.4%g at Jackson, approximately 19%g at Jackson Lake Dam, approximately 10%g at Jenny Lake, approximately 7.2%g at Kelly, approximately 7.4%g at Moose, approximately 16.5%g at Moran Junction, and approximately 4.3%g at Wilson

(Campbell, 1987). These accelerations are roughly equivalent to an intensity VII earthquake at Jackson Lake Dam, intensity VI earthquakes at Jenny Lake and Moran Junction, intensity V earthquakes at Alta, Jackson, Kelly, Moose, and Wilson, and an intensity IV earthquake at Hoback Junction. Jackson Lake Dam could sustain moderate damage, while Jenny Lake and Moran Junction could sustain light damage. Very light damage could occur at Alta, Jackson, Kelly, Moose, and Wilson. No damage should occur at Hoback Junction.

The Yellowstone River Valley in the southeastern portion of Yellowstone National Park is bounded by several active normal faults. These faults displace Quaternary/Holocene deposits and alluvium along their trace. Based upon a maximum surface rupture length of 14 miles (22 km), these faults could generate a maximum magnitude 6.6 earthquake (Wong et al., 2000). No specific recurrence interval has been determined for these faults. A magnitude 6.6 earthquake on these faults could in turn generate peak horizontal accelerations of approximately 2.1%g at Alta, approximately 1.9%g at Jackson, approximately 4.7%g at Jackson Lake Dam, approximately 3.1%g at Jenny Lake, approximately 2.8%g at Kelly, approximately 2.7%g at Moose, approximately 5.2%g at Moran Junction, and approximately 1.9%g at Wilson (Campbell, 1987). These accelerations are roughly equivalent to intensity V earthquakes at Jackson Lake Dam and Moran Junction, and intensity IV earthquakes at Alta, Jackson, Jenny Lake, Kelly, Moose, and Wilson. Very light damage could occur at Jackson Lake Dam and Moran Junction. Alta, Jackson, Jenny Lake, Kelly, Moose, and Wilson should sustain no damage. Hoback Junction would be subjected to ground accelerations of less than 1.5%g, which should not cause any damage.

The Yellowstone Lake fault extends from Dot Island in Yellowstone Lake south to Overlook Mountain. The U.S.G.S. (1972) found evidence that this fault has disturbed Quaternary Lava Creek Tuff and Mount Jackson Rhyolite deposits, as well as lacustrine deposits from Yellowstone Lake. Based upon a maximum surface rupture length of 17.5 miles (28 km), Wong and others (2000) estimated that a maximum magnitude 6.8 earthquake could be generated by this fault. Preliminary investigations of the Yellowstone Lake fault suggest a recurrence interval of approximately 7,000 years for the middle section of the fault (Marchette et al., 2001; Locke et al., 1992). A magnitude 6.8 earthquake could produce peak horizontal accelerations of approximately 3%g at Alta, approximately 2.2%g at Jackson, approximately 6%g at Jackson Lake Dam, approximately 3.9%g at Jenny Lake, approximately 3.2%g at Kelly, approximately 3.3%g at Moose, approximately 5.9%g at Moose, and approximately 2.2%g at Wilson (Campbell, 1987). These accelerations are roughly equivalent to intensity V earthquakes at Jackson Lake Dam, Jenny Lake and Moran Junction, and intensity IV earthquakes at Alta, Jackson, Kelly, Moose, and Wilson. Jackson Lake Dam, Jenny Lake, and Moran Junction could sustain very light damage, but no damage should occur at Alta, Jackson, Kelly, Moose, and Wilson. Hoback Junction would be subjected to ground accelerations of less than 1.5%g, which should not cause any damage.

Two active fault systems are also present near Teton County in northern Lincoln County. The Grey's River fault system is located in northern Lincoln County on the western side of the Wyoming Range. Evidence of late-Holocene movement has been identified on this north-south-trending normal fault (Jones and McCalpin, 1992; McCalpin, 1993). Based upon an estimated surface rupture length of 54 km, the Grey's River fault system could potentially generate a

magnitude 7.1 earthquake with a recurrence interval of approximately 2970 – 3400 years (Jones, 1995; Jones and McCalpin, 1992). However, because no movement occurred on the Grey's River fault system between approximately 5000 and 15,000 years before present, this recurrence interval may be variable (Jones and McCalpin, 1992). A magnitude 7.1 earthquake could generate peak horizontal accelerations of approximately 2.8%g at Alta, approximately 9.2%g at Hoback Junction, approximately 5.8%g at Jackson, approximately 2.5%g at Jackson Lake Dam, approximately 3.2%g at Jenny Lake, approximately 4.0%g at Kelly, approximately 3.8%g at Moose, approximately 2.6%g at Moran Junction, and approximately 5.4%g at Wilson (Campbell, 1987). These accelerations are roughly equivalent to an intensity V-VI earthquake at Hoback Junction, intensity V earthquakes at Jackson, Kelly, and Wilson, and intensity IV earthquakes at Alta, Jackson Lake Dam, Jenny Lake, Moose, and Moran Junction. Hoback Junction could sustain some light damage, while very light damage could occur at Jackson, Kelly, and Wilson. No damage should occur at Alta, Jackson Lake Dam, Jenny Lake, Moose, or Moran Junction.

