CHAPTER 4

DAM FAILURE

Wyoming has over 30,000 dams and reservoirs, ranging in size from over one million acre-feet in Pathfinder and Seminoe reservoirs above Casper to small coalbed methane and stock reservoirs scattered throughout the state. The dams and reservoirs serve a very important role for Wyoming residents and industry. Rarely, however, the dams fail, either completely or partially, and become a significant hazard for those downstream.

Dam failures can be arranged into four classifications: overtopping, foundation failure, structural failure, and other unforeseen failures. Overtopping failures result from the uncontrolled flow of water over, around, and adjacent to the dam. Earthen dams are most susceptible to this type of failure. Hydraulic failures account for approximately 28% of all dam failures. Foundation and structural failures are usually tied to seepage through the foundation of the main structure of the dam. Deformation of the foundation or settling of the embankment can also result in dam failure. Structural failures account for approximately 28% of all dam failures, and foundation problems account for another 25%. Earthquakes or sabotage account for 12% of all dam failures, while inadequate design and construction account for the remaining 7% of failures.

In 1981, the U.S. Army Corps of Engineers completed an inspection program for nonfederal dams under the National Dam Inspection Act (P.L. 92-367). This was a four-year work effort and included compiling an inventory of about 50,000 dams and conducting a review of each state's capabilities, practices, and regulations regarding design, construction, operation, and maintenance of dams. Part of the inspection included evaluating the dams and assigning a hazard potential based on the downstream effects should one of the dams fail. **(See map page 4.4)**

Dams are classified based upon hazard potential. This classification is based on the consequences if a dam were to fail, not on the potential of failure, or the existing condition of the dam. The dams were rated (1) high, (2) significant, and (3) low hazard. The Corps of Engineers based the hazard potential designation on such items as acre-feet capacity of the dam, distance from nearest community downstream, population density of the community, and age of the dam. High hazard dams would, in case of failure of the dam, likely cause loss of life. Significant hazard dams would, in case of failure, likely cause significant property damage, but no loss of life. Failure of a low hazard dam would likely cause only minimal property damage. Hazard potential classification is no guarantee of safety.

The Wyoming State Engineer's Office (WSEO) regulates dams over 20 feet high or with a storage capacity of 50 acre-feet or more, although smaller dams are also regulated if the potential for failure indicates a need. **(See map page 4.3)** According to the WSEO web site (http://www.damsafety.org/map/state.aspx?s=51, accessed 5/23/2011), as of 2009 the WSEO regulates 1,361 dams. As a part of the regulatory process the WSEO inspects these dams once every five years. Of these dams, 67 are rated high hazard, 110 are rated

significant hazard, and 1,184 are rated low hazard. **Figure 4.1** shows the general locations of dams that are inspected by the WSEO and **Figure 4.1 (c)** shows the general location and rating of dams around the state.

History

There have been a number of dam failures in Wyoming, some of which have caused loss of life and damage to property (**Table 4.1**). The most significant dam failures in terms of loss of life were in 1906 and 1927. On March 1, 1906, flooding along the North Platte River near Casper resulting from snow/ice melt caused a diversion dam to fail. A stream returned to its natural channel with a culvert too small to handle the flood, causing the water to rise against a railroad embankment. The embankment failed. Twelve were killed in a train wreck when the railroad bridge was damaged. The Teton County Local Multi-Hazard Mitigation Plan details the following dam failure in their county: On May 18, 1927, a dam that was formed by the lower Gros Ventre landslide in 1925 partially failed. A 40-foot wall of water came down the valley. The town of Kelly was severely impacted and partially destroyed, and six lives were lost. The town of Wilson was damaged, ranger buildings were destroyed, irrigation head gates were washed away, and a bridge was washed out ($75,000 to $150,000 damage). Total damages were estimated and $500,000. Total impacts were significant, equivalent to nearly $6 million in 2011 dollars. The American Red Cross had expenditures of $12,201.20. There was also a heavy livestock loss. Response was from the Red Cross, Wyoming State Government, Wyoming Governor Emerson, and the Highway Department.

