Multi-Hazard Mitigation Plan
Carbon County, Wyoming
and the Communities of
Baggs, Dixon, Elk Mountain, Encampment, Hanna, Medicine Bow, Rawlins, Riverside, Saratoga, Sinclair

Little Snake River at Baggs, February 2015

Prepared by: Beck Consulting, Red Lodge, Montana,
AMEC Foster Wheeler, Boulder Colorado, and
Carbon County Emergency Management

October 2015

Table of Contents

Tables

Executive Summary

Carbon County has prepared this multi-jurisdiction, multi-hazard mitigation plan in cooperation with the ten incorporated municipalities of Baggs, Dixon, Elk Mountain, Encampment, Hanna, Medicine Bow, Rawlins, Riverside, Saratoga, and Sinclair. Each of the jurisdictions has identified one or more projects in the plan and participated in plan development.

The plan was prepared with the assistance of the Wyoming Office of Homeland Security, Beck Consulting and AMEC Foster Wheeler. Plan goals and mitigation actions were developed as the result of input from the Local Emergency Planning Committee (LEPC), public meetings, and the local governments. Preparing and implementing this plan will make the county more disaster-resistant.

Jurisdictions in the county are vulnerable to a total of 14 hazards. The hazards of most concern to County residents were flooding, wildland fire, winter storms and blizzards, and hazardous material incidents.

In order to enhance local understanding of the plan and projects, and increase accountability for implementation, one goal was developed for each of the 11 local jurisdictions with various projects for the hazards they wish to address listed under the goals. There are 11 goals. A total of 63 projects were identified under those goals. The project types include education and awareness, prevention, protection, property protection, natural resource protection, structural, and coordination. The goals are as follows:

1. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **Town of Baggs.**
2. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **Town of Dixon.**
3. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **Town of Elk Mountain.**
4. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **Town of Encampment.**
5. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **Town of Hanna.**
6. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **Town of Medicine Bow.**
7. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **City of Rawlins.**
8. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **Town of Riverside.**
9. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **Town of Saratoga.**
10. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the **Town of Sinclair.**
11. Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in **Carbon County.**

This Page Intentionally Blank

Chapter I. Introduction

Scope and Organization of the Plan

This Multi-Hazard Mitigation Plan (MHMP/Plan) covers the jurisdictions of Carbon County, Wyoming, and the incorporated communities within the county including; Baggs, Dixon, Elk Mountain, Encampment, Hanna, Medicine Bow, Rawlins, Riverside, Saratoga, and Sinclair.

The plan is organized into 19 chapters with two appendices.

- Chapter I provides an introduction to the plan, addresses the scope, organization, preparation of the plan, public involvement to develop the plan, and provides a profile of the county and information on development trends.
- Chapter II provides a listing of the hazards to which Carbon County may be susceptible and describes the risk rating system applied to those hazards.
- Chapters III through XVII describe the hazards to which the county is vulnerable, including detailed histories of previous occurrences in the county, impacts, future impacts and a summary.
- Chapter XVIII provides the goals and mitigation actions and explains how they were developed and prioritized.
- Chapter XIX describes how the plan will be maintained and how the plan will be incorporated into other planning efforts and documents.
- The appendices document the planning process, provide a table documenting the status of the 2009 plan projects, and contain the resolutions of adoption.

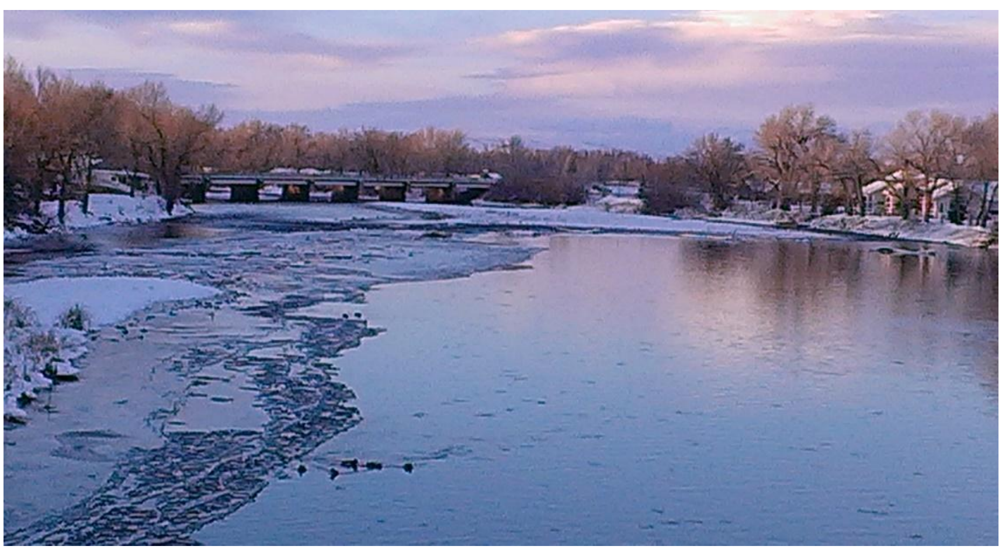


Figure 1.1 North Platte River at Saratoga, December 2014

Preparation of Plan

This plan has been prepared for Carbon County, Wyoming, and its local jurisdictions with the assistance of Beck Consulting and AMEC Foster Wheeler. This section provides a narrative overview of the planning process. Documentation of all meetings, presentations, interviews, and news releases is provided in Appendix A.

AMEC Foster Wheeler conducted the research and updated the hazard descriptions and risk assessment. Beck Consulting reviewed the local planning documents, worked with the Local Emergency Planning Committee (LEPC), elected officials, and the public to develop the goals and mitigation projects, publicized the plan update, and held public meetings so interested groups and individuals could participate in the process. Beck Consulting and AMEC produced the plan document collaboratively.

Identification of Hazards

The Wyoming Office of Homeland Security (WOHS) originally identified the hazards to which the county and its residents are vulnerable. These are the hazards that were analyzed in the 2008 plan.

In November 2014, the original list of hazards was validated separately by the Carbon County Emergency Management Director, the County Commissioners, and the LEPC for the updated analysis. The hazards analyzed in both plans include; dam failure, drought, earthquake, expansive soils, flooding, hail, hazardous materials, landslide, land subsidence, lightning, winter storms, tornadoes, windblown deposits, windstorms, wildland fire, and Yellowstone volcanic eruption.

Review and Incorporation of Existing Plans and Studies

AMEC Foster Wheeler has used the most current accepted sources and information available from a wide variety of sources to update the hazard information in this plan. Sources are cited in the text of this document and include but are not limited to local, state, and federal data bases, maps, models, plans, studies, published reports, newspaper articles, and interviews with local and state staff.

The WOHS consulted numerous plans and data bases while developing the original hazard histories and risk assessments upon which the plan and this subsequent update have been built. The State of Wyoming Multi-Hazard Mitigation Plan was updated since the development of the original multi-hazard plan for Carbon County. Sources used by WOHS are listed in the statewide plan.

All available local plans have been reviewed as well. The reviews of the local plans were for the purposes of identifying hazard mitigation tools already in place, identifying new projects, and ensuring that goals and projects in the Multi-Hazard Mitigation Plan (MHMP) will be consistent with, support, and build upon the planning work that has already been completed for the various jurisdictions.

Table 1.1 Local Documents Consulted

Jurisdiction	Document Name	Date	Comments
County	Carbon County Comprehensive Land Use Plan	2012	Contains future land use map. Recommends storm water runoff mitigation for new development.
County	Subdivision Regulations	2006	Addresses geology, soils, drainage, flooding, and floodplain. Mountain subdivision standards address grades, access fire protection, and snow loads.
County	Zoning Resolution	2011	Requires building permits\zoning certificates, requires permit for floodplain development for buildings located in Special Flood Hazard Areas (SFHA's.) Allows for zone changes based on natural characteristics of the land--slopes, soils, flooding, etc.
County	Floodplain Regulations		Dated, but enforced. Need to be updated.
County	EOP	N/A	Being revised by County EM Director currently
Baggs, Dixon	None	N/A	N/A
Elk Mountain	Ordinances	Various	No master plan. Ordinances address animals, cemetery, seniors, parks and recreation.
Encampment	Master Land Use Plan	1977	Contains a natural resources section with language re: not developing in areas vulnerable to natural hazards
Hanna	Building and construction regulations	Undated	No land use plan
Medicine Bow	Subdivision Regulations	Undated	No master plan. Planned but not developed areas identified on west and northwest side of town. Also has beautification plan.
Rawlins	Rawlins Comp. Master Plan (2010-2030)	2014	See discussion on development trends below. Incorporated mitigation actions from the 2014 master plan into the MHMP mitigation projects.
Rawlins	Economic Development Plan	Various	Various economic development and downtown plans.
Rawlins	Municipal Code	1997 and updates	Title 15. Building and Construction requires permits, Title 16 addresses manufactured homes, Title 18 Zoning.
Riverside	Master Plan	2010	Action listed to inventory sensitive lands to determine areas to protect and areas best suited for development.
Riverside	Zoning Ordinances 189, 198, 199	Various	Requires site design for drainage, mobile home regulations require foundations and tie-downs, building permits required, UBC adopted, requires abatement of dangerous buildings before occupancy.
Saratoga	Municipal Code		Requires building permits.
Saratoga	Land Use Plan	1970's	Starting on new land use plan. Working on river stabilization plan.
Sinclair	Municipal Code	N/A	Being re-codified.

Additional sources such as the census, economic information, and maps and geographic information were consulted for the County Profile section and incorporated as appropriate.

Participation by Local Jurisdictions

Each of the ten local jurisdictions in Carbon County and the county itself participated in the planning process. Obtaining participation by local elected officials was emphasized. Participation occurred in the following ways:

- By providing information on critical infrastructure and facilities,
- By providing access to local planning documents,
- By helping to determine the status of projects from the original 2009 plan,
- By participating on the LEPC (which served as the Local Planning Committee) through their functional representatives to that group,
- By meeting with the contractor at a regularly-scheduled, publicly-noticed council and commission meetings (Carbon County, City of Rawlins, and Town of Saratoga),
- By participation in the Council of Governments (COG), COG briefing and discussion,
- By reviewing and providing feedback on draft mitigation projects,
- By providing specific project ideas for their communities and the county,
- By reviewing and commenting on the draft plan, and
- By adopting the plan.

LEPC Meeting, December 17, 2014

Public Involvement Process

Members of the public, businesses, non-profits, and other interested parties had multiple opportunities to participate in plan development. These opportunities occurred during formally noticed public meetings (three held across the county), town, city council and county commission meetings (publicly-noticed regularly-scheduled meetings), and at the March 2015 Council of Governments meeting (also publicly-noticed.) The Council of Governments consists of the elected representatives from all ten incorporated communities and the county.

The public was also informed about the planning process and plan development through postings of meeting notes and drafts on the county website. The public was invited to review and submit comments to the draft plan, available at each local government office and posted on the Carbon County, Town of Saratoga, and City of Rawlins websites.

The *Rawlins Daily Times* and *Saratoga Sun* produced news articles about the plan. The local radio station broadcast information about the process. Meeting flyers, notes, sign-in sheets, news releases and news articles are provided in Appendix A which documents the planning process—including public involvement. Legal ads were purchased in the *Saratoga Sun* and *Rawlins Daily Times* announcing the availability of the draft plan and the public comment period.

County Profile

Carbon County encompasses approximately 7,897 square miles in south central Wyoming. The southern portion of the County shares its border with Colorado.

The entire county sits at relatively high elevation. The Continental Divide winds through the heart of the county in a generally north-south orientation. Peaks of 11,000 are found in the southern and eastern areas of the county and the county is home to the Pedro, Park, Ferris, Shirley, Seminoe, Sierra Madre, and Medicine Bow Mountain Ranges. The lowest area of the county is in the northwest, with elevations around 6200 feet.