The Star Valley fault system is the other active fault system in northern Lincoln County. This fault system, which has been subdivided into north and south segments, bounds the eastern edge of the Star Valley. Investigations of the Star Valley fault system determined that Holocene and late-Pleistocene offsets exist along the south fault segment (Piety et al., 1990; McCalpin et al., 1990; McCalpin, 1990). Several maximum magnitude earthquakes have been suggested for the Star Valley fault system. Piety and others (1986) proposed that the Star Valley fault system is capable of generating a maximum credible earthquake of magnitude 7.5 with a recurrence interval of 5,000 to 7,000 years. Based upon a surface rupture length of 27 miles, McCalpin and others (1990) determined that the Star Valley fault system could produce a maximum magnitude 7.2 earthquake. When McCalpin (1990) trenched a portion of the Star Valley fault near Afton, he determined that a magnitude 7.3 earthquake with a recurrence interval of 2550-6000 years is possible on this system. Because of the extensive seismic activity associated with the area surrounding the Star Valley fault, and because of the close proximity of towns to this fault system, a maximum magnitude of 7.5 will be used for this analysis. It should also be noted that it has been approximately 5500 years since the last confirmed event on the Star Valley fault at Afton. This fault system is therefore nearing its recurrence interval limit. A magnitude 7.5 earthquake could generate peak horizontal accelerations of approximately 7.5%g at Alta, approximately 17%g at Hoback Junction, approximately 14%g at Jackson, approximately 4.8%g at Jackson Lake Dam, approximately 6.7%g at Jenny Lake, approximately 7.8%g at Kelly, approximately 8.2%g at Moose, approximately 4.7%g at Moran Junction, and approximately 15%g at Wilson (Campbell, 1987). These accelerations are roughly equivalent to intensity VI earthquakes at Hoback Junction, Jackson, and Wilson, and intensity V earthquakes at Alta, Jackson Lake Dam, Jenny Lake, Kelly, Moose, and Moran Junction. Hoback Junction, Jackson, and Wilson could sustain light damage, but only very light damage should occur at Alta, Jackson Lake Dam, Jenny Lake, Kelly, Moose, and Moran Junction.

Floating or Random Earthquake Sources

Many federal regulations require an analysis of the earthquake potential in areas where active faults are not exposed, and where earthquakes are tied to buried faults with no surface expression. Regions with a uniform potential for the occurrence of such earthquakes are called tectonic provinces. Within a tectonic province, earthquakes associated with buried faults are assumed to occur randomly, and as a result can theoretically occur anywhere within that area of uniform earthquake potential. In reality, that random distribution may not be the case, as all earthquakes are associated with specific faults. If all buried faults have not been identified, however, the distribution has to be considered random. "Floating earthquakes" are earthquakes that are considered to occur randomly in a tectonic province.

It is difficult to accurately define tectonic provinces when there is a limited historic earthquake record. When there are no nearby seismic stations that can detect small-magnitude earthquakes, which occur more frequently than larger events, the problem is compounded. Under these conditions, it is common to delineate larger, rather than smaller, tectonic provinces.

The U.S. Geological Survey identified tectonic provinces in a report titled "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States" (Algermissen and others, 1982). In that report, Teton County was classified as being in a tectonic province with a "floating earthquake" maximum magnitude of 6.1. Geomatrix (1988b) suggested using a more extensive regional tectonic province, called the "Wyoming Foreland Structural Province", which is approximately defined by the Idaho-Wyoming Thrust Belt on the west, 104° West longitude on the east, 40° North latitude on the south, and 45° North latitude on the north. Geomatrix (1988b) estimated that the largest "floating" earthquake in the "Wyoming Foreland Structural Province" would have a magnitude in the 6.0 – 6.5 range.

Federal or state regulations usually specify if a "floating earthquake" or tectonic province analysis is required for a facility. Usually, those regulations also specify at what distance a floating earthquake is to be placed from a facility. For example, for uranium mill tailings sites, the Nuclear Regulatory Commission requires that a floating earthquake be placed 15 kilometers from the site. That earthquake is then used to determine what horizontal accelerations may occur at the site. A magnitude 6.5 "floating" earthquake, placed 15 kilometers from any structure in Teton County, would generate horizontal accelerations of approximately 17%g at the site. That acceleration would be adequate for designing a uranium mill tailings site, but may be too large for less critical sites, such as a landfill. Critical facilities, such as dams, usually require a more detailed probabilistic analysis of random earthquakes. Based upon probabilistic analyses of random earthquakes in an area distant from exposed active faults (Geomatrix, 1988b), however, placing a magnitude 6.5 earthquake at 15 kilometers from a site will significantly underestimate the ground acceleration that may actually occur in Teton County.

Probabilistic Seismic Hazard Analyses

The U.S. Geological Survey (USGS) publishes probabilistic acceleration maps for 500-, 1000-, and 2,500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a 10% probability that acceleration may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years.

The USGS has recently generated new probabilistic acceleration maps for Wyoming (Case, 2000). Copies of the 500-year (10% probability of exceedance in 50 years), 1000-year (5% probability of exceedance in 50 years), and 2,500-year (2% probability of exceedance in 50 years) maps are attached. Until recently, the 500-year map was often used for planning purposes for average structures, and was the basis of the most current Uniform Building Code. The new International Building Code, however, uses a 2,500-year map as the basis for building design. The maps reflect current perceptions on seismicity in Wyoming. In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased due to local soil conditions. For example, if fairly soft, saturated sediments are present at the surface, and seismic waves are passed through them, surface ground accelerations will usually be greater than would be experienced if only bedrock was present. In this case, the ground accelerations shown on the USGS maps would underestimate the local hazard, as they are based upon accelerations that would be expected if firm soil or rock were present at the surface. Intensity values can be found in Table 1.