The most costly dam failure occurred on May 14, 1984. High runoff from melting snow in the mountains of southern Wyoming and northern Colorado resulted in the failure of a small dam near Baggs. A 4-foot wall of water poured down a canyon. There was an estimated $5 million in damage to the area, including damage to a water treatment plant, crops, fences, irrigation systems, and structures. Twenty-six homes and trailers were damaged. Recovery response was from the Small Business Administration, Civil Defense, Red Cross, and the Army Corps of Engineers.

To date there have been no Presidential Declarations of a State of Emergency in Wyoming as the result of a dam failure. Additionally, there have been no state-level emergency declarations in Wyoming as the result of a dam failure.

Water remains a critical resource throughout the state. Water conservation is accomplished in part through the utilization of dams. Dams both control flooding and conserve water for summer months when rainfall is limited. The use of dams is significant to Wyoming's water management. Most counties have multiple dams located within their borders, each of which represent a hazard to property and residents, be it low, significant or high.

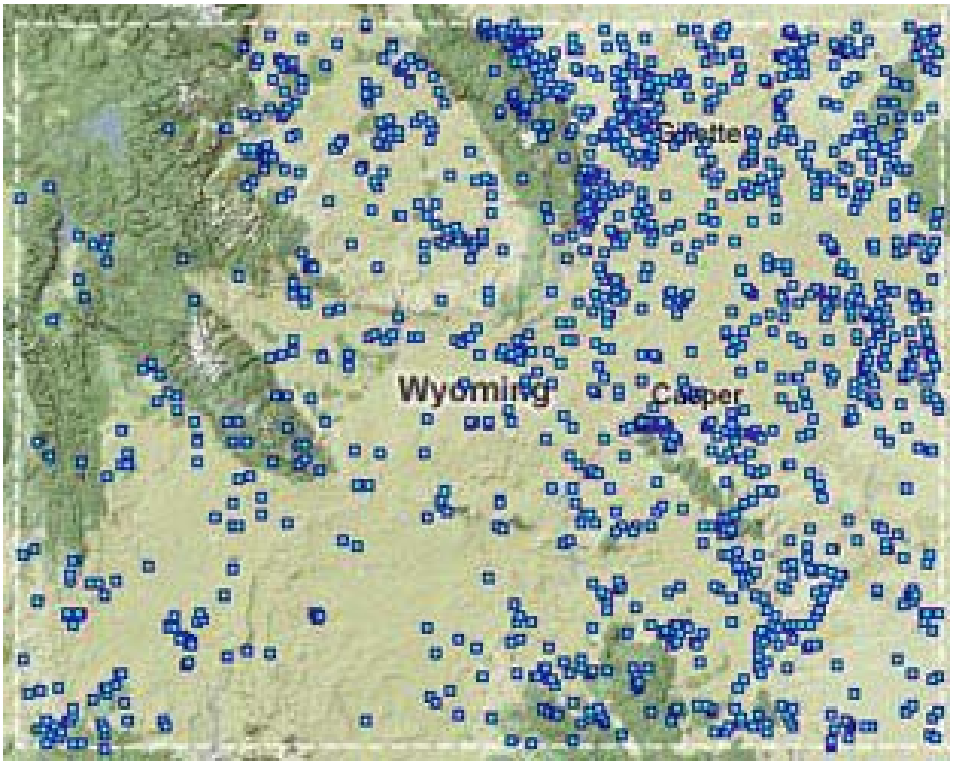


Figure 4.1—Dams inspected by the Wyoming State Engineer's Office and the U.S. Bureau of Reclamation (2009) http://www.damsafety.org/map/state.aspx?s=51, Accessed 5/23/2011