The county includes three hydrologic basins: the North Platte River Basin (including flows from the Encampment and Medicine Bow Rivers), the Little Snake Basin (including flows from Muddy Creek) in the southwest corner of the county, and the Great Divide Basin in the north and central western areas of the county. (Carbon County Land Use Plan, 1988)

Interstate 80 (I-80) passes through the county running east-west. State Highway 287 runs from the northwest corner of the county in a southerly direction turning east and south at Rawlins. Secondary Highway 789 runs south across the western portion of the county through Baggs and into Colorado. The Union Pacific has track paralleling I-80 from Rock Springs through Rawlins and east to Walcott. The mainline then leaves the Interstate corridor and follows Highway 30/287 east through Hanna and Medicine Bow.

The Bureau of Land Management (BLM) is the largest land owner in the county with 2,028,314 acres. The BLM manages their surface acres plus mineral rights of all federally-owned lands. An additional 700,094 acres of federal lands are managed by the U.S. Forest Service, Bureau of Reclamation, and the Fish and Wildlife Service. Other lands in the county are deeded private individual and corporate ownership and owned by the state. Land ownership is distributed in a checker board pattern as a remnant of federal land grants to railroads in the 1800’s.

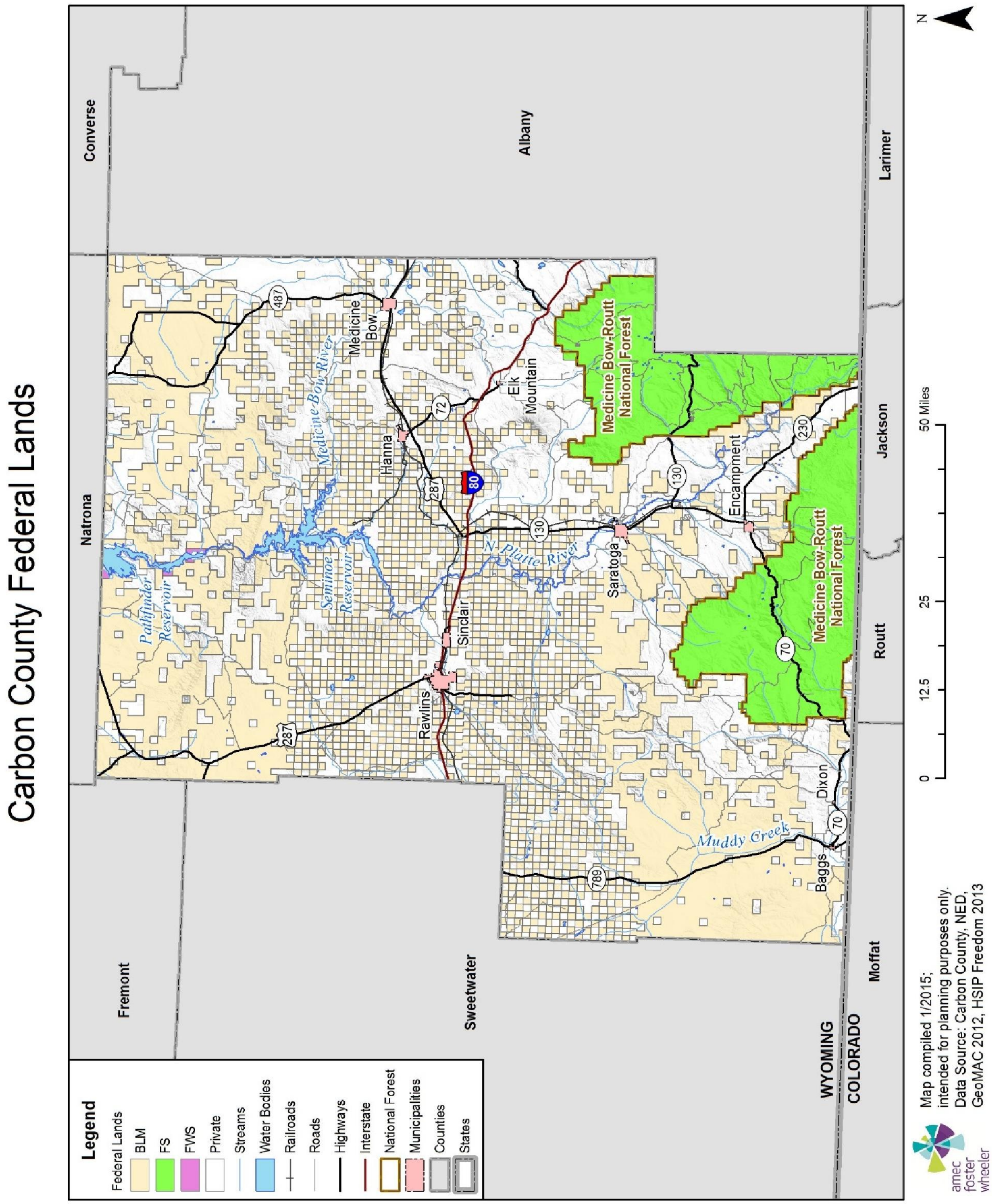


Figure 1.2 Carbon County Land Ownership Map

The topography ranges from open, high elevation basins and desert land to pine covered mountains. Pine stands in the mountains continue to experience beetle kill which has increased the wildfire hazard and affected the hydrology and runoff patterns. The county is drained primarily by the North Platte River which runs northerly across the county. The North Platte and the Seminoe Rivers fill the Seminoe Reservoir and then flow downstream to the north into the Pathfinder Reservoir.

The population of Carbon County during the last census on April 1, 2010, was 15,885. The Census Bureau estimates population between the decennial censuses. The 2013 county population estimate was 15,748. This is an increase of 246 individuals from the 2000 census (15,639.) By contrast, between 1990 and 2000, the county experienced a 6.1% population decline. The incorporated communities of Baggs, Dixon, Elk Mountain, Encampment, Hanna, Medicine Bow, Rawlins, Riverside, Saratoga, and Sinclair are situated within Carbon County.

Populations of the nine incorporated towns (see table below) all remained relatively constant with only modest changes both up and down from 2000 to 2010. Rawlins is the only community in the county with a population large enough to be designated a city. By contrast with the towns, the population of Rawlins increased by 721 individuals or 8.4% from 2000 to 2010. Rawlins, the county seat is located near the Interstate, has land available for development within the incorporated city limits, and offers a variety of businesses and services. The 2014 Rawlins Master Plan used four scenarios to project population change. According to these scenarios, the range of population increase in Rawlins is expected to be from 224 to 3,747 additional individuals by 2030. Population projection in areas with significant energy sectors is complex because large numbers of construction workers are needed on the front end of major projects (processing plants, wind farms, transmission lines, etc.) Once these projects are completed, fewer workers are needed to operate and maintain the project. This can cause fluctuation in population numbers and difficulty in planning for their needs.

Table 1.2 Populations of Incorporated Communities (2010 Census)

Town/City	Population
Baggs	440
Dixon	97
Elk Mountain	191
Encampment	450
Hanna	841
Medicine Bow	284
Rawlins	9,259
Riverside	52
Saratoga	1,690
Sinclair	433

Source: U.S. Census Bureau (census.gov)

According to the census, the county had a total 8,576 housing units in 2010. Almost half (46%) of these housing units, 3,960 units, are located in Rawlins. The 2014 Rawlins Master Plan projected the need for an additional 20 to 335 acres for residential housing. Current housing in Rawlins is inadequate—additional units of almost all types are needed and general condition of single family housing is aged and poor. Both the county policy and the Rawlins Master Plan encourage infill rather than expansion of the city boundaries. Occupied housing units in the county numbered 6,388 in 2010 with a third of the total, 2,188, unoccupied.

While the economy of the county has a basic level of stability with some diversity, both the economy and population continue to be subject to fluctuations related to national energy demands and policies. The county contains all forms of carbon-based energy including subsurface and strippable coal, methane gas, and oil and natural gas. The county also has uranium. Wind power has been developed in the county and additional wind development is proposed. In addition to the energy industry, the economy is also supported by ranching and tourism. Two of the major employers in the county include the Wyoming State Prison in Rawlins and the Sinclair Refinery, in Sinclair. The county contains a significant amount of federal public land--BLM and Forest Service. The government sector also provides many jobs.

According to the most recent figures available on County Business Patterns from the U.S. Census Bureau (2012), there were 544 business establishments in the county. The total annual payroll for the 4,387 paid employees of these establishments was $173,611,000. The sector with the most business establishments was retail trade (87) followed by Accommodation and Food Services (84), Other Services (53), Construction (51), Health Care and Social Assistance (49), and Transportation and Warehousing (46.) The Accommodation and Food Services sector employed the largest number of individuals at 729 employees, followed by Retail Trade with 687, Construction with 643, Health Care and Social Assistance employed 632. Mining, Quarrying and Oil and Gas Extraction employed 229 individuals in the county and Transportation and Warehousing employed 202 employees in 2012. (http://factfinder.census.gov)

The Bureau of Labor Statistics reported the unemployment rate in Carbon County in November 2014 was 3.9%. This is less than the rate for Wyoming at this same time which was 4.5%. The Bureau of Labor Statistics reports that the average wage in Carbon County for the second quarter of November was $882/week. According to the Wyoming Department of Administration and Information, per capita income in Carbon County in 2012 (2013 dollars) was $45,555. Per capita income is a measure of income per person derived by dividing total personal income (labor and non-labor) by the total population.

The average household size in 2010 was 2.36 persons. The median age was unchanged from 2000 at 38.9. Males made up 53.8% of the population and females 46.2% in 2010. The population reported itself as 88.8% white with 16.8% Hispanic or Latino. (http://factfinder.census.gov)

Development Trends

The following information was obtained primarily by talking with the Carbon County Planning and Development Director, Sidney Fox, County Planner/GIS Specialist, Tom Powell, Carbon County Emergency Management Coordinator/former Saratoga Mayor, John Zeiger, and the *Rawlins Comprehensive Master Plan (2010-2030) Forward Vision.*

The population of Carbon County has remained relatively stable over time although energy booms have and continue to exert influence. In general, development occurring on lands under county authority is driven either by energy activities or by recreation opportunities (depending on location in the county.) For example, new development in the Riverside area is likely to be associated with recreation while development near Medicine Bow is likely to be energy related.

According to the City of Rawlins Master Plan, estimating population associated with the energy industry is complex because many energy workers “live” temporarily in hotels and are not counted. Lack of housing in Rawlins may exacerbate this discrepancy.

Associated with energy production is the need to transport the product (oil, gas, electricity, etc.) to market. The county is home to many miles of underground pipelines and many miles of overhead transmission lines.

- The west-wide transmission corridor passes through Carbon County. This corridor is part of a national plan that has identified locations for transmission lines. The lines that are planned to cross the county include the Zephyr, Gateway South, Gateway West, and the Trans-West Express. These lines will move electricity from wind power to market.
- Idaho Power and Rocky Mountain Power (Pacificorp) are planning to build the high voltage transmission line across southern Wyoming and southern Idaho, the Gateway West Transmission Line. The transmission lines will be either 230 or 500 kV, or a combination of the two. The Bureau of Land Management has initiated the preparation of an environmental impact statement to determine if and where to permit the lines. Two proposed line locations enter Carbon County from the north running south towards Medicine Bow. Just north and west of Medicine Bow, the routes consolidate into one and turn west eventually joining the I-80 right-of-way and following that right-of-way west to the border of Carbon and Sweetwater Counties. The Gateway West project is being built independent of any particular new generation project to provide a transmission backbone to connect hubs and carry electricity from generation point to market.
- Additional wind farms are proposed in the county. The largest of these is the Chokecherry/Sierra Madre Project, just south of Sinclair and Rawlins. This project has obtained local and state approvals and is currently in the permitting process with the federal government. The project proposes up to 1,000 wind turbines and will be constructed over a 6-7 year period. The construction workforce will be seasonal and is estimated to be up to 900 peak workforce. Once completed, there will be 114 new full time permanent jobs. The Project Housing Plan anticipates the construction workers will be housed in on-site temporary living facilities\man camps when local housing options are full during the seven to eight-year construction period.
- The Continental Divide-Creston Natural Gas Development Project consist of adding oil natural gas wells to an area (1.1 million acres-1,672 sq. miles) in Carbon and Sweetwater Counties over approximately 15 years. Previous development included drilling approximately 4,700 wells on private and public lands. This project proposes up to 8,950 new wells located on public lands within an older developed field. This project could create demand for additional housing in Rawlins and Baggs, but is not expected to create a large or sudden influx of workers or new residents. Oil and gas prices have the potential to affect the scale and timing of this project and other oil and gas related development.
- The Lost Creek in-situ uranium mine located in Fremont County (just north of Carbon County) ships yellowcake (a uranium product) through Carbon County. The mine is north of Jeffrey City and is equidistant from Lander, Rawlins, and Riverton. Rawlins could experience some increased demand for housing related to this mine.
- The Pathfinder Mine (uranium) was active until the 1980's. It was recently purchased by a new owner and is likely to become active again. This mine is located in the Shirley Basin (northeastern Carbon County.)
- Medicine Bow Fuel & Power, LLC a subsidiary of DKRW Advanced Fuels has proposed a large coal-to-liquids plant and coal handling facility 13 miles south of Medicine Bow and 4 miles north of Elk Mountain, north of I-80.