Although 2,500-year probabilistic acceleration maps are adequate for designing most structures, a more conservative estimate of ground acceleration is usually necessary for dams and associated reservoirs. Wong and others (2000) developed 10,000-year (0.5% probability of exceedance in 50 years) and 50,000-year (0.1% probability of exceedance in 50 years) acceleration models for eastern Idaho and western Wyoming. Because of Jackson Lake Dam's close proximity to the Teton fault, these more conservative 10,000-year and 50,000-year acceleration models will be used to determine peak horizontal ground accelerations that could occur at Jackson Lake Dam.

Based upon the 500-year map (10% probability of exceedance in 50 years) (Figure 2), the estimated peak horizontal acceleration in Teton County ranges from approximately 12%g in the southeastern potion of the county to greater than 25%g in the southwestern, north-central, and northeastern portions of the county. These accelerations are roughly comparable to intensity VI earthquakes (9.2%g – 18%g) and intensity VII earthquakes (18%g – 34%g). Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Jackson would be subjected to accelerations of over 25%g or intensity VII.

Based upon the 1000-year map (5% probability of exceedance in 50 years) (Figure 3), the estimated peak horizontal acceleration in Teton County ranges from approximately 17%g in the southeastern portion of the county to over 40%g in the southwestern, south-central, and central portions of the county. These accelerations are roughly comparable to intensity VI earthquakes (9.2%g – 18%g), intensity VII earthquakes (18%g – 34%g), and intensity VIII earthquakes

(34%g – 65%g). Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, factory stacks may fall. Heavy furniture may be overturned. Jackson would be subjected to accelerations of approximately 40%g or intensity VIII.

Based upon the 2500-year map (2% probability of exceedance in 50 years) (Figure 4), the estimated peak horizontal acceleration in Teton County ranges from nearly 30%g in the southeastern corner of the county to over 60%g in the central portions of the county. These accelerations are roughly comparable to intensity VII earthquakes (18%g – 34%g), intensity VIII earthquakes (34%g – 65%g), and possibly intensity IX earthquakes (65%g-124%g). Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, factory stacks may fall. Heavy furniture may be overturned. Intensity IX earthquakes can cause considerable damage in specially designed structures and great damage and partial collapse in substantial buildings. Well-designed frame structures could be thrown out of plumb. Buildings can be shifted off their foundations. The ground can crack and underground pipes could be broken. Jackson would be subjected to accelerations of approximately 60%g, or intensity VIII, with local accelerations perhaps justifying an intensity IX designation.

Based upon the 10,000-year probabilistic peak horizontal acceleration model (Wong et al., 2000), Jackson Lake Dam would be subjected to accelerations of approximately 89%g, or intensity IX. Intensity IX earthquakes can cause considerable damage in specially designed structures and great damage and partial collapse in substantial buildings. Well-designed frame structures could be thrown out of plumb. Buildings can be shifted off their foundations. The ground can crack and underground pipes could be broken.

Based upon the 50,000-year probabilistic peak horizontal acceleration model (Wong et al., 2000), Jackson Lake Dam would be subjected to accelerations of approximately 119%g, or intensity IX to X. Intensity IX earthquakes can cause considerable damage in specially designed structures and great damage and partial collapse in substantial buildings. Well-designed frame structures could be thrown out of plumb. Buildings can be shifted off their foundations. The ground can crack and underground pipes could be broken. Intensity X earthquakes can destroy some well-built wooden structures and most masonry and frame structures with foundations. Railroad rails can be bent. Considerable landslides on riverbanks and steep slopes may occur. Sand and mud can shift, and water may splash out over riverbanks.

As the historic record is limited, it is nearly impossible to determine when a 2,500-year, a 10,000-year, or a 50,000-year event last occurred in the county. Because of the uncertainty

involved, and based upon the fact that the new International Building Code utilizes 2,500-year events for building design, it is suggested that the 2,500-year probabilistic maps be used for most Teton County analyses. The 10,000-year and 50,000-year probabilistic models hould be use for an analysis of Jackson Lake Dam and Reservoir. This conservative approach is in the interest of public safety.

Table 1:

Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	<0.17	Not felt	None
II	0.17 – 1.4	Weak	None
III	0.17 – 1.4	Weak	None
IV	1.4 – 3.9	Light	None
V	3.9 – 9.2	Moderate	Very Light
VI	9.2 – 18	Strong	Light
VII	18 – 34	Very Strong	Moderate
VIII	34 – 65	Severe	Moderate to Heavy
IX	65 – 124	Violent	Heavy
X	>124	Extreme	Very Heavy
XI	>124	Extreme	Very Heavy
XII	>124	Extreme	Very Heavy

Modified Mercalli Intensity and peak ground acceleration (PGA) (Wald, et al 1999).

