CHAPTER 3

HAZARD IDENTIFICATION

The following hazards have been identified in the State of Wyoming:

- Dam Failures
- Drought
- Earthquakes
- Expansive Soils
- Floods
- Hail
- Human-Caused Hazards Including Terrorism, Hazardous Materials and Hazardous Waste
- Landslides
- Lightning
- Liquefaction
- Meteor Impacts
- Mine Subsidence
- Snow Avalanches
- Tornadoes
- Toxic Elements (naturally occurring)
- Water Quality
- Wildland Fire
- Windblown Deposits
- Winter Storms and Blizzards
- Yellowstone Explosive Volcanism

Hazards that were analyzed in detail were those that had recurrence intervals less than 10,000 years and those not related specifically to health issues. These hazards were analyzed and are summarized below: dam failure, drought, earthquakes, expansive soils, floods, hail, hazardous materials and waste, landslides, lightning, liquefaction, mine subsidence, snow avalanches, tornadoes, wildland fire, windblown deposits, winter storms, and blizzards. Detailed reports on each hazard can be found in Chapters 4 through 19.

Other hazards identified but not further analyzed either had occurrence intervals greater than 10,000 years or were related specifically to health issues such as water quality or naturally occurring toxic elements. They are discussed in the second section of this chapter.

Each of Wyoming's 23 counties and two tribes has had opportunity to complete their own multi-hazard mitigation plan, with hazards addressed at the local level. Hazards presented in the local plans were reviewed and information mined from them is presented in this state-level multi-hazard mitigation plan. It was noted not all hazards identified by the State Plan are hazards perceived and addressed within the individual counties' plans and the level of perceived risk varied hazard-to-hazard and county-to-county. A table depicting information mined from the local plans is presented in each of this plan's hazard chapters, outlining the locally-perceived risk of each hazard.

A goal for the 2014 update will be to incorporate analysis of one additional hazard: Wind. In the process of completing the 2011 update the question was raised regarding the inclusion of wind hazards in the State Multi-Hazard Mitigation Plan. Additionally, data from the Wyoming State Property Risk Division revealed significant damage to state government property as a result

of wind. In fact, wind ranks third in hazards generating damage to state property. Wind, because of its constant presence in Wyoming, is just dealt with by the population and often overlooked as a hazard. However, wind, in retrospect is a both a damage-inducing hazard and is in the process of becoming a positive economic factor for Wyoming's economy. Given the damage it causes and the economic arm it has begun to generate, straight-line wind hazards warrant an analytical review.

Presidential Disaster Declarations

Wyoming has experienced the consequences of natural hazards in the past which have generated both State-Level and Presidential Disaster Declarations. Disaster Declarations have resulted from flooding, fire, tornado, winter storm, gas seepage, hail storms, and drought. The table below outlines the Presidential Disaster Declarations from 1923 to the present and is followed by a table outlining recent state-level declarations.

Presidential Disaster Declarations
Wyoming: 1923-2010

Number	Declared	State	Description
1923	07/14/2010	Wyoming	Flooding
2719	08/12/2007	Wyoming	Little Goose Fire
2665	08/14/2006	Wyoming	Jackson Canyon Fire
2654	07/13/2006	Wyoming	Thorn Divide Fire Complex
1599	08/22/2005	Wyoming	Tornado
2512	11/20/2003	Wyoming	Tongue River Fire
2460	08/31/2002	Wyoming	Commissary Ridge Fire
2436	07/01/2002	Wyoming	Reese Mountain Fire
2427	06/18/2002	Wyoming	Hensel Fire
2382	09/06/2001	Wyoming	McFarland Divide Fire
2370	08/01/2001	Wyoming	Elk Mountain #2 Fire
2367	07/26/2001	Wyoming	Green Knoll Fire
1351	12/13/2000	Wyoming	Winter Storm
2315	07/31/2000	Wyoming	Dead Horse Fire
1268	02/17/1999	Wyoming	Severe Winter Storm
3092	09/04/1987	Wyoming	Methane Gas Seepage

740	08/07/1985	Wyoming	Severe Storms, Hail, Flooding
591	07/19/1979	Wyoming	SEVERE STORMS, TORNADOES
557	05/29/1978	Wyoming	SEVERE STORMS, FLOODING, MUDSLIDES
3043	06/15/1977	Wyoming	Drought
155	07/04/1963	Wyoming	Heavy Rains, Flooding

Past history, as documented by Presidential Disaster Declarations and state-level declarations, would allow a conclusion to be drawn reflecting a natural or man-made disaster could occur in Wyoming at any time. However, when compared to other states, Wyoming has historically experienced fewer disasters overall. Wyoming recognizes and enjoys the blessing represented by this fact. However, it behooves Wyoming's population to remain vigilant and proactive in the pursuit of the mitigation of its natural hazards, to ensure Wyoming remains in the ranks of those states experiencing few disasters into the future.