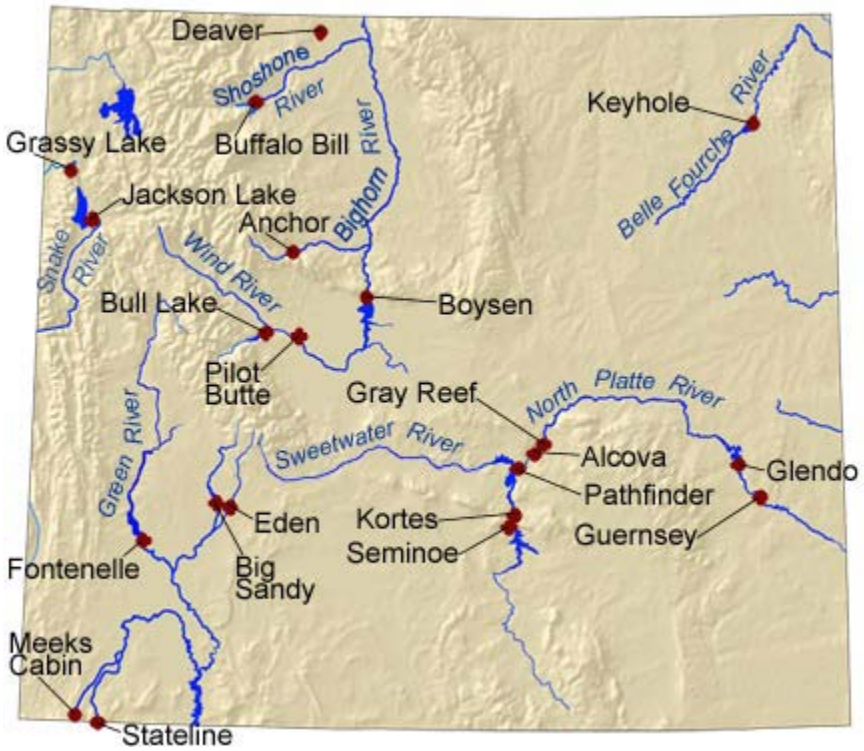
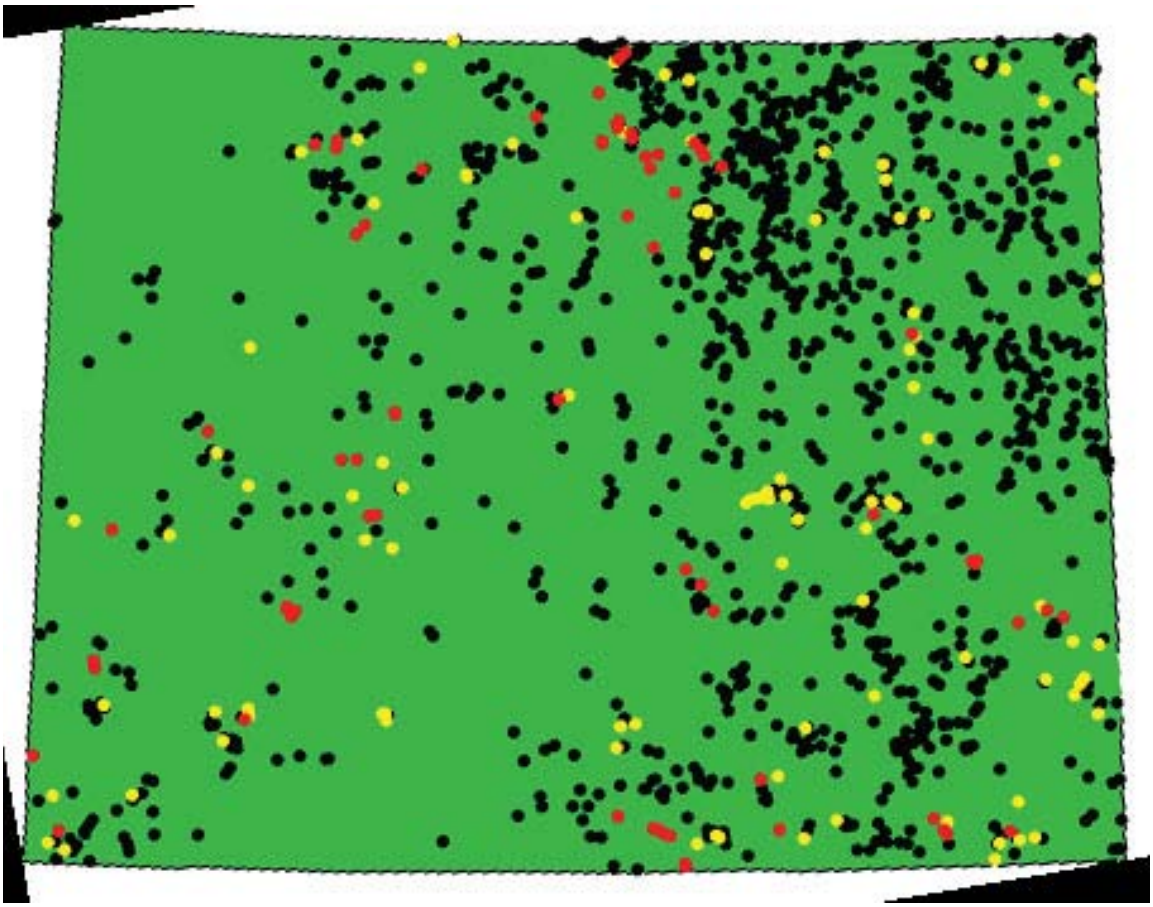


