APPENDIX B - NATURAL HAZARDS DEFINITIONS AND INFORMATION

HAZARD DEFINITIONS

The following is a description of each of the hazards evaluated in the Bear River Region's Pre-disaster Mitigation Plan. These definitions, with minor modifications and additions, were developed by DESHS and used by permission in this plan.

Flooding

Flooding is a temporary overflow of water onto lands not normally inundated by water producing measurable property damage or forcing evacuation of people and vital resources. Floods frequently cause loss of life; property damage and destruction; damage and disruption of communications, transportation, electric service, and community services; crop and livestock damage and loss, and interruption of business. Floods also increase the likelihood of hazard such as transportation accidents, contamination of water supplies, and health risk increase after a flooding event.

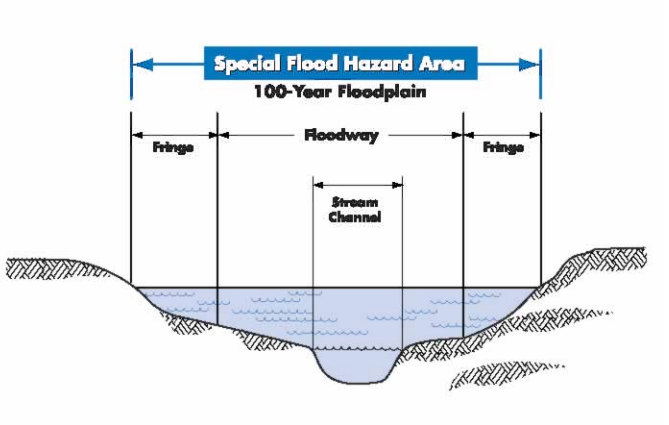
Another important consideration to make regarding flooding is the variety of flood types and other hazards that often happen at the same time flooding occurs. For example, rarely are flood waters clear and free from debris. Often, mud/sediment/debris flows happen concurrently with flooding, causing damages sometimes more severe than what flooding alone may have caused. Also, when defining and analyzing flood hazards in the Bear River Region, irrigation canals should be included. Canals are not designed to handle storm water during high rain events. By the nature of canal design, the further downstream on the canal, the less water that canal can handle. As water is extracted from the system, less water is available. This design is opposite to how a storm water system is designed, which should be able to handle higher flows further downstream (Scott Stoddard, personal communication, 8/13/09). Canals located on steep or unstable hillsides can also exacerbate problems when a landslide occurs, increasing risk and adding an element of flooding to an already dangerous situation.

As development near floodplains occurs, cut and fill of hillsides can change the hydrology of the landscape. In some circumstances, the floodplain levels can actually raise much like putting marbles one at a time in a bathtub filled with water. One by one, projects can slowly alter the floodplain until more residents and structures are at risk. Homes built earlier that were never in the FEMA floodplain to begin with could then be at risk.

Several factors determine the severity of floods including rainfall intensity, duration and rapid snowmelt. A large amount of rainfall over a short time span can result in flash flood conditions. Small amounts of rain can also result in flooding at locations where the soil has been previously saturated or if rain concentrates in an area having impermeable surfaces such as large parking lots, paved roadways, or post-burned areas with hydrophobic soils. Topography and ground cover are also contributing factors for floods. Water runoff is greater in areas with steep slopes and little or no vegetative ground cover.

Frequency of inundation depends on the climate, soil, and channel slope. In regions where substantial precipitation occurs during a particular season or in regions where annual flooding is due to spring melting of winter snow pack, areas at risk may be inundated nearly every year.

Conditions which my exacerbate floods include: steeply sloped watersheds, constrictions, obstructions, debris contamination, soil saturation and velocity.



Explanation of Common Flood Terms

FIRM: Flood Insurance Rate Map
100-year flood: Applies to an area that has a 1 percent chance, on average, of flooding in any given year. However, a 100-year flood could occur two years in a row, or once every 10 years. The 100 year-flood is also referred to as the base flood.