State-Level Emergencies

Date	Case #	Duration (days)	Location	Event Type	Resource Used	Total Costs	Notes
5/3/2005	05-0002	1	Diamondville	Flood	CAP	$ 377.92	Photographic mission to assess the extent of flooding expected *(Gorny report)*
5/11/2005	05-0004	5	Sheridan County	Flood	Nat'l Guard	$ 33,881.58	WANG, Honor Farm, City of Sheridan, Sheridan County *(Gorny report)*
6/6/2005	05-0009	9	Albany County	Flood	Honor Farm & Guard	$ 2,850.00	Costs are pmt to Honor Farm only - no cost info avail for Guard. Incident participation was used to replace a drill previously scheduled for Laramie area *(Gorny report)*
8/12/2005	05-0011		Wright	Tornado	Multiple	$ 29,882.92	Costs could include amounts for WOHS staff, WY Military Dept, WY DOT, WY DEQ *(Gorny report)*
2005 Totals						$ 66,992.42	
	Floods:	**$37,109.50**					
	Tornados:	**$29,882.92**					
6/13/2006	06-0006	5	Platte County Fire -Camp Guernsey- "Wildland Fire"	Fire	WOHS, Nat'l Guard, WY State Forestry	$ 22,762.30	Costs derived from "Estimated Costs as of June 19, 2006" - 3 blackhawk helicopters, 2 C-130's, MSV2
6/19-24/2006	06-0007(1)	5	Albany County - "Isabelle Fire"	Fire	WOHS, Nat'l Guard, WY State Forestry	$ 10,000.00	Cost derived from WebEOC Duty officer log 6-22-06 "cost to date"- 6 Humvees to transport hand crews to remote locations, MSV2 -NOTE: Per letter to Gov from Dir Moore 6-22-06 cost for Nat'l guard assistance will be borne by USDA
7/13/2006	06-0007	6	Crook County - 'Thorne Divide Complex"	Fire	WOHS, Nat'l Guard, WY State Forestry, CAP	$ 13,809.80	Aerial recon, Air support - 2 Type 3 helicopters, 2 Type 2 helicopters, 3 Type 1 helicopters, one air tanker, WY State Helitack, 1 smokebuster crew, MSV2
~ 7/12/2006	06-0008	~6	Sheridan County - "Buffalo Creek Complex"	Fire	CAP, Nat'l Guard, WOHS	$ 10,800.00	Aerial recon, Air support - 2 Blackhawk helicopters, MSV 2. Costs are estimated WOHS vehicle & staff only
7/28/2006	06-0013	~6	Platte County "Old Chicago"	Fire	WOHS	$ 11,114.00	Air support - 3 Blackhawk helicopters, MSV2 plus 2 staff

Date	*Case #*	Duration (days)	Location	Event Type	Resource Used	Total Costs	Notes
8/13/2006	*06-0015 &17*	~22	"Purdy Fire" Bridger-Teton & Shoshone Forests	Fire	WOHS, USFS	$ 50,460.00	Infrared flights, Type-2 Incident Mgmt team, 6 helicopters, fixed wing air tankers, radiometric flight (verifiable cost for radio rental, lodging for staff)
8/14/2006	*06-0018*	~10	Natrona County - "Jackson Canyon Fire"	Fire	Nat'l Guard	$ 9,602.35	Disaster Declaration 8-15-06, 3 Helicopters (1 ea Type-1, Type-2, Type-3) 2 Bell 205 Sky Crain NOTE: Received FEMA Fire Management Assistance Grant
8/15/2006	*06-0019*	2	Goshen County (LaGrange)	Flood	CAP	$ 122.72	Aerial recon
~8/21/2006			Johnson County - "Outlaw II Fire"	Fire	Nat'l Guard	$ -	2 blackhawk helicopters, 1 humvee, 3 5-ton transit vehicles, 17 Nat'l Guard personnel
8/10-13/2006	*06-0016*	4	Converse County	Fire		$ -	
2006 Totals						$ 128,671.17	
	Floods:	**$122.72**					
	Fires:	**$118,823.38**					
2/7/2007	*07-0002*	1	Albany County	Snow Removal	Nat'l Guard	$ 11,433.36	
2007 Totals						**$ 11,433.36**	
	Snow Removal:	**$11,433.36**					
2/4/2008	*08-0003*	4	Niobrara County	Snow Removal	Nat'l Guard	$ 13,510.09	Guard front-end loaders & dump trucks
5/20/2008	*08-0010*	3	Baggs	Flood	Nat'l Guard	$ 30,705.72	Guard sandbagging, MSV#2
5/22/2008	*08-0011*		Laramie	Tornado	Nat'l Guard, WOHS		Guard - debris recovery; Carrie Chitty detailed to Laramie EOC - No case file or financial entries
2008 Totals						$ 44,215.81	
	Snow Removal:	**$13,510.09**					
	Flood:	**$30,705.72**					

******Complete Case Files available from 2009 forward- all costs associated are recorded in reports******

7/3/2009	*0016IC-070609*		Natrona County	Flood	WOHS	$ 21,147.41	State Disaster Declaration
2009 Totals							
	Flood:	**$21,147.41**					

Specific Hazards Analyzed

Chapter 4: Dam Failures

Over 30,000 dams and reservoirs are located in Wyoming, ranging in size from over one million acre-feet to small stock reservoirs. Several dam failures have occurred in the state, resulting in loss of life and damage to property. The Wyoming State Engineer's Office regularly inspects dams throughout the state for safety. Dam failure impacts can be reduced through continuing dam inspections, identifying dams susceptible to failure during earthquakes, and by generating emergency action plans for high- and significant-hazard-rated dams. Dam failure inundation maps have been generated, but are not available to the public because of Homeland Security issues associated with public safety as it relates to the release of critical infrastructure data. Based upon historic data, a dam failure with at least $9.0 million in damages and ten deaths could occur in Wyoming.