- The MBF&P project is proposed on State permitted Arch Coal mine property. If the project comes to fruition, 2,307 laborers could be needed for the three-year construction period, with 450 workers required to operate the refinery for its remaining life. The two closest communities of Medicine Bow and Elk Mountain are both small. Demand for additional housing would impact the communities. A 100-lot subdivision, Wellborn, has been proposed at Medicine Bow. It is likely that workers would commute from all directions including at a minimum from Laramie, Rawlins, Medicine Bow, Elk Mountain, and Saratoga. Large numbers of additional residences would be needed, and man camps could also be brought in either temporarily or as longer-term solutions. The Wyoming ISC will require an updated socio-economic report prior to construction but no later than June 18, 2016. The updated construction schedule will show the resumption of construction no later than March 2017. MBF&P will be required to provide sufficient housing for workers over and above what the local communities can reasonably provide.

In summary, predicting development trends for Carbon County, Wyoming, is a complex undertaking. Both land use and population change are strongly correlated to the national and global demand for carbon-based and other forms of energy--and the movement of energy products from source to market.

Carbon County will likely experience population fluctuations--rapid increases in population could occur during construction of major projects and then decrease upon completion when projects become operational. The difficulty is projecting the timing and magnitude of these population changes. The population changes related to the energy sector are most likely to occur in and around Baggs, Elk Mountain, Hanna, Medicine Bow, Rawlins, and Sinclair. Smaller population changes associated with recreation are more likely to occur around Encampment, Dixon, and Riverside. The Saratoga area could experience population change related to both energy development and recreation.

This Page Intentionally Blank

Chapter II. Hazard Identification and Risk Analysis

The Carbon County Emergency Management Agency, along with the Wyoming State Geological Survey, identified 17 potential hazards that affect Carbon County, 14 of which were considered to be significant and potentially life threatening. Definitions and explanations of all potential hazards are below.

Dam Failure: Dam failure is the uncontrolled release of impounded water resulting in downstream flooding, which can affect life and property. Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, vandalism, or terrorism cause dam failures.

Drought: Drought is described as a protracted period of deficient precipitation resulting in extensive damage to vegetation.

Earthquake: A sudden motion or trembling that is caused by a release of strain accumulated within or along the edge of the Earth's tectonic plates.

Expansive Soils: Expansive soils contain clays that have the potential to swell and shrink when they become wetted or dried. Expansive soils can damage roads, bridges and other transportation infrastructure, as well as buildings. Carbon County has over an estimated value of $627,000 in buildings built on or over expansive soils. However, the historic damage figures indicated less than 1% of the total building stock has been affected. There has been less than $3,000 of actual damage in Carbon County. It is suspected that most problem areas are being dealt with during construction.

Flood: A general and temporary condition of partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any source, or (3) mudflows or the sudden collapse of shoreline land.

Flash flood: A flood event occurring with little or no warning where water levels rise at an extremely fast rate.

Hail: Hail is ice that forms, grows and ultimately falls from thunderclouds. Severe storms can drop enough hail to blanket the ground, flatten crops or clog storm sewers. Hail stones can injure humans and animals, and damage crops, buildings, cars, and infrastructure.

Hazardous Materials: As defined by the U.S. Department of Transportation (DOT), a hazardous material is one that poses an unreasonable risk to health and safety of operating or emergency personnel, the public, and/or the environment if not properly controlled during handling, storage, manufacture, processing, packaging, use, disposal, or transportation.

Landslide: A downward movement of a slope and materials under the force of gravity.

Land Subsidence: Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials. In Wyoming this is often associated with roof collapse of mined-out areas.

Lightning: Lightning is a sudden electrical discharge released from the atmosphere that follows a course from cloud to ground, cloud to cloud, or cloud to surrounding air, with light illuminating its path. Lightning's unpredictable nature causes it to be one of the most feared and deadly weather elements.

Severe Winter Storm: A winter storm can range from a moderate snow over a few hours to blizzard conditions with blinding wind-driven snow that lasts several days.

Tornadoes: Tornadoes are violently rotating column of air extending from a thunderstorm to the ground.

Urban Fire: Urban fire is described as fire usually in manmade structures within a developed city / town that has the ability to spread from one structure to another.

Windblown Deposits: Windblown deposits include areas of shifting silts and sands that can encroach on development, roads, and agricultural areas. Wyoming has some of the most significant windblown deposits in the U.S, some of which are located in Carbon County.

Windstorms: Windstorms are the violent movement of air across the surface of the earth causing damage to assets. Damaging windstorms are not common in Carbon County, but they have occurred.

Wildfire: An uncontrolled fire spreading through vegetation fuels, exposing and possibly consuming structures.

Yellowstone Volcanic Explosion: 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. 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.

The large-scale explosive events at Yellowstone occurred 640,000 years before present, 1,300,000 years before present, and 2,100,000 years before present. The recurrence intervals of these events range from 660,000 years (1,300,000 – 640,000) to 800,000 years (2,100,000 – 1,300,000). Only 640,000 years has elapsed since the last event, so 20,000 – 160,000 years may be left before a large event is expected.

There are smaller events that occur more frequently. These include several 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 occurrence of frequency (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.

Hazard Risk Analysis

Based on the histories and potential future occurrences of hazards that may cause significant impacts in Carbon County, the LEPC selected the following to be addressed in more detail in the hazard-specific chapters of this plan: dams, drought, earthquakes, floods, hail, landslides, lightning, mine subsidence, snow avalanches, tornadoes, wildfire, wind, windblown deposits, winter storms, and hazardous material spills. Hazards that were not addressed further were those that were not likely to occur in the next 100 years or those that have not been shown to have a historical impact on property or life safety in Carbon County.

At the end of each of the following hazard-specific chapters there is a summary of the risk to people and property for each hazard. The probability of the hazard occurring is assessed as well. The Carbon County Emergency Management Agency generated a ranking of hazards to determine the most significant potential threats posed by natural and man-made hazards. The attached hazard analysis is based on a high, medium and low level of risk, as defined below, based on past history and the potential for future occurrence.

High: This ranking carries the highest threat. The potential of this hazard occurring in the assessment area is considered a matter of "when" it will occur, as opposed to "if" it will occur. The potential for damage is widespread. Hazards in this category may have already occurred in the past.

Medium: This ranking carries a moderate threat level to the general population. The potential of occurrence may be the same as the "high" ranking but the potential damage is more isolated and less costly than a more widespread disaster.

Low: The lowest ranking in the survey, the occurrence and potential cost of damage to life and property is minimal.

Jurisdiction(s) Affected: This indicates how widespread the hazard is within the county, and where the risk varies across the planning area.

Estimates of potential losses were developed based primarily upon HAZUS (Hazards U.S.) information and flood plain maps, also considering historical occurrence information. In a few cases providing estimates of potential future damage is not possible because there has been no history of damage and/or the incidents of the hazards are too difficult to predict (location, intensity, duration, etc.) The narratives in the hazard assessment chapters provide information on future impacts for each hazard including potential losses when possible.

Major disaster declarations were also used to identify and assess hazards in Carbon County and Wyoming. Federal and/or state disaster declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local governments' capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Should the disaster be so severe that both the local and state governments' capacities are exceeded, a federal emergency or disaster declaration may be issued allowing for federal assistance.

The federal government may issue a disaster declaration through FEMA, the U.S. Department of Agriculture (USDA), and/or the Small Business Administration (SBA). FEMA also issues emergency declarations, which are more limited in scope and without the long-term federal recovery programs of major disaster declarations. The quantity and types of damage are the determining factors.

A USDA declaration will result in the implementation of the Emergency Loan Program through the Farm Services Agency. This program enables eligible farmers and ranchers in the affected county as well as contiguous counties to apply for low interest loans. A USDA declaration will automatically follow a major disaster declaration for counties designated major disaster areas and those that are contiguous to declared counties, including those that are across state lines. As part of an agreement with the USDA, the SBA offers low interest loans for eligible businesses that suffer economic losses in declared and contiguous counties that have been declared by the USDA. These loans are referred to as Economic Injury Disaster Loans.

Table 2.1 provides information on federal emergencies and disasters declared in Wyoming between 1963 and 2013. Wyoming did not receive any disaster declarations in 2014.

Table 2.1 Federal Disaster and Emergency Declarations in Wyoming

Event/Hazard	Year	Declaration Type	Remarks/Description
S3548 Drought	2013	USDA	Included Carbon County as a contiguous natural disaster area
S3508 Drought	2013	USDA	Included Carbon County as a primary natural disaster area
S3350 Drought	2012	USDA	Included Carbon County as a contiguous natural disaster area
S3319 Drought	2012	USDA	Included Carbon County as a contiguous natural disaster area
S3298 Drought	2012	USDA	Included Carbon County as a contiguous natural disaster area
S3290 Drought	2012	USDA	Included Carbon County as a primary natural disaster area
S3260 Drought	2012	USDA	Included Carbon County as a primary natural disaster area
DR-4007 Severe Storms, Flooding, and Landslides	2011	Presidential	Carbon County received Public Assistance
DR-1923 Flooding	2010	Presidential	
DR-1599 Tornado	2005	Presidential	
DR-1351 Winter Storm	2000	Presidential	
DR-1268 Severe Winter Storm	1999	Presidential	
DR-740 Severe Storms, Hail, Flooding	1985	Presidential	
DR-591 Severe Storms, Tornadoes	1979	Presidential	
DR-557 Severe Storms, Flooding, Mudslides	1978	Presidential	
DR-155 Heavy Rains, Flooding	1963	Presidential	
EM-3092 Methane Gas Seepage	1987	Emergency	
EM-3043 Drought	1977	Emergency	
FM-5014 Sheep Herder Hill	2012	Fire Management Assistance	

Table 2.1 Federal Disaster and Emergency Declarations in Wyoming

Event/Hazard	Year	Declaration Type	Remarks/Description
Fire			
FM-2995 Oil Creek Fire	2012	Fire Management Assistance	
FM-2993 Squirrel Creek Fire	2012	Fire Management Assistance	
FM-2992 Arapahoe Fire	2012	Fire Management Assistance	
FM-2719 Little Goose Fire	2007	Fire Management Assistance	
FM-2665 Jackson Canyon Fire	2006	Fire Management Assistance	
FM-2654 Thorn Divide Fire Complex	2006	Fire Management Assistance	
FM-2512 Tongue River Fire	2003	Fire Management Assistance	
FM-2460 Commissary Ridge Fire	2002	Fire Management Assistance	
FM-2436 Reese Mountain Fire	2002	Fire Management Assistance	
FM-2427 Hensel Fire	2002	Fire Management Assistance	
FM-2382 McFarland Divide Fire	2001	Fire Management Assistance	
FM-2370 Elk Mountain #2 Fire	2001	Fire Management Assistance	
FM-2367 Green Knoll Fire	2001	Fire Management Assistance	
FM-2315 Dead Horse Fire	2000	Fire Management Assistance	

Source: FEMA

Chapter III. Dam Failures

Dams and reservoirs serve a very important role for Wyoming residents and industry. Rarely, the dams fail, either completely or partially, and become a significant hazard for those downstream. Dam failures result in a unique source of flash flooding, when a large amount of previously detained water is suddenly released into a previously dry area due to a failure in some way of the dam.

Dam failures can be grouped 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.