Base Flood: Is the standard that has been adopted for the NFIP. It is a national standard that represents a compromise between minor floods and the greatest flood likely to occur in a given area and provides a useful benchmark.

Base Flood Elevation (BFE): As shown on the FIRM, is the elevation of the water surface resulting from a flood that has a 1% chance of occurring in any given year. The BFE is the height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum (NGVD) or 1929, the North American Vertical Datum (NAVD) of 1988, or other datum referenced in the FIS report.

Special Flood Hazard Area (SFHA): Is the shaded area on a FIRM that identifies an area that has a 1% chance of being flooded in any given year (100-year floodplain).

Floodway: Is the stream channel and that portion of the adjacent floodplain that must remain open to permit passage of the base flood without raising that water surface elevation by more than one foot.

Earthquakes

An earthquake is the abrupt shaking of the earth caused by the sudden breaking of rocks when they can no longer withstand the stresses, which build up deep beneath the earth's surface. The rocks tend to rupture along weak zones referred to as faults. When rocks break they produce seismic waves that are transmitted through the rock outward producing ground shaking. Earthquakes are unique multi-hazard events, with the potential to cause huge amounts of damage and loss. Secondary effects of a sudden release of seismic energy (earthquake) include: ground shaking, surface fault rupture, liquefaction, tectonic subsidence, slope failure, and various types of flooding.

The Intermountain Seismic Belt

The Intermountain Seismic Belt (ISB), which the Bear River Region is part of, is a zone of pronounced earthquake activity up to 120 miles wide extending in a north south direction 800 miles from Montana to northern Arizona. The Utah portion of the ISB trends from the eastern Box Elder and Cache County area south through the center of the State, along the Wasatch Front, and then southwest through Richfield and Cedar City, concluding in St. George. "The zone generally coincides with the boundary between the Basin and Range physiographic province to the west and the Middle Rocky Mountains and Colorado Plateau physiographic provinces to the east" (Eldredge 6).

Secondary Earthquake Threats

The major secondary effects of earthquakes include: ground shaking, surface fault rupture, liquefaction, tectonic subsidence, avalanches, rock fall, slope failure, and various types of flooding. Other sections discuss landslides, and flooding therefore they will not be discussed under secondary effects of earthquakes yet importance needs to be given to the fact that earthquakes can increase the likelihood of flooding and landslides.

Ground Shaking

Ground shaking causes the most impact during an earthquake because it affects large areas and is the origin of many secondary effects associated with earthquakes. Ground shaking, which generally lasts 10 to 30 seconds in large earthquakes, is caused by the passage of seismic waves generated by earthquakes. Earthquake waves vary in both frequency and amplitude. High frequency low amplitude waves cause more damage to short stiff structures, were as low frequency high amplitude waves have a greater effect on tall (high-rise) structures. Ground shaking is measured using Peak Ground Acceleration (PGA). The PGA measures the rate in change of motion relative to the established rate of accelera-

tion do to gravity.

Local geologic conditions such as depth of sediment and sediment make up, affect earthquake waves. Deep valley sediments increase the frequency of seismic waves relative to bedrock. In general, ground shaking increases with increased thickness of sediments" (Eldredge 8).

Surface Fault Rupture

During a large earthquake fault movement may propagate along a fault plain to the surface, resulting in surface rupture along the fault plain. Most faults in the Bear River Region are normal (mountain building) faults with regards to movement, meaning the footwall of the fault moves upward and the hanging wall moves in a down direction. Thus faulting is on a vertical plain, which results in the formation of large fault scarps. In historic time surface fault rupture has only occurred once in Utah; the 1934 Hansel Valley earthquake in Box Elder County with a magnitude 6.6 produced 1.6 feet of vertical offset.

Surface fault rupture presents several hazards, anything built on top of the fault or crossing the fault has a high potential of being destroyed in the event of displacement. Foundations will be cracked, buildings torn apart, damage to roads, utility lines, pipelines, or any other utility line crossing the fault. It is almost impossible to design anything within reasonable cost parameters to with stand an estimated displacement of 16 to 20 feet.