Chapter 5: Drought

Seven multi-year droughts have occurred historically in Wyoming. In 2009 the state officially exited a 10-year drought cycle. However, weather patterns would lead some to believe that the drought cycle may be restarting or continuing. Impacts from drought on the economy, society, and the environment can converge into an emergency situation. Economic impacts are especially significant for the agricultural industry, including crop losses and animal inventory losses. Other impacts include reduced water availability in communities, lost or impacted recreational opportunities (low stream flow and reduced reservoir size), and the increased occurrence and threat of wildland fires. The estimated dollar impact for the current drought, which is considered the drought of historic record, is $769.6 million (1999 through 2006). Mitigation includes modification of plans for Wyoming's economic and agricultural development, water conservation, and practices such as reduction of fuels in fire prone areas.

Chapter 6: Earthquakes

Historically, earthquakes have occurred in every county in Wyoming. Most Wyoming earthquakes outside of Yellowstone National Park (where much seismic activity is related to a magma chamber beneath the Park) occur because of movement on *active faults* (faults that have moved within the last 1.6 million years). Active faults can be exposed at the surface, indicating that they have generated earthquakes of magnitude 6.5 and greater. Active faults can also be buried with no surficial expression, indicating that they generally produce earthquakes of magnitude 6.5 and less. Exposed active faults are present in western and central Wyoming. The Teton fault (Teton County), Star Valley fault (Lincoln County), Greys River fault (Lincoln County), Rock Creek fault (Lincoln County), and the Bear River fault (Uinta County) are all capable of generating magnitude 7.0 to 7.5 earthquakes. Most of these faults are considered overdue for activation. The rest of Wyoming can be subjected to magnitude 6.5 earthquakes.

The U.S. Geological Survey (USGS) has generated probabilistic acceleration maps for Wyoming, which indicate the probability of occurrence of certain levels of ground motion (%g)

associated with earthquakes. The 2500-year probabilistic acceleration map of Wyoming indicates that ground accelerations range from 6% (Intensity V) in northeast and southeast Wyoming to over 60% (Intensity IX) in the Jackson area, the Star Valley area, the Fossil Butte National Monument area, and an area southeast of Evanston. In central Wyoming, ground accelerations of 20% (Intensity VII) are possible. Intensity V indicates very light damage, Intensity VII indicates moderate damage, and Intensity IX indicates heavy damage.

HAZUS-MH is an earthquake damage and loss estimation tool developed by FEMA. HAZUS-MH analyses for each county were used to determine where earthquake damage in the terms of dollar loss to buildings and loss of life may be the greatest. The highest dollar loss projected for a maximum earthquake in Wyoming is almost $682 million (Teton County).

For the 2011 update, HAZUS-MH was utilized in the development of 16 scenarios impacting the majority of Wyoming counties. The scenarios detail potential structural and economic damage, infrastructure damage, potential loss of life, and the impact within the scenario to emergency services. These scenarios will be helpful for discussion purposes in tabletop exercises and for preparedness purposes. Earthquake mitigation can be accomplished through education and through the adoption of building codes.

Chapter 7: Expansive Soils

Expansive soils contain clays with the potential to swell and shrink when they become wetted or dried. Although expansive soils are present in Wyoming, little work has been done to study their specific extent and potential for damage. Expansive soils can have significant impact on roads, bridges and other transportation facilities, as well as on buildings. The value of buildings potentially exposed to expansive soils was calculated for each county. Natrona County has over $1 billion in buildings built on or over expansive soils. However, the historic damage figures do not support the exposure figures. There has been less than $5 million of actual damage in Natrona County. It is suspected that most problem areas are being dealt with during construction. Further geologic studies and soil surveys are needed to better understand the location and swelling capacity of these soils. By identifying where these soils are, future construction projects could be relocated or designed to lessen the impact of expansive soils.

Chapter 8: Floods

One of the more significant natural hazards in the state is flooding, which has resulted in extensive property damage as well as injuries and death. Most floods occur because of heavy rainfall, rapid snowmelt, and the failure of man-made and natural dams. Extensive flood histories indicate that Wyoming has been subjected to about $396.9 million (2010 U.S. dollars) of documented flood-related damages. Laramie County has had about $144.4 million (2010 U.S. dollars) in flood damages, leading the rest of Wyoming counties by over $100 million. In addition to historic flood damages, building exposure values were calculated by the Wyoming State Geological Survey (WSGS) using Flood Insurance Rate Maps (FIRMs) and Census block data. The flood risk information has been updated in the 2011 Plan Update and updated information has been provided to the 23 counties. These exposure values indicate the exposure

value of buildings located within floodplains for each county. Ice jams are also included in the flood chapter. Active participation in the National Flood Insurance Program and public education are important mitigation measures.

Chapter 9: Hail

Southeastern Wyoming lies within the three-state area known as "Hail Alley." The area is battered by hailstorms more than anywhere else in the U.S. All areas within Wyoming are prone to storms that can cause significant damage and economic loss. Wyoming has experienced such storms, and has had documented historic hail damage of over $695.1 million (2010 U.S dollars). Because of the frequency of hail storms, a significant hailstorm resulting in a loss of over $120.5 million with probable associated injuries or deaths could occur at least every 100 years in the state. Mitigation of this threat can be accomplished through improved early warning systems and increased public education on the hazard.

Chapter 10: All Hazards Including Terrorism, Hazardous Materials and Hazardous Waste

Terrorism is a hazard with which Wyoming has had intimate experience in recent history. Wyoming has identified more than 250 critical infrastructure targets.