Dam failures can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding, which result in overtopping
- Earthquake
- Inadequate spillway capacity resulting in excess overtopping flows
- Internal erosion caused by embankment or foundation leakage or piping or rodent activity
- Deformation of the foundation or settling of the embankment
- Improper design
- Improper maintenance
- Negligent operation
- Failure of upstream dams on the same waterway

Overtopping failures result from uncontrolled flow of water over, around, and adjacent to the dam. Approximately 70% of failures are from floods and overtopping. Older dams are more susceptible to overtopping failure. Foundation and structural failures are usually tied to seepage through the foundation of the main structure of the dam. Seepage or piping accounts for about 12% of dam failure. Deformation of the foundation or settling of the embankment can also result in dam failure.

The Wyoming State Engineer's Office regulates dams over 20 feet high or with a storage capacity of 50 acre-feet or more, although smaller dams are also inspected in highly populated areas. As of 2012 there were 1,515 dams inspected by the State Engineer once every five years. Of those dams, 84 were rated high hazard, 106 were rated significant hazard, and 1,325 were rated low-hazard by the Wyoming State Engineer's Office. Carbon County has 121 high, medium, and low hazard significance dams that are inspected by the Wyoming State Engineer's Office as part of the Safety of Dams program. Ten are classified as having a high hazard, and fourteen are classified as significant hazard (Wyoming State Engineer's Office). Seminoe Reservoir is a significant sized reservoir located within the northern central portion of the county. Figure 3.1 shows the dams in Carbon County, and the high and significant hazard dams are listed in Table 3.1. Since the development of the last plan, a few dams have been added or removed (due to change in hazard significance) from the list below. High Savery Dam was added as a high hazard dam, and Silver Lake was reclassified from high to low hazard when inundation mapping was performed after 2009. Little Robber and Little Sage Creek were added as significant hazard dams, and Atlantic Rim and Kortes were reclassified as low hazard. (Wyoming State Engineer's Office).

Table 3.1 High and Significant Hazard Dams in Carbon County

Name	Owner	River	Hazard Class	Nearest Downstream City	Distance to Nearest Downstream City (miles)	EAP*
Turpin Park	T.A. Ranch (Bert Johnson)	Turpin Creek	H	Widdowfield	12	N
Cow Creek Lake	Silver Spur Ranches	Cow Creek	H	Saratoga	21	N
North Spring Creek	Kelly Land And Cattle Com	North Spring Creek	H	Saratoga	57	N
Hog Park Main Dam	City Of Cheyenne-Cbpu	Hog Park Creek	H	Encampment	14	Y
South Spring Creek Lake	Don Hanson	South Spring Creek	H	Saratoga	24	N
Spring Creek	Pete & Betty McKee	Cave Creek	H	Leo	7	N
Hog Park Saddle Dam No. 2	City Of Cheyenne-Cbpu	Hog Park Creek	H	Encampment	14	Y
Hog Park Saddle Dam No. 1	City Of Cheyenne-Cbpu	Hog Park Creek	H	Encampment	14	Y
Seminoe	Bureau of Reclamation	North Platte River	H	Red Buttes	64	Y
High Savery	Wyoming Water Development Commission	Savery Creek	H	Savery	20	Y
Ver Plancke	Tony Swanda	Antelope Creek	S	Vx Ranch	1	N
Sand Lake	Wheatland Irrigation Dist	Deep Creek	S	Arlington	12	N
Pierce	Pierce Reservoir Assn. -	Rock Creek Offstream	S	Como Bluffs Fish Hatchery	8	N
Gunst	Pete Romois	Beaver Creek	S	Unnamed Ranch	1	N
Water Valley Fish & Recreation	Duane Francis	Soldier Creek	S	Riverside	6	N
Rawlins Wastewater Treatment Plant (S 1)	City Of Rawlins	Sugar Creek, Trib North Platte	S	Rawlins	0	N
Rawlins Wastewater Treatment Plant (A 1)	City Of Rawlins	Sugar Creek, Trib North Platte	S	Rawlins	0	N
Rawlins Wastewater	City Of Rawlins	Sugar Creek, Trib North	S	Rawlins	0	N

Table 3.1 High and Significant Hazard Dams in Carbon County

Name	Owner	River	Hazard Class	Nearest Downstream City	Distance to Nearest Downstream City (miles)	EAP*
Treatment Plant (A 2)		Platte				
Rawlins Wastewater Treatment Plant (A 3)	City Of Rawlins	Sugar Creek, Trib North Platte	S	Rawlins	0	N
Rawlins Wastewater Treatment Plant (ST1)	City Of Rawlins	Sugar Creek, Trib North Platte	S	Rawlins	0	N
Rawlins Wastewater Treatment Plant (ST2)	City Of Rawlins	Sugar Creek, Trib North Platte	S	Rawlins	0	N
Rawlins Wastewater Treatment Plant (S 2)	City Of Rawlins	Sugar Creek, Trib North Platte	S	Rawlins	0	N
Little Robber	Bureau of Land Management	Little Robbers Gulch	S	Baggs	13	Y
Little Sage Creek	Bureau of Land Management	Little Sage Creek	S	Rawlins	13	?

Source: Wyoming State Engineer's Office
*EAP: Emergency Action Plan

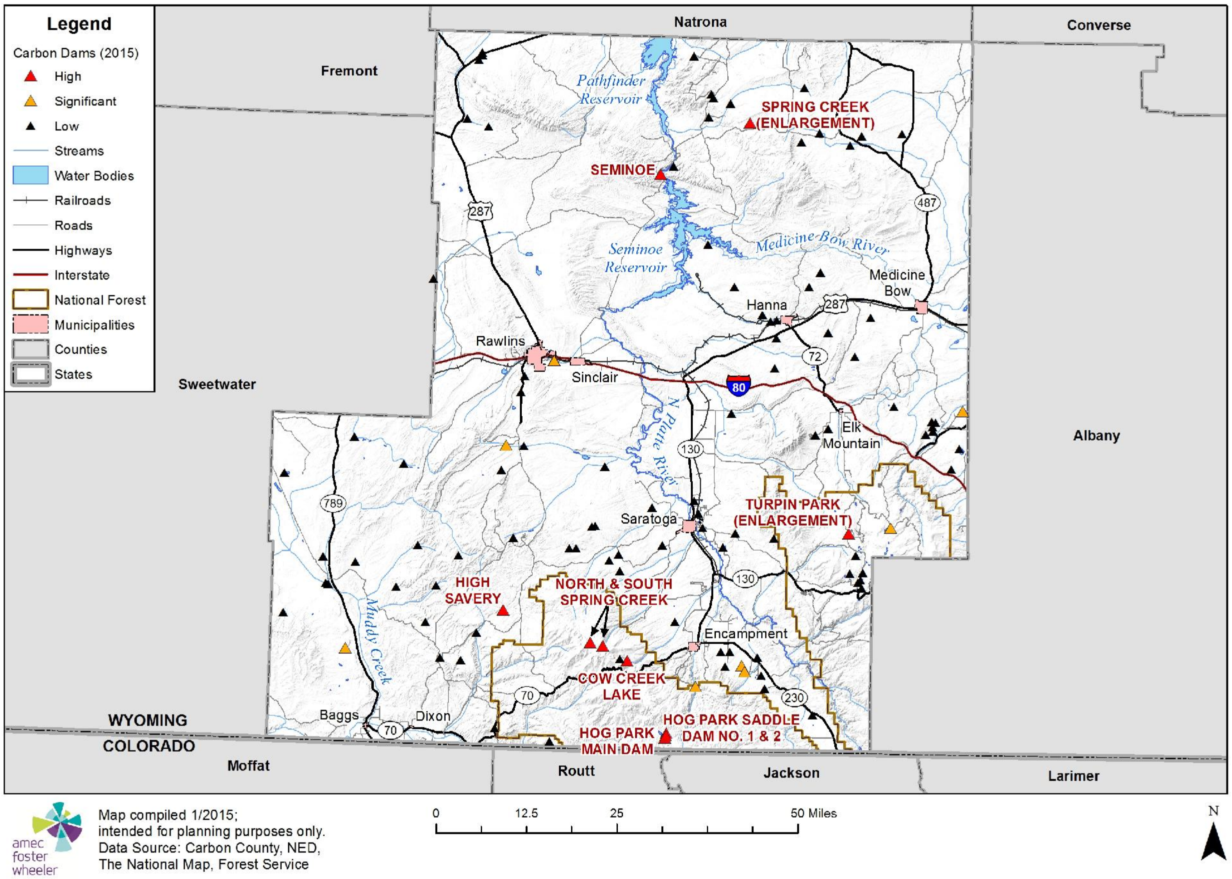


Figure 3.1 Dams in Carbon County

In 1981, the U.S. Army Corps of Engineers completed an inspection program for non-federal 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 effects downstream should one of the dams fail. 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 dam failures would involve property losses over $1 million and have probable loss of life. Significant hazard dam failures would cause over $1 million in property damage and involve possible loss of life. Failure of a low hazard dam would likely cause only minimal property damage and no loss of life. Hazard potential classification is no guarantee of safety. Hazard classifications can also change over time due to development within the inundation zone.

History

There have been a number of dam failures in Wyoming, some of which have caused the loss of life and damage to property. Five documented dam failures occurred in Carbon County. Details of these events are provided in Table 3.2. One of these events occurred during above normal runoff in May of 1984, causing $5 million in damages within the county.

Table 3.2 Carbon County Dam Failures

Location	County	Start Date	End Date	Deaths	Injuries	Estimated Damage – Property	Information
North Platte River, tributaries near Saratoga, tributaries near Little Snake River	Carbon	12 May 1984	17 May 1984				Rain storms combined with snowmelt runoff on Little Snake River when water breached a dam. Damage to rural property in Baggs. Greater than 100-year flood.
Baggs, Savery, Dixon, Little Snake River	Carbon	14 May 1984				$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.
Dixon	Carbon	16 May 1984					A greater than 100-year flood caused by snowmelt runoff augmented by an upstream reservoir failure had a discharge of 13,000 CFS.
35NW Laramie	Albany and Carbon	10 June 1986		0	0	$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.
	Carbon	1 January 1996					Ver Plancke 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.

Source: 2014 Wyoming Multi-Hazard Mitigation Plan, Appendix H, pg. H-164

Impacts

Carbon County has had at least $5,275,000 in damage from five dam failures since 1984. This equates to one dam failure recurrence interval of about once every six years. The average annualized loss is roughly $170,161, although this figure is skewed by the high damage of the May 14, 1984 event and by the absence of quantitative data on damages for three of the five dam failure events in Carbon County.

Future Impacts

With 27 high or significant dams within the county there is a possibility of dam failure flooding in the future, with the potential for at least $1 million in flood damages and loss of life. The U.S. Bureau of Reclamation controls most of the larger dams in the state, including Seminoe Dam. The Bureau of Reclamation dams and reservoirs all have inundation maps for a dam failure. If Seminoe dam failed, the impacts would be most significant to the counties north and east of Carbon County, particularly Natrona and Converse Counties, including the City of Casper. The probability of such an event is low, but there is evidence of earthquake faults in the area (see earthquake section).

Future Development

Although dam failures are a relatively low frequency hazard, future development could still be threatened if structures are built in inundation zones. Flooding due to a dam failure event is likely to exceed the special flood hazard areas regulated through local floodplain ordinances. Carbon County and other jurisdictions should consider the dam failure hazard when permitting development downstream of the high and significant hazard dams. Low hazard dams could become significant or high hazard if development occurs below them.

Regular monitoring of dams, exercising and updating of Emergency Action Plans (EAPs), and rapid response to problems when detected at dams are ways to mitigate the potential impacts of these rare, but potentially catastrophic, events.

Summary

PROPERTY AFFECTED: Medium
POPULATION AFFECTED: Medium
PROBABILITY: Medium
JURISDICTION AFFECTED: Baggs, Dixon, Encampment, Riverside, Saratoga, County

Chapter IV. Droughts

Of all the natural weather-related disasters, drought is by far the most costly to our society. It indirectly kills more people and animals than the combined effects of hurricanes, floods, tornadoes, blizzards, and wildfires. And, unlike other disasters that quickly come and go, drought's long-term unrelenting destruction has been responsible in the past for mass migrations and lost civilizations. The 1980 and 1988 droughts in the U.S. resulted in approximately 17,500 heat-related deaths and an economic cost of over $100 billion. Drought occurs in four stages and is defined as a function of its magnitude (dryness), duration, and regional extent. Severity, the most commonly used term for measuring drought, is a combination of magnitude and duration.