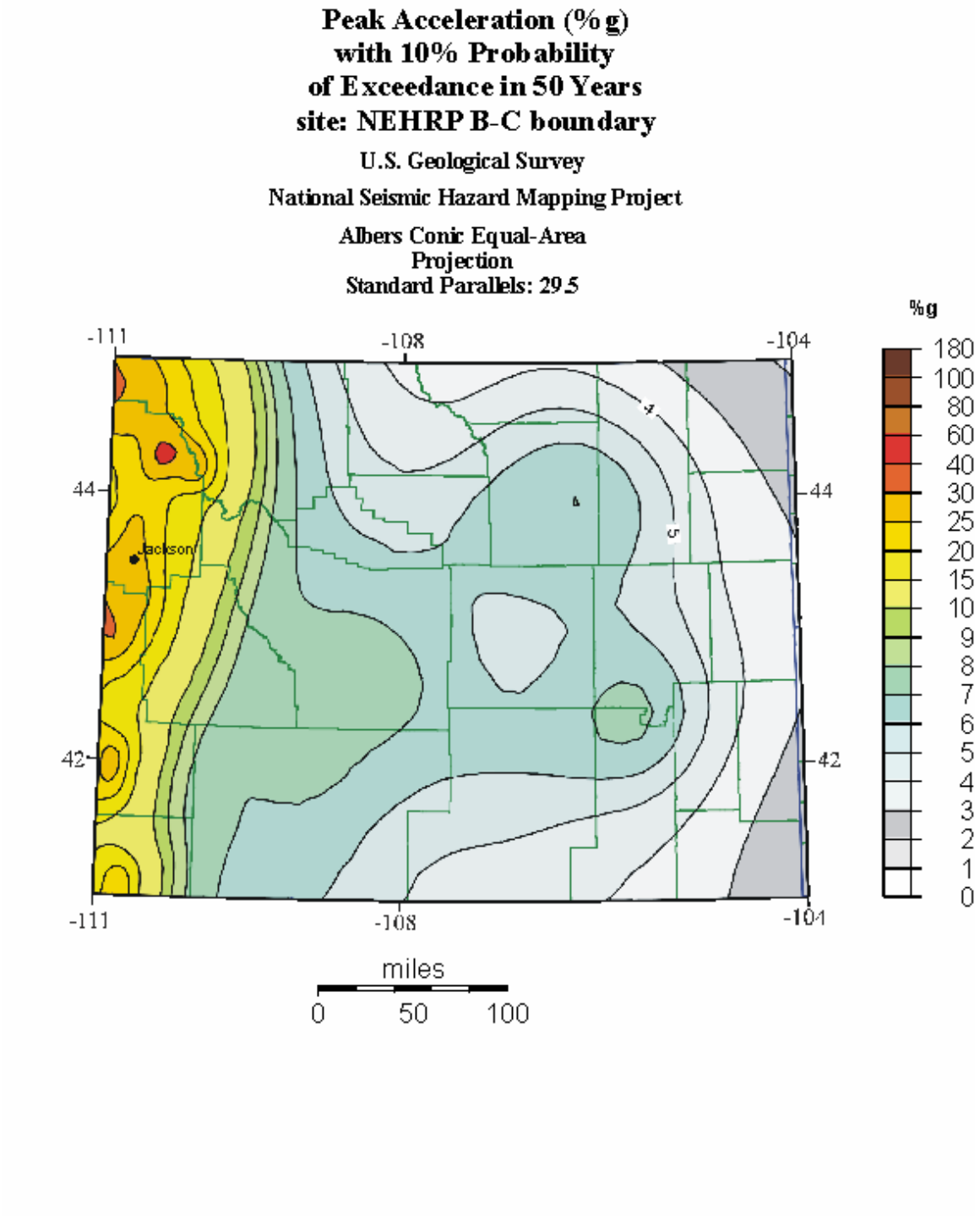

Figure 2. 500-year probabilistic acceleration map (10% probability of exceedance in 50 years).