Wyoming is one of a few states who have had their infrastructure targeted in a conspiracy to sabotage through utilization of explosives against the oil pipelines and refineries, including a natural gas plant. In another terrorism incident two individuals were investigated for terrorism activity by the FBI and local authorities, and pled guilty in U.S. District Court for the destruction of interstate power lines. Terrorism risk assessments and response actions are addressed in Wyoming's Response Plan, in compliance with the National Response Framework.

Hazardous materials and waste pose a significant threat to human health and the environment within Wyoming. Major transportation routes cross the state, including interstate highways and railways. Hazardous materials are continually transported on these and other routes. In addition, mineral exploration and production activities, especially oil and gas, require the use of various hazardous materials. The result is a spill of hazardous materials or waste occurred every 24 hours in Wyoming over the past several years.

Several federal agencies have responsibilities regarding the handling of hazardous materials and waste, and state and local authorities are under mandate to comply with emergency response and emergency planning contingencies. Under these mandates, certain facilities handling hazardous substances are required to submit Risk Management Plans to local and state authorities. These plans are designed to aid in the response to spills, to protect public health and safety, and to reduce environmental impact.

Chapter 11: Landslides

Landslides are one of the most common geologic hazards in Wyoming, with the highest occurrence density found in the northwestern and western parts of the state. Here, mountainous terrain, higher precipitation levels, higher levels of seismic activity, and local geology combine to produce the greater number of landslides. Various landslides have closed roads and railways in the state, as well as damming rivers with subsequent ponding, later dam breakage, and flooding.

Obvious Wyoming landslides were mapped by the WSGS and a 100-foot buffer added around each area. Census block building values were combined with this information to produce building exposure values for landslide areas. These values indicate the potential for significant damage to buildings in the state. Recurring problems with landslides along various highways are also of concern. The Wyoming Department of Transportation (WYDOT) spends approximately $1.0 million per year to remove landslides from roads, repair road damage, and study or stabilize existing landslides. WYDOT has spent as much as $8.0 million (1998) in a single year on landslide damages. Human activities, especially road and highway building, can exacerbate landslide development.

Chapter 12: Lightning

Although not as significant in relation to some of the other natural hazards, lightning remains a certain danger. Lightning has caused a number of deaths and injuries in Wyoming; it threatens outdoor recreationists, especially those venturing to high, exposed areas. Lightning can be responsible for wildland fires which are addressed in Chapter 17. The worst lightning-caused events on record occurred in August 1988. According to the U.S. Bureau of Land Management, lightning ignited 29 fires, setting 4,159 acres ablaze. Total damages from these fires reached $780,330 ($1,460,238 in 2010 U.S. dollars). Mitigation of lightning as a direct hazard to human health is best accomplished through public education and awareness.

Chapter 13: Liquefaction

Liquefaction occurs when near-surface (within 30 feet), relatively young (less that 10,000 years old), water-saturated sands act as a viscous fluid during an earthquake. Few cases have been documented in Wyoming. However, areas containing saturated sands prone to liquefaction were identified and mapped within the state. These areas were digitally crossed with census block data to produce a map identifying exposure values in dollars for buildings in each Wyoming county. These values range from $0.00 in 13 of the 23 counties, to almost $1.9 billion in Teton County. This data is useful not only for projecting possible loss values for existing buildings, but also as an aid in siting new construction projects.

Chapter 14: Mine Subsidence

Early coal mines in Wyoming were not designed and/or constructed well, resulting in later mined-out area collapse. Many of these mined-out areas were below developing towns, causing damage to homes, buildings, and streets; some of this collapse continues. The Wyoming Department of Environmental Quality has spent $85 million mitigating the effects of mine subsidence and mine reclamation in an effort to reduce or remove mining impacts. Mitigation of mine subsidence involves continued efforts to prevent further subsidence and avoiding construction over mined-out areas.

Chapter 15: Snow Avalanches

Wyoming is one of the top-ranking states for avalanche hazard. Avalanches threaten not only backcountry users, including skiers, snowboarders, and snow machine operators, but also motorists along mountain roadways. Western Wyoming and especially Teton County are notorious for avalanche susceptibility. There have been 69 deaths due to avalanches in the state from 1913 through 2010.

Mitigation of avalanche dangers includes avalanche control practices at ski areas, backcountry avalanche advisories, and daily issuance of avalanche advisories. WYDOT mitigation efforts include the use of various avalanche triggering devices, as well as road closures to reduce the avalanche threat. Public education and awareness remains the most important mitigation activity for avalanches. The use of geographic information systems (GIS) technology to create avalanche maps coupled with historic data on avalanche path activity, and the mapping of backcountry ski and snowmobile trails with avalanche data included, are ways in which public education and awareness are being addressed.

Chapter 16: Tornadoes

Tornadoes are a significant hazard in Wyoming, with the state ranking 25th in the number of annual tornadoes (10) and 33rd in fatalities (six deaths per million people), for the period of 1950 to 1994. Tornadoes are especially prevalent in the eastern part of the state, but have been reported in all counties. Records indicate that there have been 553 recorded tornado events in Wyoming between 1907 and 2010. Of these, 193 have been classified as damaging. Damage is defined by events resulting in loss of property, life, and any events of F2 (damage rating of considerable on Fujita scale) or greater. The worst-case scenario for a tornado in Wyoming would result in over $111 million in damage, numerous injuries, and possible loss of life. Mitigation for tornado hazard is limited because of the random and unpredictable nature of tornadoes. Structural reinforcement has had some success in mitigating loss to buildings. Other mitigation methods are construction of shelters, public communication and warning systems such as the Emergency Alert System. Both structural reinforcement and communication/warning measures are implemented in Wyoming.