Surface fault rupture doesn't occur on a single distinct plain; instead it occurs over a zone often several hundred feet wide known as the zone of deformation. This zone of deformation occurs mainly on the down thrown side of the main fault trace. Tectonic subsidence, caused by antithetic faults moving in the opposite direction of the main fault, slide down hill on the main fault scarp creating grabens (down dropped blocks) within the zone of deformation.

Hintze described an "enigma" of Utah in that seismicity does not always coincide with surface fault scarps or faults (Geologic History of Utah, 1988). The epicenter of the earthquake may be miles away from the surface faulting.

Liquefaction

Soil liquefaction occurs when water-saturated cohesionless sandy soils are subject to ground shaking. When liquefaction occurs, soils behave more like a viscous liquid (quicksand) and lose their bearing capacity and shear strength. Two conditions must be met in order for soils to liquefy: (1) the soils must be susceptible to liquefaction (sandy, loose, water-saturated, soils typically between 0 and 30 feet below the ground surface) (2) ground shaking must be strong enough to cause susceptible soils to liquefy (lips). The loss of shear strength and bearing capacity due to liquefaction causes buildings to settle or tip and light buoyant structures such as buried storage tanks and empty swimming pools to float upward. Liquefaction can occur during earthquakes of magnitude 5.0 or greater.

Lateral Spread

Soils, once liquefied, can flow on slopes with angles of .5 to 5 percent this movement of liquefied soils is known as lateral spread. "The surficial soil layers break up and sections move independently, and are displaced laterally over a liquefied layer" (Eldredge 10). Liquefaction can cause damage in several ways, with lateral spreading being one of the most common. Displacement of three (3) or more feet may occur and be accompanied by ground cracking and vertical displacement. Lateral spreading causes roads, buildings, buried utilities, and any other buried or surface structure to be pulled apart.

Various Flooding Issues Related to Earthquakes

Earthquakes could cause flooding due to the tilting of the valley floor, dam failure and seiches in lakes and reservoirs. Flooding can also result from the disruption of rivers and streams. Water tanks, pipelines, and aqueducts may be ruptured, or canals and streams altered by ground shaking, surface faulting, ground tilting, and landsliding.

Seiches

Standing bodies of water are susceptible to earthquake ground motion. Water in lakes and reservoirs may be set in motion and slosh from one end to the other, much like in a bathtub. This motion is called a seiche (pronounced "saysh"). A seiche may lead to dam failure or damage along shorelines.

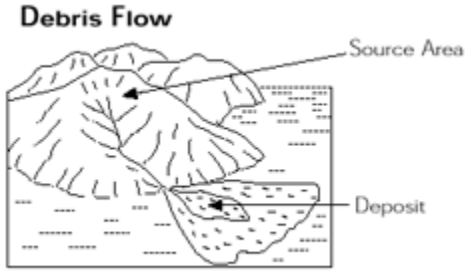
Landslides

Landslides are defined as, "…the movement of a mass of rock, debris, or earth down a slope (Cruden, 1991)." Landslides, often referred to as mass wasting or slope failure, are one of the most common natural disasters. Slope failures can vary considerably in shape, rate of movement, extent, and effect on surrounding areas. Slope failures are classified by their type of movement, and type of material. The types of movement are classified as falls, slides, topples, and flows. "The types of material include rock, debris (coarse grained soil) and earth (fine grained soil)" (Eldredge 17). "Types of slope failures then are identified as rock falls, rock slides, debris flows, debris slides, and so on" (Eldredge 17). Slope failures occur because of either an increase in the driving forces (weight of slope and slope gradient) or a decrease in the resisting forces (friction, or the strength of the material making up a slope). "Geology (rock type and structure), topography (slope gradient), water content, vegetative cover, and slope aspect are important factors of slope stability" (Eldredge 18).