Figure 4.1 (b) - U.S. Bureau of Reclamation Facilities in Wyoming http://www.usbr.gov/projects/FacilitiesByState.jsp?StateID=WY Accessed 5/23/2011



Fibure 4.1 (c) - Red: High-Hazard Potential Dam
Yellow: Significant-Hazard potential Dam
Black: Low-Hazard Potential Dam
http://www.damsafety.org/media/Documents/STATE_INFO/State%20Performance%20Data/Performance%20Reports/Wyoming%20Dam%20Safety%20Report.pdf Accessed 5/23/2011

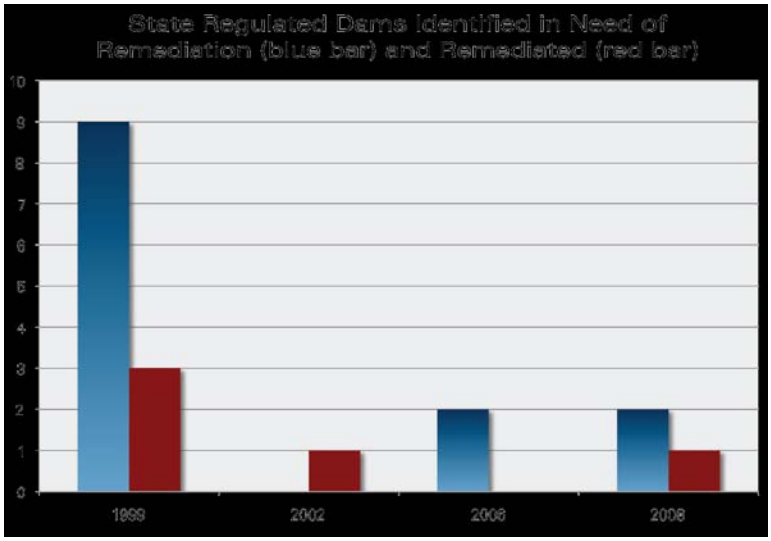


Figure 4.1 (d) - State Regulated Dams Identified in Need of Remediation (blue bar) and Remediated (red bar) 1999 – 2008 Accessed 5/23/2011