The first stage of drought is known as a meteorological drought. The conditions at this stage include any precipitation shortfall of 75% of normal for three months or longer. The second stage is known as agricultural drought. Soil moisture is deficient to the point where plants are stressed and biomass (yield) is reduced. The third stage is the hydrological drought. Reduced stream flow (inflow) to reservoirs and lakes is the most obvious sign that a serious drought is in progress. The fourth stage is the socioeconomic drought. This final stage refers to the situation that occurs when physical water shortage begins to affect people.

As these stages evolve over time, the impacts to the economy, society, and environment converge into an emergency situation. Without reservoir water to irrigate farms, food supplies are in jeopardy. Without spring rains for the prairie grasslands, open range grazing is compromised. Without groundwater for municipalities, the hardships to communities result in increases in mental and physical stress as well as conflicts over the use of whatever limited water is available. Without water, wetlands disappear. The quality of any remaining water decreases due to its higher salinity concentration. There is also an increased risk of fires, and air quality degrades as a result of increased soil erosion in strong winds (blowing dust).

History and Instrumentation Record

The most recent statewide drought started in 2012 and ended in the beginning of 2014. Prior to this drought, the multi-year drought beginning in 1999 and ending in 2009 is considered by many to be the most severe in collective memory.

Figure 4.1 shows the percent area of Wyoming falling into one of five U.S. Drought Monitor categories. This figure shows that at the peak of the 2012 drought a little over 10% of Wyoming fell in the “D4 – Exceptional” drought category, and 100% of Wyoming experienced at least “D0 – Abnormally Dry” conditions. The U.S. Drought Monitor data are not aggregated by county, so it is not possible to repeat this analysis for Carbon County specifically. Historically, some long-time residents have indicated that they remember streams drying up in the 1930s (dust bowl years) and 1950s, which suggests that these periods were also severe and sustained drought years.

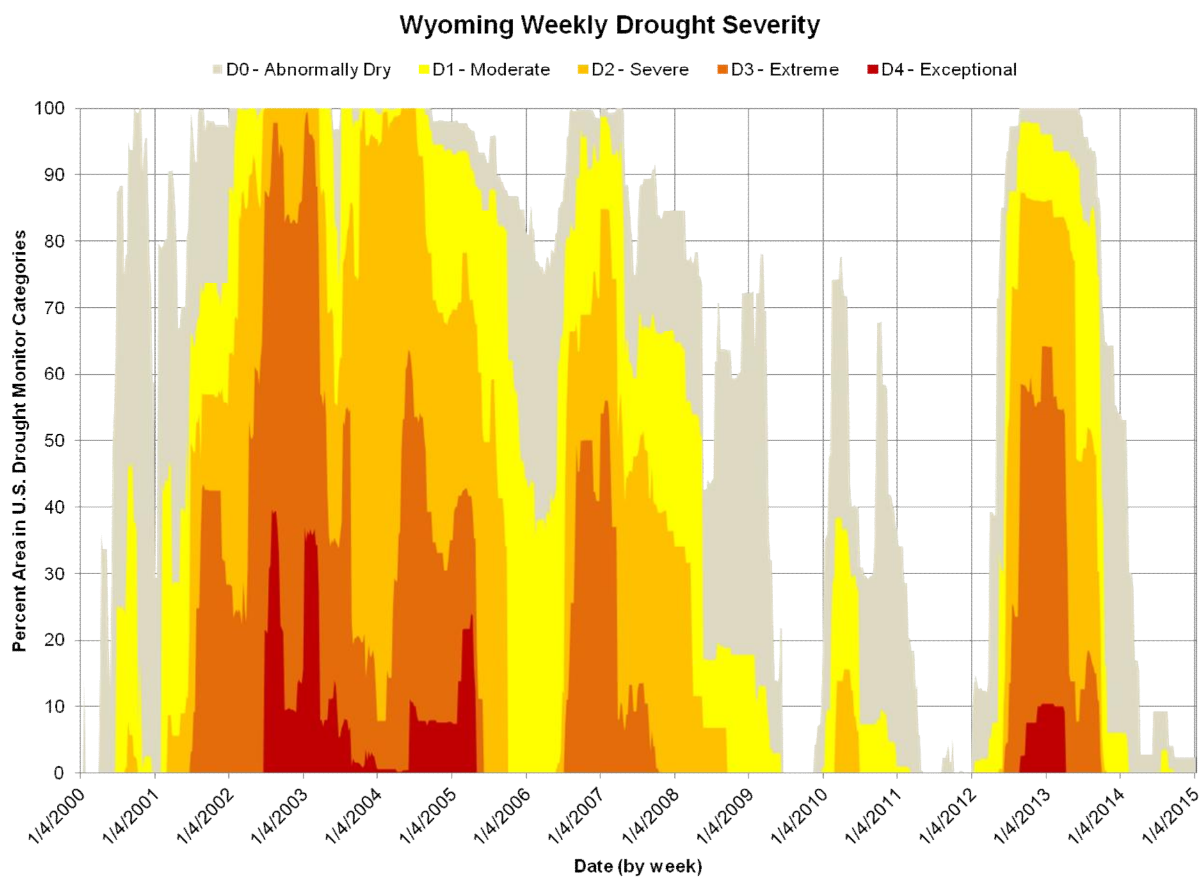


Figure 4.1. Wyoming Weekly Drought Severity[1]

Precipitation data from 1895 to 2014 are available for climate divisions within Wyoming through the National Climatic Data Center (NCDC) U.S. Climate Divisional Database[2]. Carbon County, which has an area of approximately 7,964 square miles, falls within three climate divisions: 80% within climate division 10 (Upper Platte), 19% within climate division 3 (Green and Bear Drainage), and 1% within climate division 8 (Lower Platte).

Annual precipitation data for these three climate divisions were downloaded from the NCDC website, and an area-weighted-average was calculated to create an average annual value of precipitation specific to Carbon County. The average precipitation for the 1895-2014 period of record is 13.2 inches. Since 1895, there have been eight multi-year (three years or longer) droughts in the county, as defined by annual precipitation being less than the long-term average. These periods are shown in Table 4.1. The drought of 2012-2013 is not listed in this table because it is not considered a multi-year drought per the definition given above.

---

[1] Source: United States Drought Monitor, http://droughtmonitor.unl.edu/MapsAndData/DataTables.aspx, accessed 1/16/2015.

[2] The U.S. Climate Divisional Dataset contains long-term historical climate data (1895-2014) for the contiguous United States. See: http://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php

Table 4.1 Carbon County's Recent Worst Multi-Year Droughts*		
Period	**Average Annual Precipitation (inches)**	**Percent of 1895-2014 Average Annual Precipitation (13.2")**
2000-2002	10.10	76.6%
1952-1956	10.77	81.7%
1931-1935	11.34	86.0%
1987-1990	11.47	87.0%
1900-1904	11.67	88.5%
1958-1963	11.68	88.6%
1895-1898	11.84	89.8%
2005-2008	11.85	89.9%

*The drought of 1999-2009 is cited in the text, but using precipitation as the sole metric for drought, the years 1999, 2003, and 2004 had average or above-average precipitation and are therefore not shown in this table.

Table 4.1 shows that the driest time period in the period of record for precipitation was 2000-2002, which was the beginning of the decade-long drought period at the beginning of the 21st century. The single driest year in the record was 1902, followed closely by 2012 and 2002 with 8.1, 8.4, and 8.7 inches of precipitation, respectively. Figure 4.2 presents a graph of the annual precipitation, the average precipitation for the 1895-2014 period of record (13.2 inches), and the 5-year moving average. Imposing a linear trend line over the annual values reveals no long-term trend, indicating that precipitation totals are not increasing or decreasing with time.

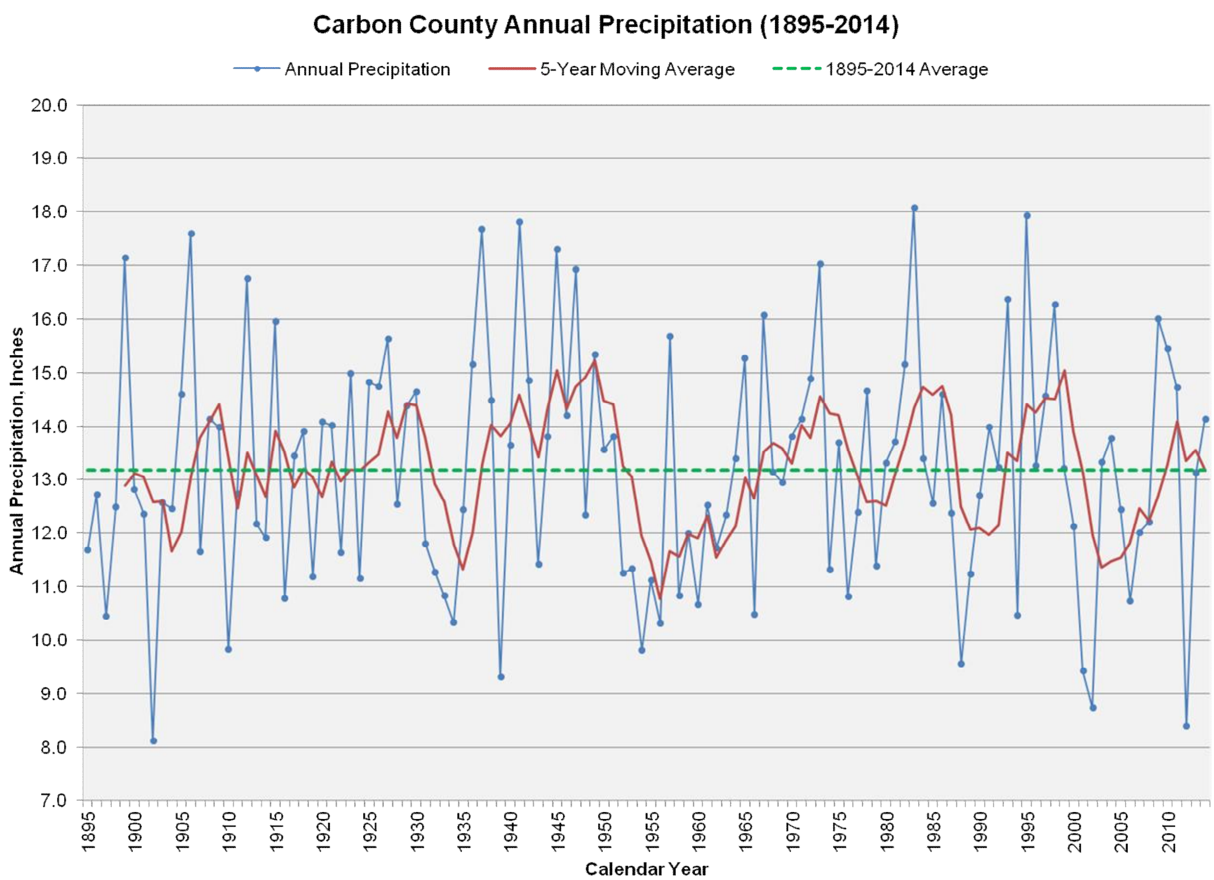


Figure 4.2 Carbon County Annual Precipitation (1895-2014)

The United States Drought Monitor provides a more comprehensive snapshot of drought conditions across the county than precipitation alone. It is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. The map is based on measurements of climatic, hydrologic, and soil conditions as well as reported impacts from contributors around the country. Figure 4.3 shows the drought monitor map for the State of Wyoming during the worst of the 2012-2013 drought (January 8, 2013) and for current conditions (January 13, 2015).