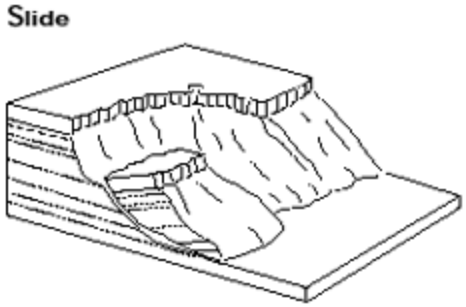
Certain landslides, such as debris flows can be exacerbated by flooding and water saturation. Landslides alone can be dangerous, but adding flooding to the situation can increase risk.

Three Common Types of Landslides in Utah

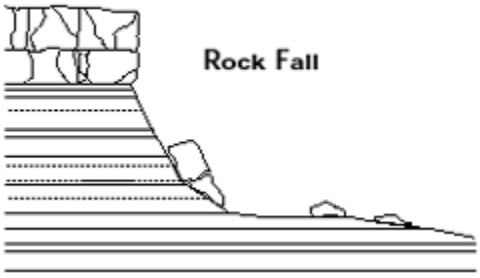
Debris flows consist of sediment-water mixtures that flow down a streambed or hillside, commonly depositing sediment at canyon mouths in fan like deposits know as alluvial fans.



Slides are down slope movements of soil or rock on slopes.



Rock falls consist of rock(s) falling from a cliff or cut slope and are very common in the canyon country of southern Utah.



Conditions That Make Slopes More Susceptible to Landslides

- Discontinuities: faults, joints, bedding surfaces.
- Massive Materials over soft materials.
- Orientations of dip slope: bedding plans that dip out of slope.

- Loose structure and roundness.
- Adding weight to the head of a slide area: rain, snow, landslides, mine waste piles, buildings, leaks from pipes, sewers, and canals, construction materials fill materials.
- Ground shaking: earthquakes or vibrations.
- Increase in lateral spread caused by mechanical weathering.
- Removal of lateral support.
- Human activities: cut and fill practices, quarries, mine pits, road cuts, lowering of reservoirs.
- Removing underlying support: under cutting of banks in a river.
- Increase in pore water pressure: snow melt, rain, and irrigation.
- Loss of cohesion.

Steep Slopes

According to the Utah Governor's Office of Planning and Budget (UGOPB), steep slopes are considered areas with a slope angle of 20% or greater over a minimum horizontal distance of 30 feet (UGOPB, n.d.). Areas with steep slopes put development and lands are risk for a variety of reasons. Steeper slopes can fail, leading to damaged property and resources. Risk to avalanche increases in areas with high angle slopes. Erosion is often associated with steep slopes as well, as displacement of soils and debris is more likely to occur with severe weather events. Steeper terrain is also increases wildfire risk in dry areas with adequate fuel loads. Complicating the risk associated with steep slopes is that mitigation can be more expensive, as construction and engineering solution cost more to implement.

Utah Governor's Office of Planning and Budget. (n.d.) *Steep Slopes.* Retrieved from http://www.planning.utah.gov/CriticalLands/Critical%20Lands%20PDFs/steepslopes.pdf

Wildfire

A wildfire is an uncontrolled fire spreading through vegetative fuel often exposing or consuming structures. Wildfires often begin unnoticed and spread quickly and are usually sighted by dense smoke. Wildfires are placed into two classifications Wildland and Urban-Wildland Interface.
Wildland fires are those occurring in an area where development is essentially nonexistent, except for roads, railroads, or power lines. Urban-Wildland Interface fire is a wildfire in a geographical area where structures and other human development meet or intermingle with wildland or vegetative fuels.

When discussing wildfires it is important to remember that fires are part of a natural process and are needed to maintain a healthy ecosystem. Three basic elements are needed for a fire to occur (1) a heat source (2) oxygen and (3) fuel. Major ignition sources for wildfire are lightning and human causes such as arson, recreational activities, burning debris, and carelessness with fireworks. On average, 65 percent of all wild fires started in Utah can be attributed to human activities. Once a wildfire has started, vegetation, topography and weather are all conditions having an affect wildfire behavior.

Severe Weather

For the purpose of this mitigation plan the term severe weather is used to represent downbursts, lightening, heavy snowstorms, blizzards, avalanches, hail, and tornados.