Table 4.1 - Wyoming Historical Dam Failures								
Start Date	**End Date**	**County**	**Location**	**Deaths**	**Injuries**	**Estimated Property Damage**	**Estimated Crop Damage**	**Information**
3/1/1906		Natrona	Casper, North Platte River	12				Flooding resulting from snow/ice melt, a diversion dam giving way, a stream returned to natural channel culvert too small to handle flood, rose against railroad embankment, earth gave way. Twelve were killed in a train wreck and a railroad bridge was damaged.
5/18/1927		Teton	Jackson, Kelly, Wilson, Gros Ventre River	6		162,000		Flooding was caused by a hole in the dam that was caused by a landslide that resulted from an earthquake. The flood came from a 40-foot-high down valley wall of water equal to 100,000 acre-feet. Town of Kelly carried away; town of Wilson damaged; ranger buildings destroyed, washed out irrigation head gates; bridge washed out ($75,000 to $150,000); Red Cross expenditures ($12,201.20); heavy livestock loss. In addition to the damage, 6 lives were lost. Response was from the Red Cross, Wyoming State Government, Governor Emerson and the Highway Department.
7/28/1955		Albany	Double Four Ranch					On the 28th, the observer at the Double Four Ranch noted that cloudbursts west of Garrett on the headwaters of the North Laramie River the day before had caused damage, and that the river rose 6 - 8 feet about midnight, washing out a dam and flooding ditches in his locality.
8/10/1955		Niobrara	4 miles north of old Whitman Post Office					A very heavy rain occurred about 4 miles north of the old Whitman Post office on the 10th. This caused some dams to break. One ranch lost 21 head of cattle in a local flood.
8/10/1955		Niobrara	4 miles north of old Whitman Post Office					A very heavy rain occurred about 4 miles north of the old Whitman Post office on the 10th. This caused some dams to break. One ranch lost 21 head of cattle in a local flood.
6/15/1963	6/16/1963	Fremont	Lander, Middle Popo Agie			90,000		A greater than 500 year flood from a combination of heavy rain (3 inches) and failure to earthen reservoir caused minor damage to homes, inundated part of the city, resulting in an estimated $90,000 in damage according to city officials. The following are discharge amounts: Middle Popo Agie River below the Sinks, near Lander - 4180 cubic feet per second (CFS). North Popo Agie River near Milford - 4500 CFS, Little Popo Agie River near Lander - 2010 CFS.
9/1/1965		Sweetwater	Green River					Earthen dam holding the reservoir developed a leak, and flood-gates were opened to release as much water as rapidly as possible. Discharge from reservoir was 19,100 CFS. (Calculated 100-year flood has a flow of 25,300 CFS.)
7/8/1969		Platte	Wheatland, Wheatland Reservoir 1			1,000,000		Dam break with wall of water 50 feet high damaged crops, livestock killed and families forced to evacuate. Over $1 million worth of damage.
7/21/1973		Niobrara and Weston	Niobrara and Weston counties			275,000		Torrential rains accompanied by hail caused flash flooding in the area creek and river, making roads impassable in spots and damaging bridges. Several earthen dams went out. Although hail size was not specified, banks of hail 3 to 4 feet high were observed along roads and creeks. Crop and property damage was substantial.