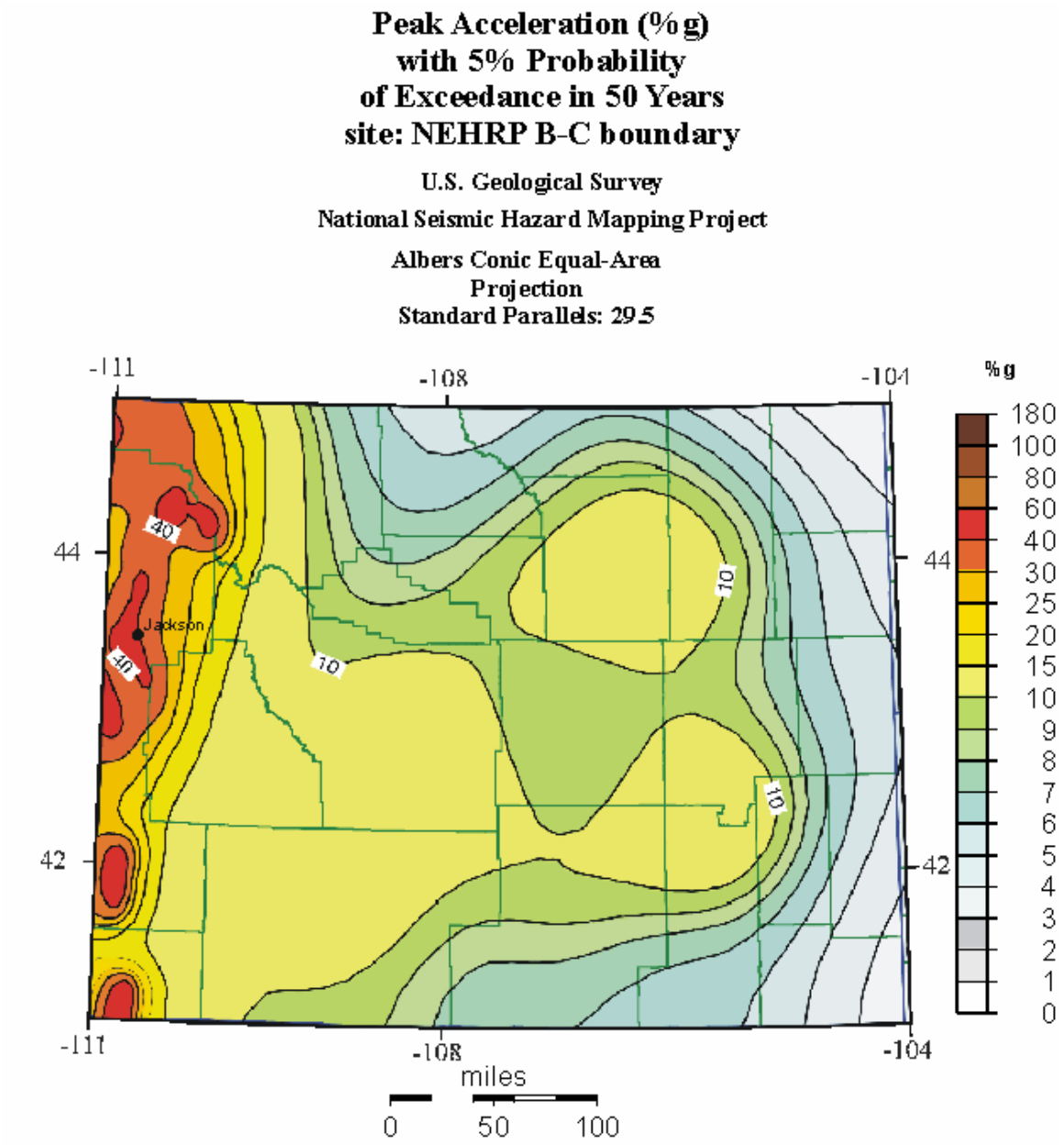

Figure 3. 1000-year probabilistic acceleration map (5% probability of exceedance in 50 years).

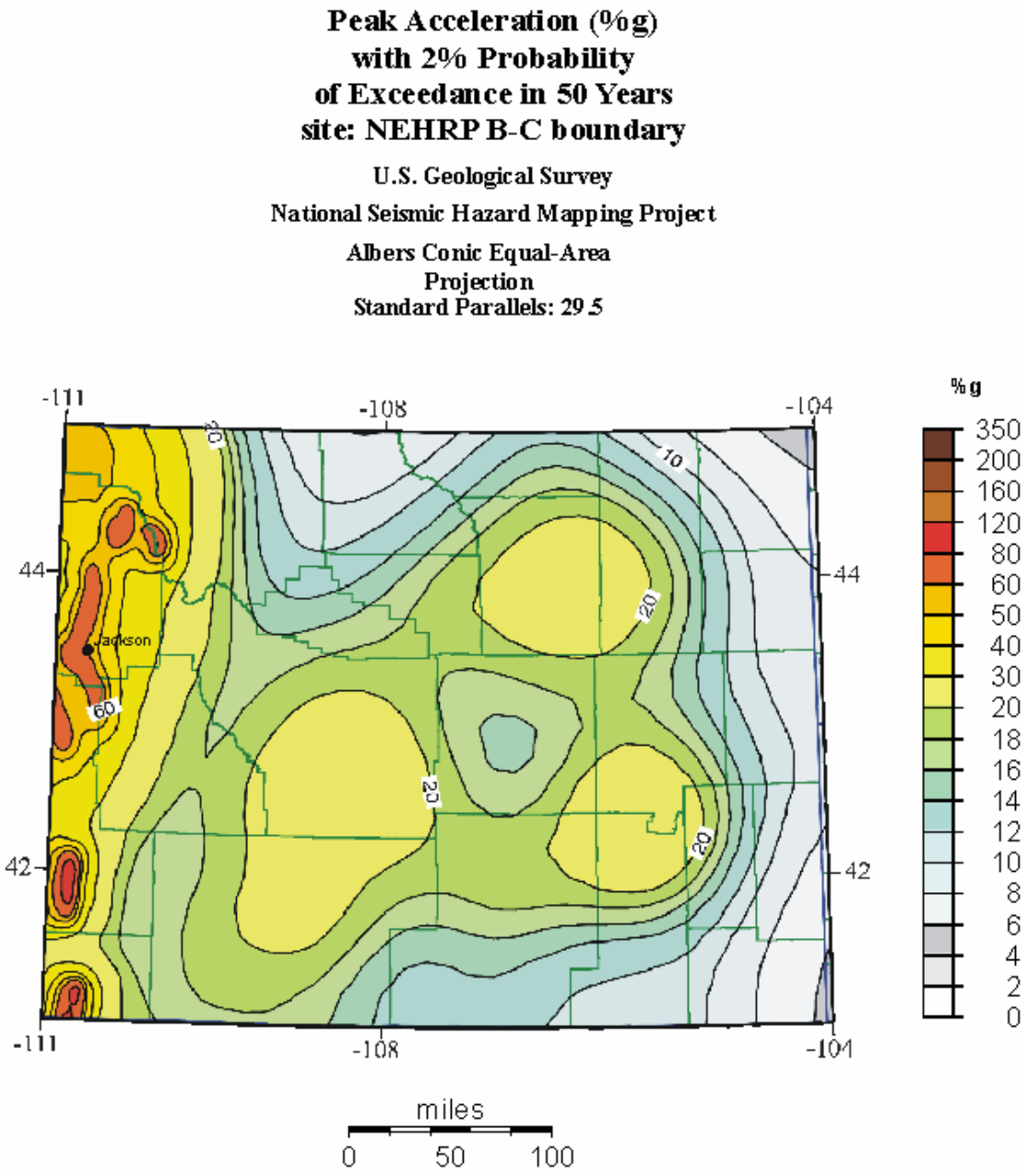

Figure 4. 2500-year probabilistic acceleration map (2% probability of exceedance in 50 years).