Downbursts

A downburst is a severe localized wind, blasting from a thunderstorm. Depending on the size and location of these events, the destruction to property may be devastating. Downbursts fall into two categories by size. Microbursts cover and area less than 2.5 miles in diameter. Macrobursts cover an area with a diameter larger than 2.5 miles.

Lightening

During the development of a thunderstorm, the

rapidly rising air within the cloud, combined with the movement of the precipitation within the cloud, causes electrical charges to build. Generally, positive charges build up near the top of the cloud, while negative charges build up near the bottom. Normally, the earth's surface has a slight negative charge. However, as the negative charges build up near the base of the cloud, the ground beneath the cloud and the area surrounding the cloud becomes positively charged. As the cloud moves, these induced positive charges on the ground follow the cloud like a shadow. Lightening is a giant spark of electricity that occurs between the positive and negative charges within the atmosphere or between the atmosphere and the ground. In the initial stages of development, air acts as an insulator between the positive and negative charges. When the potential between the positive and negative charges becomes too great, there is a discharge of electricity that we know as lightning.

Heavy Snowstorms

A severe winter storm deposits four or more inches of snow during a 12-hour period or six inches of snow during a 24-hour period. According to the official definition given by the U.S. Weather Service, the winds must exceed 35 miles per hour and the temperature must drop to 20° F or lower. All winter storms make driving extremely dangerous.

Blizzards

A blizzard is a snowstorm with sustained winds of 40 miles per hour (mph) or more or gusting winds up to at least 50 mph with heavy falling or blowing snow, persisting for one hour or more, temperatures of ten degrees Fahrenheit or colder and potentially life-threatening travel conditions. The definition includes the conditions under which dry snow, which has previously fallen, is whipped into the air and creates a diminution of visual range.

Hail Storms

Hailstones are large pieces of ice that fall from powerful thunderstorms. Hail forms when strong updrafts within, the convection cell of a cumulonimbus cloud carries water droplets upward causing them to freeze. Once the droplet freezes, it collides with other liquid droplets that freeze on contact. These rise and fall cycles continue until the hailstone becomes too heavy and falls from the cloud.

Drought

Drought is a normal recurrent feature of climate, although many, in Utah, erroneously consider it a rare and random event. It occurs in virtually all-climatic zones, while its characteristics vary significantly from one region to another. Droughts, simple put, are cumulative hazards, which result from long periods of below normal precipitation. Drought is a temporary aberration and differs from aridity since the latter is restricted to low rainfall regions and is a permanent feature of climate.

The State of Utah uses the Palmer Drought Severity Index or (PDSI) to quantify the existence of a drought. Using the PDSI, drought is expressed as a negative number. Much of the basis, used by the State, to determine drought years, or drought periods, comes from the PDSI. In addition, the PDSI is used by the State Climatologist, the National Geophysical Data Center of NOAA, and the National Drought Mitigation Center.

For the most part droughts no longer affect the availability of drinking water, thus no longer place people's lives at risk, the same cannot be said for a person's livelihood. Numerous water projects throughout the state have placed enough water in storage to insure drinking water. Prolonged droughts have a significant effect on agricultural and agribusinesses, within the state dependent on irrigation water. Droughts also stress wildlife, and heighten the risk of wildfire.

Tornados and High Winds

According to the National Oceanic and Atmospheric Administration, a tornado is defined as a violently rotating column of air extending from a thunderstorm to the ground. While there have not been many destructive tornados in Utah's history, several have caused damages and casualties. The most

destructive of these was the Salt Lake City tornado on August 11, 1999. This F2 tornado caused $170 million in damages, injured 80 people, and caused one casualty (Alder et al., 2005).

In the Bear River Region, many of the tornados on record have been in mostly unpopulated areas, and have not caused any substantial damages or threats to life. However, history has shown the potential for tornados in the region, and communities should be aware of that potential, and the possible risk of a tornado touching down in their community.