Table 4.1 - Wyoming Historical Dam Failures								
Start Date	**End Date**	**County**	**Location**	**Deaths**	**Injuries**	**Estimated Property Damage**	**Estimated Crop Damage**	**Information**
1/1/1978		Campbell						Durham Dam 1 was an earthen dam with its base keyed into the foundation constructed in 1973. During the spring of 1978, this dam was overtopped and erosion resulted in a complete failure of the structure with a peak discharge of 5630 CFS. No damage was reported.
1/1/1978		Sheridan						The Reynolds #1 Dam partially failed. This earthen dam had its base keyed into the foundation. The breach resulted from overtopping and subsequent erosion. There was no property damage or loss of life.
5/19/1978		Campbell	Near Gillette					The Caballo Dam was voluntarily breached. The structure, constructed in 1948, was built of earthen material, but its base was not keyed into the foundation. The dam had saturated and started to overtop, so it was voluntarily breached to save as much of the structure as possible. The peak discharge was 2170 CFS.
4/9/1982		Johnson						The Case Reservoir on Seventy-Six Draw was overtopped and the erosion action of the water resulted in a complete failure of the structure. It was an earthen dam, built in 1951, and its base was keyed into the foundation.
9/29/1982		Natrona	South Casper Creek					The Shriner Reservoir Dam was reported as having completely failed. The exact date of this failure is unknown. Constructed in 1908.
7/22/1983		Converse	Laramie Range drainage, eastward southwest of Douglas near LaPrele Reservoir					Heavy thunderstorms sat almost stationary on east slopes of Laramie Mountains for hours. Caused widespread flooding along creeks and streams, runoff collapsed dam sending 10 to 15 feet high wall of water thru nearby ranch.
5/12/1984	5/17/1984	Carbon	North Platte River, tributaries near Saratoga, tributaries near Little Snake River					Rain storms combined with snowmelt runoff augmented on Little Snake River when water breached a dam. Damage to rural property in Baggs. Greater than 100-year flood.
5/14/1984		Carbon	Baggs, Savery, Dixon, Little Snake River			5,000,000		High runoff from melting snow in the mountains of southern Wyoming and northern Colorado; Burst small dam, 4 foot wall of water poured down canyon (sudden warm temps & heavy blanket of snow). $5 million damage to area; damage to water treatment plant, land crops, fences, irrigation systems, structures, livestock, 26 homes and trailers damaged. Recovery response was from small business administration, Civil Defense, Red Cross, and Army Corps of Engineers. Runoff estimated at 500-year level.
5/16/1984		Carbon	Dixon					A greater than 100-year flood caused by snowmelt runoff augmented by an upstream reservoir failure had a discharge of 13,000 CFS.

Table 4.1 - Wyoming Historical Dam Failures								
Start Date	**End Date**	**County**	**Location**	**Deaths**	**Injuries**	**Estimated Property Damage**	**Estimated Crop Damage**	**Information**
6/10/1986		Albany and Carbon	35NW Laramie			275,000		Pierce Dam failed at 1941 MST, spilling its contents into Rock Creek. This was about 35 miles northwest of Laramie along the Albany and Carbon County line. A bridge over Rock Creek along Wyoming Highway 13 was undercut. There was some flooding of buildings and ranch lands where Rock Creek runs into the Medicine Bow River.
1/1/1996		Carbon						VerPlanke Dam had a structural failure. The embankment slumped and failed. A 3-foot wall of water went over Wyoming Highway 230. Some ranch buildings and fences were damaged.
7/1/1998		Campbell	26 W Wright					Heavy rains caused a stock dam to breach on the Iberland Ranch, flooding Wyoming Highway 387.
August, 2008		Laramie	7 SE Cheyenne					Herford Ranch Reservoir #2. Damage was caused by outlet structure failure. No property damage costs, however extensive repairs to the dam estimated at $100,000.
May 19, 2010		Laramie	5 SE Cheyenne					Herford Ranch Reservoir #1. Damage was caused by outlet structure and pipe failure. No property damage costs.
June 16, 2010		Uinta	10 SE Mountainview					Reed Reservoir. Damage was caused by outlet structure failure. No property damage costs.

Impacts

From 1906 to present, there have been $6.8 million in reported damages and 18 deaths caused by dam failures in Wyoming. The damages in 2010 dollars are $19.75 million.

Probability of Future Dam Failures

The U.S. Bureau of Reclamation controls most of the larger dams in the state. The dams and reservoirs all have inundation maps in the event of a dam failure. Because of homeland security concerns, however, data on inundation areas remains unavailable for public consumption, making the study and analysis of inundation areas for the purposes of publication within this plan non-productive.

The failure of many of the large dams may lead to hundreds of millions of dollars in damage. As documented in the bar graph earlier in this chapter, dam inspections and mitigation efforts remain ongoing throughout the State of Wyoming by agencies responsible for dam safety.

Past experience outlined in the table above reflects 24 dam failures in the past 100 years, out of nearly 1,400 dams statewide, with only two of those leading to $1 million or more damage. The probability of a catastrophic dam failure, assuming past experience will continue into the future, would lead one to expect the probability the occurrence of a dam failure is limited. However, should failure of a large dam occur, significant property damage and risk to lives is likely.