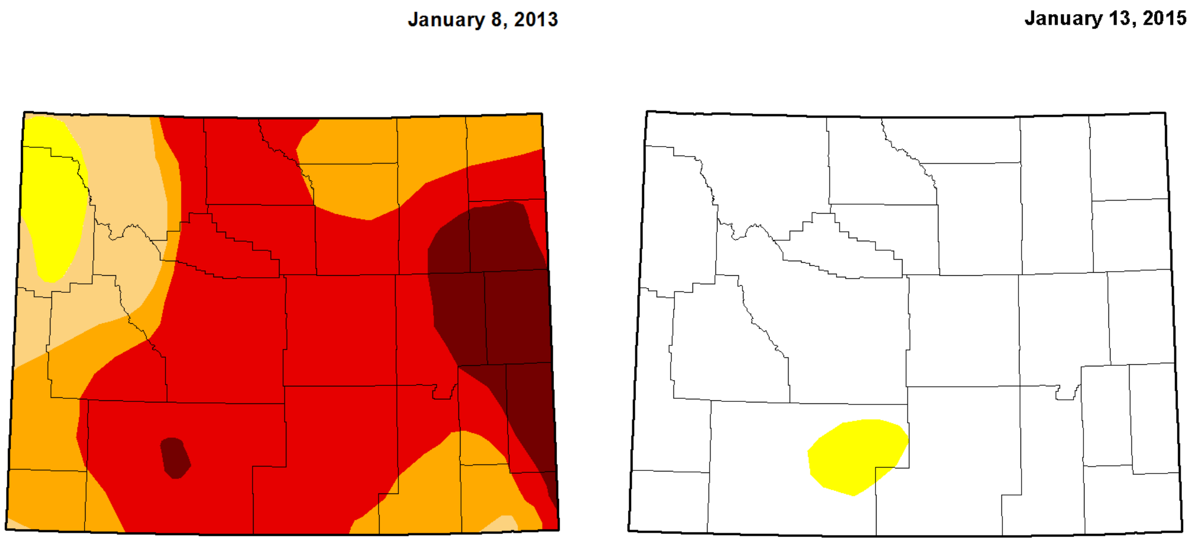


Figure 4.3. U.S. Drought Monitor, Wyoming (map courtesy of NDMC-UNL).

Figure 4.3 shows that most of Carbon County was in the D3 – Extreme drought category during the week of January 8, 2013, which was the peak of the 2012-2013 drought. Currently (January 2015), only a small portion of Wyoming, including a tip of Carbon County, is experiencing abnormally dry conditions, and no part of the state is considered to be in drought.

Impacts

Based upon Table 4.1, Figure 4.1, and Figure 4.2, the three year period of 2000-2002 is as significant, if not more significant than any other droughts in the last 100 years for Carbon County. Because it was a severe, multi-year drought that occurred in the recent past, the 2000-2002 period will be considered the "drought of record" for the remainder of this analysis.

Drought impacts are wide-reaching and may be economic, environmental, and/or societal. The most significant impacts associated with drought in a planning area are those related to water intensive activities such as agriculture, wildfire protection, municipal use, wildlife preservation, tourism, and recreation. While not the only sector impacted by drought, agricultural dollar impacts are often used to show the effects of drought due to the availability of data. During the update of this plan in 2015, agricultural statistics data were obtained from the Wyoming Field Office of the National Agricultural Statistics Service of the USDA.

To get a sense of the economic impact of drought in Carbon County, agricultural production during the 2000-2002 drought was compared to the average agricultural production during five non-drought years preceding the drought, i.e., 1994-1998. According to the 2012 Census of

Agriculture for Carbon County conducted by the USDA National Agricultural Statistics Service, in 2012 there were 319 farms in the county with an average size of 7,442 acres. Of the total market value of agricultural products sold, crop sales accounted for 14% and livestock sales accounted for 86%. The vast majority (93%) of land use by farms was for pasture, and crops made up only 5% of farm land use. Top crop items based on acres were, from greatest-to-least acreage: forage, corn for silage, dried herbs, vegetables, and onions.

Unfortunately, historical agricultural production data specific to Carbon County are not available. In order to provide an estimate of the economic impact of drought, agricultural data for the State of Wyoming were analyzed. Table 4.2 shows the peak commodity production changes from the pre-drought period of 1994 to 1998 compared to the 2000 to 2002 drought.

Table 4.2 Peak Commodity Production Changes from Pre-Drought (1994-1998) to Drought (2000-2002)

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	Lowest Production During Drought (2000-2002)	Year of Lowest Production	Percent Change
Winter Wheat	6,029	1,000 bu.	2,375	2002	-61%
Spring Wheat	648	1,000 bu.	96	2002	-84%
Barley	8,383	1,000 bu.	4,680	2002	-44%
Oats	1,648	1,000 bu.	750	2002	-54%
Dry Beans	691	1,000 cwt.	514	2001	-26%
Sugar Beets	1,151	1,000 tons	659	2002	-43%
Corn	6,328	1,000 bu.	4,165	2002	-34%
Alfalfa Hay	1,581	1,000 tons	1,150	2002	-27%
Other Hay	817	1,000 tons	450	2002	-45%
Cattle/ Calves Inventory	1,536	1,000 head	1,320	2002	-14%

Dollar Impacts

The dollar impact data are only available at a statewide, rather than county, level. As mentioned previously, the drought of record began in 2000 and continued through 2002. Dollar impacts of drought are derived from "Wyoming Agricultural Statistics 2003" that is compiled by the Wyoming Agricultural Statistics Service of the U.S. Department of Agriculture. Supplemental data beyond 2003 were provided by the Cheyenne, Wyoming office of the agency and are included to illustrate how drought is one factor in agricultural dollar impacts but does not fully explain production and value.

The data below represent changes in production value for crops and changes in inventory value for cattle and calves. As such, the data should be considered impact value versus loss value. For example, with cattle and calves (Tables 4.3 through 4.11) inventory, the inventory has decreased during the drought. Therefore the value of inventory on hand has decreased. The inventory decreased, however, because of the sale of the cattle and calves. The sales resulted in an increase in cash receipts to the farming and ranching community. The net result, however, is a decrease in inventory value, which is a negative drought impact.

Table 4.3 1999 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Prod. Average (1994-1998)	Units	1999 Production	Value (USD)	Production and Inventory Value Impact (USD)
Winter Wheat	6029	1,000 bu.	6105	2.12/bu	+ 161,120
Spring Wheat	648	1,000 bu.	264	2.54/bu	- 976,376
Barley	8383	1,000 bu.	7310	3.03/bu	- 3,251,190
Oats	1648	1,000 bu.	1539	1.45/bu	- 158,050
Dry Bean	691	1,000 cwt.	788	16.00/cwt	+ 1,555,200
Sugar Beet	1150	1,000 tons	1205	39.00/ton	+ 2,145,000
Corn	6328	1,000 bu.	6136	1.94/bu	- 372,480
Alfalfa Hay	1581	1,000 tons	1782	67.00/ton	+ 13,467,000
Other Hay	817	1,000 tons	1008	60.00/ton	+ 11,436,000
Cattle/Calves Inventory	1536	1,000 head	1580	770.00/head	+ 33,880,000
TOTAL					+ $57,886,224

Table 4.4 2000 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	2000 Production	Value (USD)	Production and Inventory Value Impact (USD)
Winter Wheat	6029	1,000 bu.	4080	2.70/bu	- 5,262,300
Spring Wheat	648	1,000 bu.	232	2.70/bu	- 1,124,280
Barley	8383	1,000 bu.	7885	3.08/bu	- 1,533,840
Oats	1648	1,000 bu.	1156	1.55/bu	- 252,650
Dry Bean	691	1,000 cwt.	762	16.80/cwt	+ 1,196,160
Sugar Beet	1150	1,000 tons	1556	32.50/ton	+ 195,000
Corn	6328	1,000 bu.	7656	2.02/bu	+ 2,682,560
Alfalfa Hay	1581	1,000 tons	1449	85.00/ton	- 11,220,000
Other Hay	817	1,000 tons	650	80.00/ton	- 13,392,000
Cattle/Calves Inventory	1536	1,000 head	1550	780.00/head	+$10,920,000
TOTAL					- $17,791,350

Table 4.5 2001 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	2001 Production	Value (USD)	Production and Inventory Value Impact (USD)
Winter Wheat	6029	1,000 bu.	2880	2.70/bu	- 8,502,300
Spring Wheat	648	1,000 bu.	168	2.90/bu	- 1,393,160
Barley	8383	1,000 bu.	6970	3.32/bu	- 4,691,160
Oats	1648	1,000 bu.	1344	1.65/bu	- 501,600
Dry Bean	691	1,000 cwt.	514	23.00/cwt	- 4,066,400
Sugar Beet	1150	1,000 tons	794	39.70/ton	- 14,133,200
Corn	6328	1,000 bu.	6375	2.30/bu	+ 108,100
Alfalfa Hay	1581	1,000 tons	1276	110.00/ton	- 33,550,000
Other Hay	817	1,000 tons	605	105.00/ton	- 22,302,000
Cattle/Calves Inventory	1536	1,000 head	1470	780.00/head	- 51,480,000
TOTAL					-$140,511,720

Table 4.6 2002 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	2002 Production	Value (USD)	Production and Inventory Value Impact (USD)
Winter Wheat	6029	1,000 bu.	2375	$3.70/bu	- $ 13,519,800
Spring Wheat	648	1,000 bu.	96	$3.90/bu	- $ 2,154,360
Barley	8383	1,000 bu.	4680	$3.23/bu	- $ 11,960,690
Oats	1648	1,000 bu.	750	$2.20/bu	- $ 1,975,600
Dry Bean	691	1,000 cwt.	624	$18.30/cwt	- $ 1,222,440
Sugar Beet	1150	1,000 tons	659	$42.30/ton	- $ 20,769,300
Corn	6328	1,000 bu.	4165	$2.60/bu	- $ 5,623,800
Alfalfa Hay	1581	1,000 tons	1150	$111.00/ton	- $ 47,841,000
Other Hay	817	1,000 tons	450	$106.00/ton	- $ 38,944,400
Cattle/Calves Inventory	1536	1,000 head	1320	$760.00/head	- $164,160,000
TOTAL					- $308,171,390

Table 4.7 2003 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	2003 Production	Value (USD)	Production and Inventory Value Impact (USD)
Winter Wheat	6029	1,000 bu.	3915	3.35/bu	- 7,081,900
Spring Wheat	648	1,000 bu.	150	3.65/bu	- 1,819,160
Barley	8383	1,000 bu.	7125	3.45/bu	- 4,340,100
Oats	1648	1,000 bu.	1058	1.85/bu	- 1,091,500
Dry Bean	691	1,000 cwt.	648	16.30/cwt	- 746,540
Sugar Beet	1150	1,000 tons	752	39.70/ton	- 5,800,600
Corn	6328	1,000 bu.	6450	2.50/bu	+ 305,000
Alfalfa Hay	1581	1,000 tons	1560	82.00/ton	- 1,722,000
Other Hay	817	1,000 tons	770	75.00/ton	- 3,555,000
Cattle/Calves Inventory	1536	1,000 head	1400	890.00/head	- 121,040,000
TOTAL					- $156,891,800

Table 4.8 2004 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	2004 Production	Value (USD)	Production and Inventory Value Impact
Winter Wheat	6,029	1,000 bu.	3,510	3.2/bu	-8,060,800
Spring Wheat	648	1,000 bu.	240	3.25/bu	-1,326,000
Barley	8,383	1,000 bu.	7,050	3.41/bu	-4,545,530
Oats	1,648	1,000 bu.	795	1.55/bu	-1,322,150
Dry Bean	691	1,000 cwt.	541	25.9/cwt	-3,885,000
Sugar Beet	1,150	1,000 tons	812	41.7/ton	-14,094,600
Corn	6,328	1,000 bu.	6,550	2.48/bu	+550,560
Alfalfa Hay	1,581	1,000 tons	1,305	74.5/ton	-20,562,000
Other Hay	817	1,000 tons	756	69.5/ton	-4,239,500
Cattle/Calves Inventory	1,536	1,000 head	1,300	1,020/head	-240,720,000
TOTAL					- $298,205,020