Abridged Modified Mercalli Intensity Scale

Intensity value and description:

I Not felt except by a very few under especially favorable circumstances.

II Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration like passing of truck. Duration estimated.

IV During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably.

V Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight.

VII Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars.

VIII Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed.

IX Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks.

XI Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.

Summary

There have been numerous historic earthquakes with a magnitude greater than 2.0 recorded in and near Teton County. Because of the limited historic record, it is possible to underestimate the seismic hazard in Teton County if historic earthquakes are used as the sole basis for analysis. Earthquake and ground motion probability maps and specific fault analyses give a more reasonable estimate of damage potential in Teton County.

Current earthquake probability maps that are used in the newest building codes suggest a scenario that would result in moderate to heavy damage to buildings and their contents, with damage increasing from the southeast to the west and north-central. More specifically, the probability-based or fault activation-based worst-case scenario could result in the following damage at points throughout the county:

Intensity X Earthquake Areas

Jackson Lake Dam

Intensity X earthquakes can destroy most masonry and frame structures with foundations and some well-built wooden structures. Railroad rails can be bent. Considerable landslides on riverbanks and steep slopes may occur. Sand and mud can shift, and water may splash out over riverbanks.

Intensity IX Earthquake Areas

Hoback Junction
Jackson (in certain areas)
Jenny Lake
Moose
Teton Village
Wilson

Intensity IX earthquakes can cause considerable damage in specially designed structures and great damage and partial collapse in substantial buildings. Well-designed frame structures could be thrown out of plumb. Buildings can be shifted off their foundations. The ground can crack and underground pipes could be broken.

Intensity VIII Earthquake Areas

Kelly
Jackson
Moran Junction

Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, factory stacks may fall. Heavy furniture may be overturned.

References

Algermissen, S.T., Perkins, D.M., Thenhaus, P.C., Hanson, S.L., and Bender, B.L., 1982, Probabilistic estimates of maximum acceleration and velocity in rock in the contiguous United States: U.S. Geological Survey Open File Report 82-1033, 99 p., scale 1:7,500,000.

Blackwelder, E., 1926, Earthquakes in Jackson Hole, Wyoming: Bulletin of the Seismological Society of America, v. 16, no. 3, p. 196.

Bodle, R.R., 1946, United States earthquakes 1944: U.S. Coast and Geodetic Survey, Serial No. 682, 43 p.

Brazee, R.J., and Cloud, W.K., 1959, United States earthquakes 1957: U.S. Department of Commerce, Coast and Geodetic Survey, 108 p.

Brazee, R.J., and Cloud, W.K., 1960, United States earthquakes 1958: U.S. Department of Commerce, Coast and Geodetic Survey, 76 p.

Byrd, J.O.D., Smith, R.B., and Geissman, J.W., 1994, The Teton fault, Wyoming: Toographic signature, neotectonics, and mechanisms of deformation: Journal of Geophysical Research, v. 99, p. 20,095-20,122.

Campbell, K.W., 1987, Predicting strong ground motion in Utah, *in* Gori, P.L., and Hays, W.W., editors, Assessment of regional earthquake hazards and risk along the Wasatch front, Utah, Volume 2: U.S. Geological Survey Open File Report 87-585, pp. L1-90.

Case, J.C., 2000a, Earthquakes in Wyoming: Wyoming State Geological Survey, Wyoming Geo-notes No. 66, pp. 49-56.

Case, J.C., 2000b, Probability of damaging earthquakes in Wyoming: Wyoming State Geological Survey, Wyoming Geo-notes No. 67, pp. 50-55.

Case, J.C., 1997a, Earthquakes and active faults in Wyoming: Wyoming State Geological Survey Preliminary Hazards Report 97-2, 58 p.

Case, J.C., 1997b, Historical seismicity of south-central and southeastern Wyoming: Wyoming State Geological Survey Wyoming Geo-notes Number 56, pp. 54-59.

Case, J.C., 1997c, Overview of historical seismicity in western Wyoming, Part 1: Wyoming State Geological Survey Geo-notes Number 54, pp.53-62.

Case, J.C., 1997d, Overview of historical seismicity in western Wyoming, Part 2: Wyoming State Geological Survey Geo-notes Number 55, pp. 43-52.

Case, J.C., Larsen L.L., Boyd, C.S., and Cannia, J.C., 1997, Earthquake epicenters and suspected active faults with surficial expression in Wyoming: Wyoming State Geological Survey Geologic Hazards Section Preliminary Hazards Report 97-1, scale 1:1,000,000.