Chapter 17: Wildland Fire

Wyoming, because of its semi-arid climate and rural character, is vulnerable to catastrophic wildland fires. With increasing population in the wildland/urban interface, wildland fire is becoming an increasing threat to buildings within subdivisions and other high density development. Analysis indicates a direct relationship between annual precipitation and the number of acres burned from wildland fires. The most dramatic example of this was in 1988 when a total of 1.5 million acres burned and only 8.55 inches of precipitation fell. Both figures are a record high and low, respectively, between the years 1960 and 2010. The projected damage by county in terms of building exposure values ranges from about $1.1 million in Bighorn County to over $1.5 billion in Teton County. Mitigation of wildland fire hazard in Wyoming has been undertaken through various efforts of technology, public education and awareness, and projects to reduce or eliminate fuels.

Chapter 18: Windblown Deposits

Wyoming has some of the most significant windblown deposits in the U.S. Although past problems with windblown deposits are not well documented, increasing development in rural areas across the state can be expected to result in destabilization of sand dunes. There are accounts of such problems in the Casper area, with dunes moving into subdivisions, across roads, and impinged on homes. However, the problems were easily fixed, and no significant dollar losses have been associated with windblown deposits. Mitigation will involve identifying possible problem areas during development, and stabilizing these areas as development continues.

Chapter 19: Winter Storms and Blizzards

Severe winter storms affect far more people in Wyoming than their summer counterparts, even though they are inherently less violent. Severe snowstorms are generally extensive across the state and usually require a day or two to cross and completely exit the state. The most significant blizzard in Wyoming's history occurred from January 2, 1949 to February 20, 1949. Snowfall in parts of eastern and southeastern Wyoming measured up to 30 inches, with drifts 20 to 30 feet high. Seventeen people perished, along with 55,000 head of cattle and over 105,000 sheep. Total economic loss was more than $9 million dollars. In 2010 dollars, the loss would be over $80.6 million. Based on historic data, a worst-case scenario for a winter storm in Wyoming could be as high as $191.9 million, the loss of life could be as high as 17 to 20, enough power lines could be toppled that emergency intervention could be required, and the livestock industry could lose 15 to 20% of its inventory. There is a reasonable possibility that a significant winter storm will occur each year in Wyoming.

Hazards Identified But Not Analyzed

Several hazards were identified but eliminated due to their overly long expected occurrence of frequency (greater than 10,000 years), low probability of occurrence, or their identification as ongoing health issues. These include the following:

Yellowstone Explosive Volcanism

Very large-scale explosive volcanic activity has occurred in the Yellowstone area within the past 2.5 million years, which, in geologic time, is very recent. Because of this, the Yellowstone volcanic area is considered a substantial threat across Wyoming and well beyond. As can be gathered from **Figures 3.1** and **3.2**, the volume and extent of volcanic materials produced from past eruptions at Yellowstone were immense. It is possible that another eruption of similar magnitude will occur, but probably not within the next 20,000 or more years. In the event that another large-scale eruption did occur, thickness of the volcanic material produced would once again be immense. For example, it is predicted that ash in southeastern Wyoming would be over three feet deep. In addition Smith and Siegel stated in *Windows into the Earth*, 2000: "Devastation would be complete and incomprehensible at the caldera. Imagine Yellowstone National Park and everything in it destroyed…. Nearby towns like West Yellowstone, Gardiner, and Cooke City, Montana, likely would be wiped out by ash, mudflows or pyroclastic flows…. A Yellowstone caldera explosion today would dump ash over hundreds of thousands of square miles…"

The large-scale explosive events at Yellowstone occurred about 0.64 million years before present (Ma), about 1.3 Ma, and about 2.1 Ma (for more exact dates, consult Christiansen, 2001). The recurrence intervals of these events range from 660,000 years (1.3 to 0.64 Ma) to 800,000 years (2.1 to 1.3 Ma). Only 640,000 years have elapsed since the last event, so 20,000 to 160,000 years may be left before another large event is expected. There are smaller events that occur more frequently. These include several rhyolitic lava flows that were emplaced at approximately 150,000 years before present, 110,000 years before present, and 70,000 years before present. These events were localized within the Yellowstone area, not having the widespread effect of the previously described explosive events.

Because of the overly long expected recurrence interval (greater than 10,000 years) for explosive volcanism at Yellowstone, and the fact that a good response or mitigation plan is not possible for an event of this magnitude, it was not analyzed in this document.