Table 4.9 2005 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	2005 Production	Value (USD)	Production and Inventory Value Impact
Winter Wheat	6,029	1,000 bu.	4,350	3.5/bu	-5,876,500
Spring Wheat	648	1,000 bu.	315	3.19/bu	-1,062,270
Barley	8,383	1,000 bu.	5,580	3.28/bu	-9,193,840
Oats	1,648	1,000 bu.	600	1.6/bu	-1,676,800
Dry Bean	691	1,000 cwt.	776	18.7/cwt	1,589,500
Sugar Beet	1,150	1,000 tons	801	42.8/ton	-14,937,200
Corn	6,328	1,000 bu.	6,860	2.45/bu	+1,303,400
Alfalfa Hay	1,581	1,000 tons	1,560	75/ton	-1,575,000
Other Hay	817	1,000 tons	756	72/ton	-4,392,000
Cattle/Calves Inventory	1536	1,000 head	1,400	1,140/head	-155,040,000
TOTAL					- $190,860,710

Table 4.10 2006 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	2006 Production	Value (USD)	Production and Inventory Value Impact
Winter Wheat	6,029	1,000 bu.	3,645	4.58/bu	-10,918,720
Spring Wheat	648	1,000 bu.	234	3.8/bu	-1,573,200
Barley	8,383	1,000 bu.	4,845	3.32/bu	-11,746,160
Oats	1,648	1,000 bu.	684	2.15/bu	-2,072,600
Dry Bean	691	1,000 cwt.	590	22/cwt	-2,222,000
Sugar Beet	1150	1,000 tons	798	46.8/ton	-16,473,600
Corn	6,328	1,000 bu.	5,805	2.64/bu	-1,380,720
Alfalfa Hay	1,581	1,000 tons	1,400	101/ton	-18,281,000
Other Hay	817	1,000 tons	715	103/ton	-10,506,000
Cattle/Calves Inventory	1,536	1,000 head	1,400	1,010/head	-137,360,000
TOTAL					- $212,534,000

Table 4.11 Production and Inventory Value Impact for Worst Year of Drought

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	Worst Yearly Production During Drought	Year	Value (USD)	Production and Inventory Value Impact (USD)
Winter Wheat	6,029	1,000 bu.	2,375	2002	3.70/bu	- 13,519,800
Spring Wheat	648	1,000 bu.	96	2002	3.90/bu	- 2,152,800
Barley	8,383	1,000 bu.	4,680	2002	3.23/bu	- 11,960,690
Oats	1,648	1,000 bu.	750	2002	2.20/bu	- 1,975,600
Dry Bean	691	1,000 cwt.	514	2001	23.00/cwt	- 4,071,000
Sugar Beet	1,150	1,000 tons	659	2002	42.30/ton	- 20,769,300
Corn	6,328	1,000 bu.	4,165	2002	2.60/bu	- 5,623,800
Alfalfa Hay	1,581	1,000 tons	1,150	2002	111.00/ton	- 47,841,000
Other Hay	817	1,000 tons	450	2002	106.00/ton	- 38,902,000
Cattle/Calves Inventory	1,536	1,000 head	1,300	2004	1,020.00/head	- 240,720,000
TOTAL						- $387,535,990

Future Potential Impacts

The 2000-2002 drought can be shown to be the drought of historic record, and Tables 4.3 through 4.11 show that there were significant economic impacts on the agricultural industry from this drought. The worst-case year was 2002, with a negative dollar impact of $308,171,390 statewide. Carbon County is 8.1% of the State of Wyoming in land area. If it is assumed that the drought impact is equally distributed across the state, which in reality it is not, the potential drought impact in Carbon County for 2002 would be approximately $25,000,000. The total impact statewide for the 2000-2002 drought is $466.5 million dollars. If it is assumed that the drought impact is equally distributed across the state, which in reality it is not, the potential drought impact in Carbon County would be approximately $37.8 million dollars.

Development Trends

Drought vulnerability will increase with future development as there will be increased demands for limited water resources. Given that population growth and associated new development is limited in scale, future development is unlikely to exacerbate drought conditions in the short term. Drought has the potential to negatively impact ranchers growing grass pasture and forage crops, putting this industry, which comprises the majority of Carbon County's agricultural sector, at greater risk compared to less water-intensive economic industries.

Summary

PROPERTY AFFECTED: High
POPULATION AFFECTED: High
PROBABILITY: High
JURISDICTION AFFECTED: All jurisdictions in the county

Chapter V. Earthquakes

An earthquake is generally defined as a sudden motion or trembling in the earth caused by the abrupt release of slowly accumulated strain. The most common types of earthquakes are caused by movements along faults and by volcanic forces, although they can also result from explosions, cavern collapse, and other minor causes not related to slowly accumulated strains.

Historically, earthquakes have occurred in every county in Wyoming (Figure 5.1). The first was reported in Yellowstone National Park in 1871, and the most recent likely occurred in the Park. Yellowstone National Park is one of the more seismically active areas in the United States.

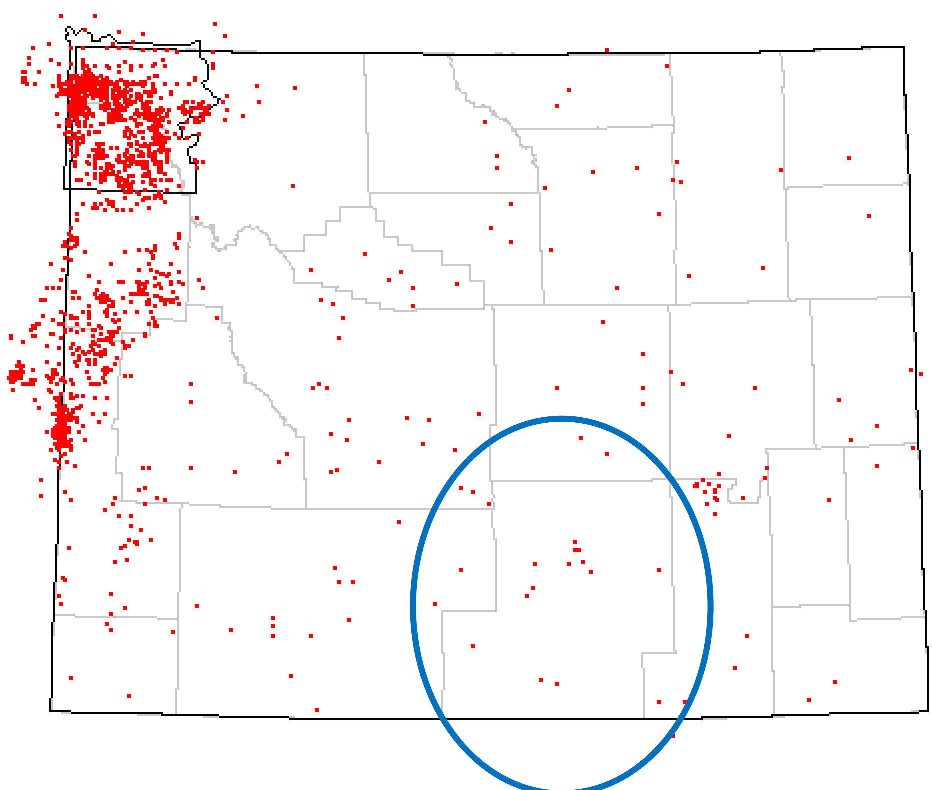


Figure 5.1 Historical Earthquakes in Wyoming, 1871 to 2014 (Carbon County circled in blue)

Source: http://www.wrds.uwyo.edu/wrds/wsgs/hazards/quakes/quake.html

Figure 5.1 shows the locations of the epicenters of earthquakes greater than magnitude 2.5 as of 2014.

Historical Seismicity in Carbon County

Twenty-five magnitude 2.0 or intensity II and greater earthquakes have been recorded in Carbon County. These earthquakes are discussed below.

The first earthquake that was felt and reported in Carbon County occurred just southwest of Rawlins on March 28, 1896. The intensity IV earthquake shook for about two seconds. Residents of Rawlins reported that windows and dishes rattled and lamps swayed. The local newspaper also reported that “Several years ago a similar disturbance was felt here, but at that time it was considerably more severe" (The Rawlins Republican, April 3, 1896). The earlier earthquake may have been a November 7, 1882 event that occurred between Laramie, Wyoming, and Estes Park, Colorado. Kirkham and Rogers (1985) reported that the earthquake was felt as an intensity V event in Rawlins.

On March 10, 1917, another intensity IV earthquake was recorded approximately one mile northeast of Rawlins. The earthquake was felt as a distinct shock that caused wooden buildings to noticeably vibrate. Stone buildings were not affected by the event (Rawlins Republican, March 15, 1917).

The next two earthquakes in Carbon County occurred in the Medicine Bow area. The first was recorded on February 5, 1938, less than a mile southeast of Medicine Bow. The intensity III earthquake was felt as a slight shock in Medicine Bow (Neumann, 1940). On August 28, 1952, an intensity IV earthquake occurred in the same area. Area residents felt this event and reported buildings creaking and loose objects rattling (Murphy and Cloud, 1954).

Most of the earthquakes recorded in Carbon County occurred in the 1970's. A small earthquake of no assigned intensity or magnitude was detected on April 13, 1973, approximately six miles west of Hanna. No one reported feeling this event (Reagor, Stover, and Algermissen, 1985). On May 29, 1973, another earthquake of no specific magnitude or intensity occurred near the Ferris Mountains, approximately 21 miles northeast of Lamont. This earthquake was also not felt (Reagor, Stover, and Algermissen, 1985). Two more small earthquakes of no specific magnitude or intensity were recorded in Carbon County on May 30, 1973, and June 1, 1973. Again, no one felt these earthquakes, which were centered approximately 6 miles west of Hanna (Reagor, Stover, and Algermissen, 1985). On August 3, 1973, a magnitude 4.1 earthquake was recorded on the southeastern margin of Seminoe Reservoir, approximately 13 miles northwest of Hanna. A few days later, a magnitude 3.6 earthquake was recorded approximately nine miles northwest of Hanna on August 10, 1973. Explosions were later identified as being the probable causes of the August 3 and August 10 earthquakes (Coffman and von Hake, 1975). A small earthquake of no assigned magnitude occurred approximately 11 miles northwest of Hanna on August 17, 1973. The U.S. Geological Survey did not report this event as explosion; however, the record was so weak that a definite origin is uncertain (Reagor, Stover, and Algermissen, 1985). A second earthquake of no specific magnitude or intensity occurred on August 17, 1973, approximately nine miles west-northwest of Medicine Bow. No one reported feeling this event (Reagor, Stover, and Algermissen, 1985). On November 21, 1973, another earthquake resulting from a probable explosion was recorded on the western side of Seminoe Reservoir, approximately 20 miles north-northeast of Sinclair. No magnitude was assigned to the event (Coffman and von Hake, 1975).

On December 26, 1973, a small earthquake of no specific magnitude or intensity was recorded approximately 29 miles north-northwest of Hanna. An explosion is thought to be the cause of this earthquake (Reagor, Stover, and Algermissen, 1985). On July 11, 1975, an earthquake occurred on the southeastern margin of Seminoe Reservoir, approximately 12 miles northwest of Hanna. Residents in Rawlins felt the earthquake as an intensity II event (Coffman and Stover, 1977). A magnitude 2.3, intensity V earthquake occurred on January 27, 1976, approximately 12 miles north of Rawlins. Many reports from the Park Drive area indicated that dishes were rattled, pictures fell from walls, lamps were knocked off tables, and one wall in a residence was reportedly cracked. Several people reported that they were thrown out of bed. (*The Daily Times*, January 28, 1976.) The last earthquake recorded in Carbon County in the 1970s occurred on March 3, 1977. This magnitude 4.2, intensity V earthquake occurred in the Sierra Madre Mountains, approximately 18.5 miles west-northwest of Encampment. Doors and dishes were rattled in southern Carbon County homes, but no significant damage was reported (The Laramie Daily Boomerang, March 6, 1977).

Only one earthquake was recorded in Carbon County in the 1980s. On November 1, 1989, a magnitude 3.0 earthquake occurred in the Sierra Madre Mountains, approximately 12 miles west of Encampment. Residents of Saratoga reported feeling this earthquake (U.S. Geological Survey, 1989).