Case, J.C., 1996, Historical seismicity of northeastern and east-central Wyoming: Wyoming State Geological Survey Wyoming Geo-notes Number 51, pp. 50-55.

Case, J.C., 1996, Historical seismicity in Southwestern Wyoming: Wyoming State Geological Survey Wyoming Geo-notes Number 50, pp. 52-56.

Case, J.C., 1993, Geologic Hazards in Wyoming: Wyoming State Geological Survey Wyoming Geo-notes Number 40, pp. 46-48.

Chambers, H.P., 1988, A regional ground motion model for historical seismicity along the Rock Creek fault, western Wyoming: unpublished M.S. thesis, University of Wyoming, Laramie, 95 p.

Coffman J.L., von Hake, C.A., Spence, W., Carver, D.L., Covington, P.A., Dunphy, G.J., Irby, W.L., Person, W.J., and Stover, C.W., 1975, United Staes Earthquakes 1973: U.S. National Oceanic and Atmospheric Administration and U.S. Geological Survey, 112 p.

Doser, D.I., and Smith, R.B., 1983, Seismicity of the Teton-southern Yellowstone region, Wyoming: Bulletin of the Seismological Society of America, v. 73, no. 5, p. 1369-1394.

Geomatrix Consultants, Inc., 1988a, Seismotectonic evaluation of the northwestern Wind River Basin: Report prepared for the U.S. Bureau of Reclamation, Contract No. 6-CS-81-07310, 116 p.

Geomatrix Consultants, Inc., 1988b, Seismotectonic evaluation of the Wyoming Basin geomorphic province: Report prepared for the U.S. Bureau of Reclamation, Contract No. 6-CS-81-07310, 167 p.

Gibbons, A.B., and Dickey, D.D., 1983, Seismotectonic study, Jackson Lake dam and reservoir, Minidoka project, Wyoming: U.S. Bureau of Reclamation Seismotectonic Report 83-8, 123 p.

Gilbert, J.D., Ostenaa, D.A., and Wood, C., 1983, Seismotectonic study, Jackson Lake dam and reservoir, Minidoka project, Wyoming: U.S. Bureau of Reclamation Seismotectonic Report 83-8, 123 p.

Heck N.H., and Bodle, R.R., 1930, United States earthquakes 1953: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 785, 51 p.

Humphreys, W.J., 1915, Seismological reports for March, 1915, *in* Abbe, C., editor, monthly weather review: U.S. Department of Agriculture, Weather Bureau Monthly Weather Review, v. 43, no. 3, p. 142-145.

Humphreys, W.J., 1921, Seismological reports for October 1914 to June 1924: U.S. Weather Bureau, Monthly Weather Review, Section V-Seismology.

Jones, L.A.C., 1995, The Quaternary Geology of the Eastern Side of the Grey's River Valley and the Neotectonics of the Grey's River Fault in Western Wyoming: unpublished M.S. thesis, Utah State University, Logan, 116 p.

Jones, L.C.A., and McCalpin, J.P., 1992, Quaternary faulting on the Grey's River fault, a listric normal fault in the overthrust belt of Wyoming: Geological Society of America Abstracts with Programs, v.24, no.6, p.20.

Locke, W.W., Meyer, G.A., and Pings, J.C., 1992, Morphology of a postglacial fault scarp across the Yellowstone (Wyoming) caldera margin and its implications: Bulletin of the Seismological Society of America, v. 82, p. 511-516.

Love, J.D., 1961, Reconnaissance study of Quaternary faults in and south of Yellowstone National Park, Wyoming: Geological Society of America Bulletin, v. 72, p. 1749-1764.

Love, J.D., and Christiansen, A.C., 1985, Geologic map of Wyoming: U.S. Geological Survey, scale 1:500,000.

Love, J.D., and Love, C.M., 1978, Geologic map of the Cache Creek Quadrangle, Teton County, Wyoming: U.S. Geological Survey Open File Report 78-480, scale 1:24,000.

Love, J.D., and Montagne, J. de la, 1956, Pleistocene and recent tilting of Jackson Hole, Teton County, Wyoming: Wyoming Geological Association 11th Annual Field Conference Guidebook, p. 169-178.

Love, J.D., Reed, Jr., J.C., and Christiansen, A.C., 1992, Geological map of Grand Teton National park, Teton county, Wyoming: U.S. Geological Survey Map I-2031, scale 1:62,500 scale.

Love, J.D., and Taylor, D.W., 1962, Faulted Pleistocene strata near Jackson, northwest Wyoming: U.S. Geological Survey Professional Paper 450-D, pp. D136-D139.

Marchette, M.N., Pierce, K.L., McCalpin, J.P., Haller, K.M., and Dart, R.L., 2001, Map and data for Quaternary faults and folds in Wyoming, U.S. Geological Survey unpublished Open-File Report , scale 1:750,000.

McCalpin, J.P., 1993, Neotectonics of the northeastern Basin and Range margin, western USA: Zeitschrift fuer Geomorphologie N. Folge, v.94, p.137-157.

McCalpin, J.P., and Warren, G. A., 1992, Quaternary faulting on the Rock Creek fault, overthrust belt, Wyoming: Geological Society of America Abstracts with Programs, v.24, no.6, p.51.

McCalpin, J.P., 1990, Latest Quaternary faulting in the northern Wasatch to Teton corridor (NWTC): Final Technical Report prepared by Department of Geology, Utah State University, Logan, UT, for the U.S. Geological Survey, 42 p.