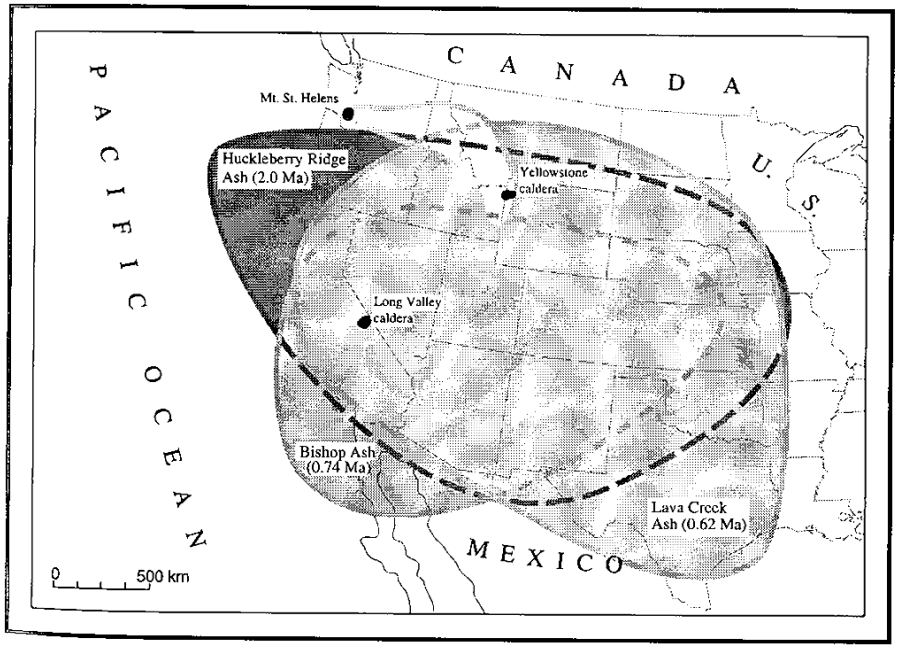

Figure 3.1—Map showing areas covered by airborne ash flows, tuffs, and pumices of four large Cenozoic volcanic eruptions of the western U.S. Note the 0.62 Ma (~620,000 years before present) Yellowstone eruption and the 2.0 Ma (~2,000,000 years before present) Yellowstone eruption. From Smith and Braile, 1993. Ages of Yellowstone tuffs based on most recently determined age dates may differ from ages of ashes shown on this diagram.

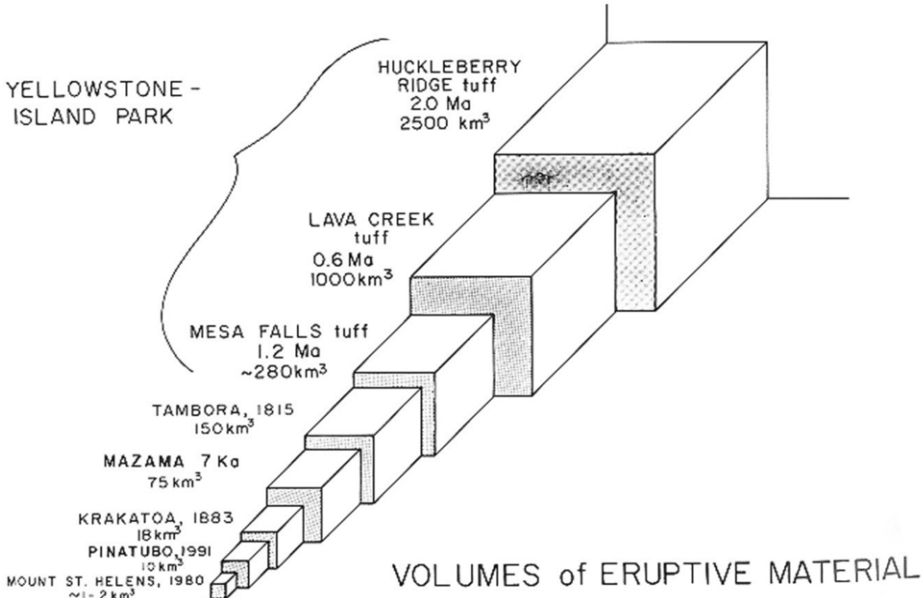

Figure 3. 2—Volumes of eruptive materials from volcanic explosions. From Smith and Braile, 1993. Ages of Yellowstone tuffs based on most recently determined age dates may differ from ages of ashes shown on this diagram (see Christiansen, 2001).

Meteor Impacts

The Earth is subject to impacts from comets and asteroids. Based on size of the projectile, the impacts pose a significant hazard to life and property. According to the NASA Ames Research Center, the annual probability of the Earth (and therefore Wyoming) being struck by a large asteroid or comet is extremely small. Therefore, no further analysis was deemed necessary in this document.

Water Quality

Water quality is an ongoing health issue and is generally not considered to be a natural disaster. State river basin plans are currently being developed by the Wyoming Water Development Commission, and the plans are addressing water quality issues. Water quality falls into the disaster category when hazardous materials are involved, and these issues are addressed in the Hazardous Materials section.

Naturally Occurring Toxic Elements

Naturally occurring toxic elements—radon, selenium, fluoride, gamma radiation, and others—are not addressed because they are ongoing health issues, and are not considered natural disasters or emergencies.

Hazards Rankings

In previous versions of the Wyoming Multi-Hazard Mitigation Plan, the WOHS contacted state, federal, and local personnel regarding various aspects of the Wyoming Multi-Hazard Mitigation Plan (Plan). They were all asked to consider ranking hazards statewide. Rankings have remained stable throughout the life of the multi-hazard mitigation plan. **Table 3.1** presents a summary of each hazard analyzed. The hazards were first rated high, medium, or low based on probability of occurrence and potential impact. Those ranks, combined with a review of damage estimates in U.S. dollars (USD), led to the final hazard rank. Also, for each hazard, estimates of property damage for both historic values and values projected as a worst case scenario are presented.

- High-ranking hazards are drought, earthquakes, hazardous materials, and winter storms.
- Medium-ranking hazards are dam failures, floods, hail, landslides, tornadoes, and wildland fire.
- Low-ranking hazards are snow avalanches, coal mine subsidence, expansive soils, lightning, liquefaction, and windblown deposits.