Dam Failure

Dam failures result from the failure of a man made water impoundment structure, which often results in catastrophic down grade flooding. Dam failures are caused by one or a combination of the following: "breach from flooding or overtopping, ground shaking from earthquakes, settlement from liquefaction, slope failure, internal erosion from piping, failure of foundations and abutments, outlet leaks or failures, vegetation and rodents, poor construction, lack of maintenance and repair, misuse, improper operation, terrorism, or a combination of any of these" (Eldredge, 46). The Utah State Engineer has been charged with regulating non-federal dams in the State dams since 1919. "In the late 1970's Utah started its own Dam Safety Section within the State of Utah Engineers Office to administer all non-federal dams in response to the Federal Dam Safety Act (PL-92-367)" (Eldredge, 46).

The State Dam Safety Section has developed a hazard rating system for all non-federal dams in Utah. Downstream uses, the size, height, volume, and incremental risk/damage assessments or dams are all variables used to assign dam hazard ratings in Dam Safety's classification system. Using the hazard ratings systems developed by the Dam Safety Section, dams are placed into one of three classifications high, moderate, and low. Dams receiving a low rating would have insignificant property loss due to dam failure. Moderate hazard dams would cause significant property loss in the event of a breach. High hazard dams would cause a possible loss of life in the event of a rupture. The frequency of dam inspection is designated based on hazard rating with the Division of Water Rights inspecting high-hazard dams annually, moderate hazard dams biannually and low-hazard dams every five years.

Agricultural (Infestation, Disease, Livestock/Crop Loss)

Agricultural losses can be detrimental to residents and local economies in the Bear River Region. Insect infestation and other types of crop loss can not only affect a farmer's livelihood, but can lessen the amount of feed available for livestock, and lead to increased feed prices. Disease can also have extremely negative effects for the agricultural economy and residents livelihoods, where animals and crop populations can quickly be decimated. Where the Bear River Region relies quite substantially on agricultural incomes, these threats should be taken seriously and planned for accordingly.

Avalanche

An avalanche is a flow of snow down a steep slope. Generally, the snow is released due to a mechanical failure in structure of the snow, which often occurs after the deposit of multiple layers of snowfall (snowpack). There are three different types of avalanches, slab, powder snow, and wet snow, with slab avalanches being the most common in backcountry recreation accidents. Gravity can trigger avalanches, however they may also be triggers by other forces such as human use, such as skiing or snowmobiling. Large-scale avalanches often coincide with severe winter weather events.

Volcanic

According to the Natural Disasters Association, volcanoes are a "landform created by magma by the earth's interior." Volcanic eruptions have the potential to have a wide variety of impacts ranging from loss of life, to destruction of property, lands, and agricultural production. The closest active volcano to the region is Yellowstone, which could have a catastrophic effect on the region. Volcanic activity also creates several other hazards such as landslides,

tsunamis and debris flows. Another aspect of volcanic activity that poses a risk is geothermal activity. Geothermal activity has the potential to heat bodies of water used for recreation, as well as release dangerous gasses into the atmosphere.

Radon

According to the Environmental Protection Agency (EPA), radon "is an odorless, tasteless and invisible gas produced by the decay of naturally occurring uranium in soil and water" (EPA, 2014). Radon's only known risk is its ability to cause lung cancer in humans. Radon can exist in both indoor and outdoor areas. If an indoor space is found to have high levels of radon, the EPA recommends have the space repaired immediately to reduce levels to a safer level.

Source:
Environmental Protection Agency. (2014). *Radon*. Retrieved from http://www.epa.gov/radon/aboutus.html

Tsunami

A tsunami is a set of waves, most commonly associated with the ocean that cause impacts to bodies of water and their surrounding shorelines. Tsunamis can also be associated with lakes in landlocked environments. Generally, three events trigger tsunamis, volcanoes, earthquakes and landslides. When faulting occurs near the surface during an earthquake, the resulting uplift or slippage creates a wave of water that grows as it reaches shore. Deposits of a landslide in a body of water can have a similar impacts, displacing water in an area and creating waves. Damage associated with tsunamis is a result of flooding from the corresponding waves.