McCalpin, J.P., Piety, L.A., and Anders, M.H., 1990, Latest Quaternary faulting and structural evolution of Star Valley, Wyoming in Roberts, Sheila, editor, Geologic field tours of western Wyoming and parts of adjacent Idaho, Montana, and Utah: Geological Survey of Wyoming Public Information Circular No. 29, p. 5-12.

McGrew, L.W., 1961, Structure of Cenozoic rocks along the northwestern margin of the Julesburg Basin, southeastern Wyoming (abstract): Geological Society of America, Rocky Mountain Section, Annual Meeting Program, Laramie, Wyoming, May 11-13, 1961, p. 22.

Murphy, L.M., and Ulrich, F.P., 1952, United States earthquakes 1950: U.S. Coast and Geodetic Survey, Serial No. 755, 47 p.

Murphy, L.M., and Cloud, W.K., 1954, United States earthquakes 1952: U.S. Department of Commerce, Coast and Geodetic Survey, Serial No. 773, 112p.

Murphy, L.M., and Cloud, W.K., 1955, United States earthquakes 1953: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 785, 51 p.

Neumann, F., 1938, United States earthquakes 1936: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 610, 45 p.

Neumann, F., and Bodle, R.R., 1932, United States earthquakes 1930: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 539, 25 p.

Neumann, F., 1927, Seismological report, October, November, December, 1925, and supplement for 1924: Department of Commerce, U.S. Coast and Geodetic Survey Serial No. 388, 120 p.

Ostenaa, D.A., and Gilbert, J.D., 1988, Late Quaternary behavior of the Teton fault, Wyoming (Abs.): Geological Society of America Abstracts with Programs, v. 20, p. A14.

Pierce, K.L., and Morgan, L.A., 1992, The track of the Yellowstone hotspot-Volcanism, faulting, and uplift, *in* Link, P.K., Kuntz, M.A., and Platt, L.B., eds.: Geological Society of America Memoir 171, p. 1-53.

Piety, L.A., Wood, C.K., Gilbert, J.D., Sullivan, J.T., and Anders, M.H., 1986, Seismotectonic study for Palisades Dam and Reservoir, Palisades project: U.S. Bureau of Reclamation Seismotectonic Report 86-3, 198 p.

Reagor, B.G., Stover, C.W., and Algermissen, S.T., 1985, Seismicity map of the State of Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1709, scale 1:1,000,000.

Smith, R.B., Byrd, J.O.D., and Susong, D.D., 1990a, Neotectonics and structural evolution of the Teton fault *in* Roberts, Sheila, editor, Geologic field tours of western Wyoming and parts of adjacent Idaho, Montana, and Utah: Geological Survey of Wyoming Public Information Circular No. 29, P. 127-138.

Smith, R.B., Byrd, J.O.D., and Susong, D.D., 1993, The Teton fault, Wyoming: seismotectonics, Quaternary history, and earthquake hazards, *in* Snoke, A.W., Steidtmann, J.R., and Roberts, S.M., editors, Geology of Wyoming: Geological Survey of Wyoming Memoir No. 5, p. 628-667.

Stover, C.W., 1985, Preliminary isoseismal map and intensity distribution for the Laramie Mountains, Wyoming, earthquake of October 18, 1984: U.S. Geological Survey Open File report 85-137, 9 p.

Susong, D.D., Smith, R.B., and Bruhn, R.L., 1987, Quaternary faulting and segmentation of the Teton fault zone, Grand Teton National Park, Wyoming: EOS, Transactions of the American Geophysical Union, v. 68, p. 1452.

U.S. Geological Survey, 1972, Geologic map of Yellowstone National Park: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-711, scale 1:125,000.

U.S.G.S. National Earthquake Information Center: http://wwwneic.cr.usgs.gov/

University of Utah Seismograph Station Epicenter Listings:
http://www.seis.utah.edu/HTML/EarthquakeCatalogAndInfo.html

Voight, B., 1978, Lower Gros Ventre slide, Wyoming, U.S.A., *in* Voight, b., editor, Rockslides and avalanches, 1, natural phenomena: Elsevier Scientific Publishing Company, New York, p. 113-166.

Wald, D.J., Quitoriano, V., Heaton, T.H., and Kanamori H., 1999, Relationships between peak ground acceleration, peak ground velocity and modified Mercalli Intensity in California: Earthquake Spectra, v. 15, no. 3, 557-564.

West, M.W., 1989, Neotectonics of the Darby-Hogsback and Absaroka thrust plates, Teton County, Wyoming and Summit County, Utah with applications to earthquake hazard assessment: Golden, Colorado School of Mines, unpublished Ph.D. dissertation, 450 p., 17 pls.

West, M.W., 1994, Seismotectonics of North-Central Utah and Southwestern Wyoming: Utah Geological Survey Special Study 82, Paleoseismology of Utah, v.4, 93 p.

Wong, I., Olig, S., and Dober, M., 2000, Preliminary Probabilistic Seismic Hazard Analyses Island Par, Grassy Lake, Jackson Lake, Palisades, and Ririe Dams: Report prepared by URS Greiner Woodward-Clyde for the U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.

Wong, I., Dober, M., and Fenton, C., 2001, Probabilistic Seismic Hazard Analyses Alcova, Glendo, Guernsey, Kortes, Pathfinder, and Seminoe Dams: Report prepared by URS Greiner Woodward-Clyde for the U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.