In this 2011 update a Mitigation Committee meeting was convened on May 18, 2011 to rank Wyoming hazards and potential mitigation projects. The minutes of the meeting are included as an attachment. The initial ranking was first in the order of low, medium-low, medium and high. This designation was followed by a ranking within each of those designations. The following hazard ranking was determined by those attending the meeting, based on the Mitigation Committee's feeling of hazard's impact in the State. You will note the ranking determined by the Mitigation Committee varies somewhat from the ranking determined by previous versions of the State Multi-Hazard Mitigation Plan.

Low Hazard Risk:

1. Dam Failure
2. Expansive Soils
3. State Facilities
4. Liquefaction
5. Landslide
6. Avalanche
7. Tornado

Medium-Low:

8. Drought
9. Hazardous Materials

Medium:

10. Earthquake
11. Flood
12. Lightening
13. Hail

14. All Hazards

High:

15. Winter Storm
16. Wild Land Fires

The following table and map compare risk and vulnerabilities among each of Wyoming Counties using 2010 Census data.

Wyoming Overall Risk - Social Vulnerability & Population Density

COUNTY	SOCIAL VULNERABILITY INDEX	SVI 5=HIGH 1=LOW	2010 POPULATION DENSITY	POPULATION DENSITY RISK 4=HIGH 1=LOW	2010 POPULATION	SQUARE MILES	OVERALL RISK SVI + Density Risk	
ALBANY	HIGH	5	7.5	1	36299	4273	6	MEDIUM
BIG HORN	MEDIUM	3	3.7	0	11668	3137	3	LOW
CAMPBELL	MEDIUM-LOW	2	7	1	46133	4797	3	LOW
CARBON	MEDIUM-LOW	2	2	0	15885	7896	2	LOW
CONVERSE	LOW	1	2.8	0	13833	4255	1	VERY LOW
CROOK	MEDIUM-LOW	2	2.1	0	7083	2859	2	LOW
FREMONT	HIGH	5	3.9	0	40123	9182	5	MEDIUM
GOSHEN	MEDIUM	3	5.6	0	13249	2225	3	LOW
HOT SPRINGS	HIGH	5	2.4	0	4812	2004	5	MEDIUM
JOHNSON	MEDIUM-HIGH	4	1.7	0	8569	4166	4	MEDIUM LOW
LARAMIE	MEDIUM	3	30.4	5	91738	2686	8	HIGH
LINCOLN	LOW	1	3.6	0	18106	4069	1	VERY LOW
NATRONA	MEDIUM-HIGH	4	12.5	2	75450	5340	6	MEDIUM
NIOBRARA	MEDIUM	3	0.9	1	2484	2626	4	MEDIUM LOW
PARK	MEDIUM	3	3.7	0	28205	6942	3	LOW
PLATTE	MEDIUM-LOW	2	4.2	0	8667	2085	2	LOW
SHERIDAN	HIGH	5	10.5	2	29116	2523	7	MEDIUM HIGH
SUBLETTE	LOW	1	1.2	0	10247	4883	1	VERY LOW
SWEETWATER	LOW	1	3.6	0	43806	10425	1	VERY LOW
TETON	LOW	1	4.6	0	21294	4008	1	VERY LOW
UINTA	MEDIUM	3	9.5	1	21118	2082	4	MEDIUM LOW
WASHAKIE	MEDIUM-HIGH	4	3.7	1	8533	2241	5	MEDIUM
WESTON	MEDIUM-LOW	2	2.8	1	7208	2398	3	LOW

Risk Range Population Density Formula

0-5.07 = 0	0	0.00%
5.08-10.23 = 1	5.07	16.67%
10.24-15.2 = 2	10.23	33.64%
15.3-20.27 = 3	15.2	50.00%
20.28-25.43 = 4	20.27	66.67%
25.44-30.4 = 5	25.43	83.64%
	30.4	100.00%

Overall Risk Formula

0-1.5	VERY LOW	0	0.00%
1.6-3	LOW	1.5	16.67%
3.1-4.5	MEDIUM LOW	3	33.64%
4.6-6	MEDIUM	4.5	50.00%
6.1-7.5	MEDIUM HIGH	6	66.67%
7.6-9	HIGH	7.5	83.64%
		9	100.00%