Local Mitigation Plan Risk Assessments

A review of the local plans reflects they recognize the hazard dam failure represents within their borders. They have utilized data researched and available to them through the State Multi-Hazard Mitigation Plan. Additionally, they have ranked dam failure risk within their borders based on the population impacted, probability of occurrence within their borders and the property impacted.

Dam risk assessments contained within some local plans provide the names, locations and inundation maps for dams within their plans. Due to public safety concerns, dam locations and inundation information provided at the local level will not be provided within the State Plan.

Below is a table outlining information mined from the local plans' dam failure hazard sections. The table shows previous historical incidents of dam failure within each county's borders as outlined in their plans and extrapolates, based on population impacted, probability of occurrence within their borders, and property impacted, the risk perceived by each county relative to dam failure hazards.

Dam Failure
Information Mined from Local Plans

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low	Loss Potential	Previous Incident(s)
ALBANY	Y	2010	Y	Medium	$9 million	2
BIG HORN	Approvable	2010	Y	High	$53.9 million	0
CAMPBELL	Expired	2005	Y	Medium	Only State Total Provide	3
CARBON	Y	2008	Y	Medium	$1 million	5
CONVERSE	N/Draft	2005			Incomplete Information to determine	
CROOK	N/Draft	2003	Y		State-level Info from State Plan	
FREMONT	Expired	2005	N			
GOSHEN	Y	2007	Y	High	$2,000 Million	0
HOT SPRINGS	N					
JOHNSON	Y	2008	Y	High	hundreds of millions	0
LARAMIE	Expired	2005	N			
LINCOLN	Y	2006	Y	High	$1 million	0
NATRONA	Approvable	2010	N			
NIOBRARA	Y	2009	Y	Low	Insufficient Info to determine	0 (2 in other cntys impacted Niobrara)
PARK	Y	2006	Y	High	hundreds of millions	0
PLATTE	Expired	2004	Y	Medium	$44.562 million	1
SHERIDAN	Y	2009	Y	High	$1 million	0
SUBLETTE	Y	2008	Y	Low	$1 million	1
SWEETWATER	N					
TETON	Y	2009	Y	Medium	$1 million +	1
UINTA	N/Draft	2011	Y		Not Stated	0
WASHAKIE	Expired	2005	Y	High	hundreds of millions	0
WESTON	N					
NORTHERN ARAPAHO TRIBE	N					
EASTERN SHOSHONE TRIBE	N					

Proposed State Mitigation Projects

The following mitigation projects have been proposed by state, federal, and local entities in the process of generating the Wyoming Multi-Hazard Mitigation Plan. Chapter 22 has all proposed mitigation projects.

- Refine computer models to determine potential damage to dams from earthquakes.
- Drill test cores on older hydraulic fill dams in western Wyoming to determine liquefaction or piping potential of the dam.
- Identify homes built in inundation areas of dam failures.
- Update hazard rating of all dams statewide.
- Develop and train a team to respond to landslide dams to prevent failure.
- Increase height of dams to compensate for sediment behind dams.
- Spillway modifications to reflect current analysis on design storms.
- Provide all-hazards weather radios to all residences in Wyoming.
- Identify and inspect shelters in hazard prone areas.
- Provide hazards info to shelters, emergency facilities in public buildings, campgrounds, and phone books.
- Develop reseeding plans for losses due to all hazard events.
- GIS training for local jurisdictions with emphasis on hazards recognition and

analysis for application to mitigation planning.

- Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.
- Education programs encompassing multi-hazard insurance for business, resident and government application.
- Education programs encompassing multi-hazard mitigation for business, resident and government application.
- Planning studies regarding transportation of essential and/or key personnel during all hazard events.
- Continue outreach to counties on identifying cost effective and feasible mitigation projects.
- Promote Continuity of Operations and Continuity of Government, statewide.
- Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.
- Identify, document, and advertise all volunteer agency's locations and contact information.