Overall Risk
State of Wyoming Counties

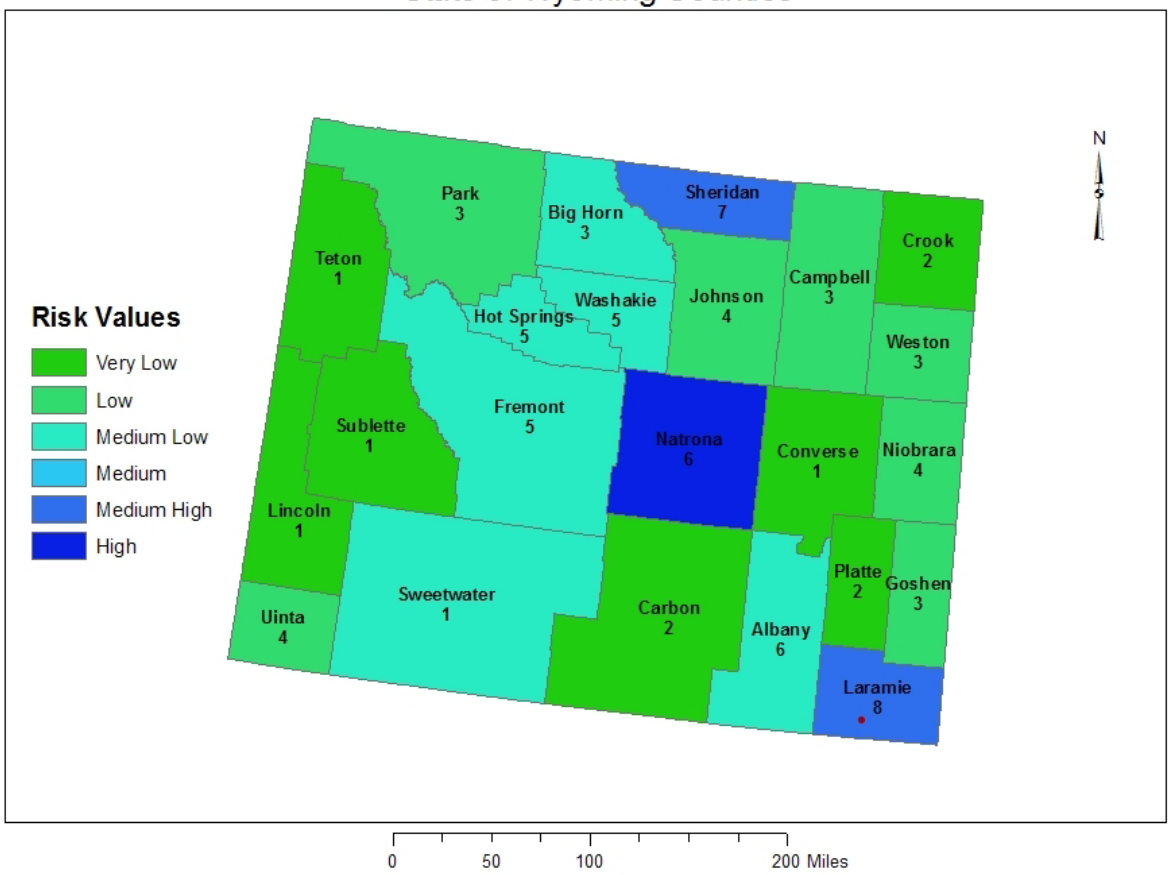

Table 3.1—Hazards Summary and Ranking.										
Hazard	**Years**	**Deaths**	**Injuries**	**Estimated accumulative historic damage (current year USD)**	**Estimated accumulative historic damage (2010 USD)**	**Projected statewide building exposure damage**	**Worst case scenario damage - single event**	**Probability**	**Potential impact**	**Hazard rank**
Avalanche	1911 - 2010	77	13	0	15,000	0		High	Low	Low
Dam failure	1906 - 2007	18	0	6,802,000	19,761,956	N/A	10,546,000	Low	High	Low
Drought	1999 - 2009	N/A	N/A	1,094,300,000	N/A	N/A	901,760,000	High	High	Medium Low
Earthquake	N/A	N/A	N/A	N/A	N/A	2,353,793,000	799,095,000	Medium	High	Medium
Expansive soils	N/A	0	0	0	5,486,500	1,247,114,339		Medium	Low	Low
Flood	1905 - 2010	88	72	126,684,273	397,061,000	2,574,246,614	141,193,000	Medium	Medium	Medium
Hail	1926 - 2010	13	100	304,240,617	695,373,547	N/A	141,240,000	Medium	Medium	Medium
Hazardous Materials	N/A	N/A	N/A	N/A	N/A	N/A		High	Medium	Medium Low
Landslides	1950-2010	N/A	N/A	~1,000,000/yr	~ 1,100,000/yr	315,323,291	9,374,000	Medium	Medium	Low
Lightning	1959 - 2010	36	107	4,400,000	6,316,600	N/A		High	Low	Medium
Liquefaction	N/A	0	0	0	0	2,596,755,390		Low	Low	Low
Tornado	1907 - 2010	6	127	57,851,305	169,158,980	N/A	130,062,000	Medium	Medium	Low
Wildland Fire	1988-2010	1	11	5,567,333	N/A	8,528,103,488		High	Medium	High
Windblown deposits	N/A	0	0	0	0	0		Low	Low	Low
Winter storms	1883 - 2010	74	374	160,938,800	471,640,200	191,900,000	225,000,000	High	High	High

Hazards and State Facilities

A complete analysis of State facilities and hazards can be found in Chapter 20, **Vulnerability of State Facilities to Hazards**. State buildings in Wyoming are potentially subjected to a number of hazards that may affect the stability of the buildings, endanger occupants, or result in a loss of services. In addition, the ability of some buildings to serve as shelters may be compromised because of the natural hazards to which they may be subjected.

A rank of hazard priorities for State buildings is presented in **Table 3.2**.

Table 3.2—Ranking of Hazards' Potential Impacts on State Buildings.

Rank	Hazard	Total Impact (USD)	Impact per Building (USD)
1	Earthquake/Liquefaction	135,709,825	598,251
2	Flood	27,585,841	162,279
3	Wildland Fire	36,105,149	91,637
4	Landslide	687,304	32,728
5	Expansive Soils	Low	Low

References Cited

Christiansen, R.L., 2001, The Quaternary and Pliocene Yellowstone Plateau volcanic field of Wyoming, Idaho, and Montana: U.S. Geological Survey Professional Paper 729-G, p. G1-G145, 3 plates.

Smith, R.B. and Braile, L.W., 1993, Topographic signature, space-time evolution, and physical properties of the Yellowstone-Snake River Plain volcanic system: the Yellowstone hotspot, *in* Snoke, A.W., Steidtmann, J.R., and Roberts, S.M., editors, Geology of Wyoming, Wyoming State Geological Survey Memoir 5, v. 2, p. 694-754.