Several earthquakes occurred in Carbon County in the 1990s. On April 13, 1991, and April 19, 1991, magnitude 3.2 and magnitude 2.9 earthquakes, respectively, occurred near the center of Seminoe Reservoir. The April 13 event was centered approximately 22 miles northeast of Sinclair, and the April 19 event was centered approximately 24 miles northeast of Sinclair. On December 18, 1991, a magnitude 3.1 earthquake occurred southwest of Seminoe Reservoir, approximately 15 miles northeast of Sinclair. The last earthquake reported in the area occurred on August 23, 1993. This magnitude 3.0 earthquake, occurred near the center of Seminoe Reservoir, approximately 18 miles northwest of Hanna. No one reported feeling these Seminoe Reservoir area earthquakes (Case, 1994; U.S.G.S. National Earthquake Information Center). Two additional earthquakes were felt in Carbon County in the 1990’s. On August 6, 1998, a magnitude 3.6 earthquake occurred approximately 13 miles north of Rawlins. Residents in Rawlins reported hearing a sound and then feeling a jolt. This non-damaging earthquake was also felt in Sinclair. A magnitude 4.3 earthquake occurred on April 5, 1999, approximately 29 miles north-northwest of Baggs. It was felt in Rawlins, Sinclair, Baggs, Wamsutter, and Rock Springs. Residents of Rawlins reported that pictures fell off walls. The most significant damage occurred between Baggs and Creston Junction, and at Wamsutter. The owner of a ranch house, located approximately 30 miles north of Baggs, reported that cinder block walls in the basement of the home cracked, separated, and may have to be replaced. A motel and associated residence in Wamsutter also suffered cracks in the cinder-block walls of the basement.

Since 2000, nine earthquakes of magnitude 2.5 or greater have been recorded in Carbon County (USGS National Earthquake Information Center). No one reported feeling any of these nine events. The largest of these, a magnitude 3.5 earthquake, was recorded on August 13, 2004 on the west side of Pathfinder Reservoir, in the Seminoe Dam area.

In the fall of 2014, a 3.2 magnitude earthquake occurred at Hog Park Reservoir. The event was felt at Riverside, but no damages were reported.

Regional Historical Seismicity

Several earthquakes have also occurred near Carbon County. As previously mentioned, an earthquake occurred on November 7, 1882, between Laramie and Estes Park, Colorado. Residents in Rawlins reported feeling the earthquake as an intensity V event (Kirkham and Rogers, 1985).

On August 11, 1916, an earthquake was recorded in southeastern Fremont County, approximately 21 miles northwest of Lamont. No damage was reported from this intensity III event (Reagor, Stover, and Algermissen, 1985).

An intensity IV earthquake occurred in Albany County on November 10, 1935. This earthquake, thought to have an epicenter in Laramie, was felt in Laramie, Rawlins, and Rock River. In

Laramie, buildings shuddered slightly, dishes rattled, and a low rumbling sound was heard. The earthquake lasted less than ten seconds (The Laramie Republican-Boomerang, November 11, 1935). On August 27, 1938, an intensity III earthquake was recorded in northern Albany County, approximately 34 miles northeast of Medicine Bow. No damage was associated with the event (Neumann, 1940).

On January 22, 1954, an earthquake was recorded in southwestern Albany County, approximately 42 miles east-southeast of Riverside. This intensity IV earthquake resulted in a very strong but brief shock felt in Jelm (Murphy and Cloud, 1956). On January 23, 1954, an intensity IV earthquake was detected in southern Natrona County, approximately 50 miles north of Hanna. Although this event did not result in any reported damage, one area resident reported that he thought that an intruder in the attic of his house had fallen down (Casper Tribune-Herald, January 24, 1954). On May 22, 1955, an intensity V earthquake in southwestern Albany County, approximately 42 miles east-southeast of Riverside, caused considerable concern. Many Jelm and Woods Landing residents reported hearing a loud rumbling noise, which was then followed by shaking. Dishes, windows, and cupboards were rattled in many cabins in the Woods Landing area. Reflecting the fears of the time, one Jelm resident thought that an atomic bomb had dropped on Denver. A group of fishermen camping near Woods Landing reported that they were rolled around in their tent. The earthquake was not felt in Laramie (The Laramie Republican and Boomerang, May 23, 1955; Murphy and Cloud, 1957). On August 6, 1958, an intensity IV earthquake in the same area was felt in Fox Park, Laramie, and Centennial. Windows rattled and dishes shook in Fox Park, and one Laramie resident thought there was an explosion in his basement (The Laramie Daily Boomerang, August 7, 1958). This earthquake was followed on August 15, 1958, by an intensity III event in the same general area. Residents in the Centennial area reported that buildings shook (The Laramie Daily Boomerang, August 15, 1958). In Fox Park, a light tremor was felt (Brazee and Cloud, 1960). On December 25, 1959, a magnitude 4.3, intensity V event was recorded approximately 38 miles southeast of Riverside. The earthquake was felt in Fox Park, Jelm, and Laramie. In Fox Park, slight cracks formed in a concrete block building under construction. Many residents of Fox Park felt the earthquake and described it as a pretty strong jolt. All Jelm residents felt the earthquake, with many reporting creaking walls (Eppley and Cloud, 1961).

On September 10, 1964, a magnitude 4.1 earthquake occurred in eastern Sweetwater County, approximately 30 miles west of Rawlins. One Rawlins resident reported that the earthquake caused a crack in the basement of his Happy Hollow home. No other damage was reported (*The Daily Times*, September 11, 1964). On November 24, 1966, a small earthquake with no specific intensity or magnitude occurred approximately 40 miles west-southwest of Rawlins. No one reported feeling this earthquake (Reagor, Stover, and Algermissen, 1985).

The only earthquake to occur near Carbon County in the 1970s occurred on April 22, 1973, in southeastern Fremont County, approximately 34 miles north-northwest of Lamont. This magnitude 4.8, intensity V earthquake rattled dishes and disturbed pictures on walls in Jeffrey City (*Casper Star-Tribune*, April 24, 1973). No other earthquakes occurred in the region until October 18, 1984, when an earthquake in northern Albany County caused damage in Carbon County. The magnitude 5.5, intensity VI earthquake, which was centered approximately 38 miles northeast of Medicine Bow, was felt in Wyoming, South Dakota, Nebraska, Colorado, Utah, Montana, and Kansas. Stover (1985) reported that cracks were found in the exterior brick walls of the Douglas City Hall and a public school in Medicine Bow. Chimneys were cracked at Casper, Douglas, Guernsey, Lusk, and Rock River. A wall in a Laramie-area school was also slightly cracked by the earthquake. This earthquake was one of the largest felt in eastern Wyoming. There were a number of aftershocks to the main event, with the most significant being a magnitude 4.5, intensity IV event, and a magnitude 3.8 event occurring on October 18, 1984; a magnitude 3.5 event on October 20, 1984; magnitude 3.3 events on October 19, November 6, and December 17, 1984; a magnitude 3.1 event on October 22, 1984; a magnitude 3.2 event on October 24, 1984; and a magnitude 2.9 event on December 5, 1984. On June 12, 1986, a magnitude 3.0 earthquake occurred in the same general area.

A magnitude 3.8, intensity III earthquake occurred in southeastern Fremont County on June 1, 1993. No damage was reported from this event, which was centered approximately 7 miles northwest of Lamont (Case, 1994). On October 9, 1993, a magnitude 3.7, intensity IV earthquake occurred in eastern Albany County, approximately 39 miles north-northeast of Medicine Bow. The earthquake was felt in Garrett. A magnitude 3.4 earthquake occurred in southeastern Fremont County, approximately 14 miles northwest of Lamont on December 11, 1996. No damage was associated with this earthquake.

On April 13, 2000, a magnitude 3.3 earthquake occurred in northern Albany County, approximately 40 miles northeast of Medicine Bow. No damage was reported. Two earthquakes occurred in northeastern Sweetwater County in May 2000. A magnitude 4.0 event was recorded on May 26, 2000, approximately 5 miles southwest of Lamont. Four days later, on May 30, 2000, a magnitude 3.2 event was recorded in the same area. Area residents reported feeling both earthquakes (U.S.G.S. National Earthquake Information Center).

A search of the U.S.G.S. earthquake database during the 2015 update of this plan did not reveal significant earthquakes of note since 2000 in the vicinity of Carbon County.

Deterministic Analysis of Regional Active Faults with a Surficial Expression

Carbon County contains an active fault system called the South Granite Mountain fault system, which should be included in a deterministic analysis. The South Granite Mountain fault system is composed of several northwest-southeast trending fault segments in southeastern Fremont County and northwestern Carbon County. Geomatrix (1988b) divided the South Granite Mountain fault system into five segments. The segments, from east to west, are the Seminoe Mountains segment, the Ferris Mountains segment, the Muddy Gap segment, the Green Mountain segment, and the Crooks Mountain segment. Geomatrix (1988b) discovered evidence of late-Quaternary faulting on the Ferris Mountains and Green Mountain segments of the fault system. They concluded that the Ferris Mountains segment was capable of generating a maximum credible earthquake of magnitude 6.5 – 6.75 with a recurrence interval of 5,000 to 13,000 years. They also concluded that the Green Mountain segment was capable of generating a maximum credible earthquake of magnitude 6.75, with a recurrence interval of 2,000 to 6,000 years (1988b). Geomatrix (1988b) did not find evidence of late-Quaternary movement on the Seminoe Mountains, Muddy Gap, and Crooks Mountain fault segments. These segments, however, may be extensions of the known active faults in the South Granite Mountain fault system. They should therefore be considered to be potentially active. Geomatrix (1988b) estimated the length of the Seminoe Mountains segment to be 22.5 miles (36 km). Such a fault length would result in a magnitude 6.85 earthquake if the entire length ruptured (Wells and Coppersmith, 1994). The length of the Crooks Gap fault segment was estimated to be 21.25 miles (34 km) (Geomatrix, 1988b). This fault length could generate a magnitude 6.86 earthquake if the entire length ruptured (Wells and Coppersmith, 1994). The Muddy Gap fault system is approximately 14.4 miles (23 km) in length (Geomatrix, 1988b). If the entire fault ruptured, a magnitude 6.66 earthquake could be generated (Wells and Coppersmith, 1994).

There are two approaches to doing a deterministic analysis on a segmented fault system such as the South Granite Mountain fault system. The first approach involves finding the shortest distance from the area of interest to a specific fault segment. A deterministic analysis is then applied to each individual fault segment. The second approach involves measuring the distance from the area of interest to the closest point on the fault system as a whole. An average magnitude is then used for activation anywhere along the entire fault. For the purposes of this report, the second, more conservative approach will be used. Because the active segments of the South Granite Mountain fault system have been assigned a maximum magnitude of 6.75, it may be reasonable to assume that a magnitude 6.75 earthquake could be generated anywhere along the length of the fault system. A magnitude 6.75 earthquake could generate peak horizontal accelerations of approximately 3.1%g at Arlington, approximately 4.5%g at Elk Mountain, approximately 1.8%g at Encampment and Riverside, approximately 9.4%g at Hanna, approximately 21%g at Lamont, approximately 4.9%g at Medicine Bow, approximately 5%g at Rawlins, approximately 3%g at Saratoga, approximately 5.1%g at Sinclair, approximately 45%g at Seminoe Reservoir Dam, and approximately 9.4%g at Pathfinder Reservoir Dam (Campbell, 1987). These accelerations would be roughly equivalent to an intensity VIII earthquake at Seminoe Reservoir Dam, an intensity VII earthquake at Lamont, intensity VI earthquakes at Hanna and Pathfinder Reservoir Dam, intensity V earthquakes at Elk Mountain, Medicine Bow, Rawlins, and Sinclair, and intensity IV earthquakes at Arlington, Encampment, Riverside, and Saratoga. Earthquake intensity levels are shown in Table 5.1. Seminoe Reservoir Dam could sustain moderate to heavy damage whereas moderate damage could occur in Lamont. Hanna and Pathfinder Reservoir Dam could sustain light damage and Elk Mountain, Medicine Bow, Rawlins, and Sinclair could sustain very light damage. No damage would occur in Arlington, Encampment, Riverside, and Saratoga.

Several other active fault systems exist in southwestern Wyoming, including the Chicken Springs, Bear River, Rock Creek, and Grey's River fault systems. The Bear River, Rock Creek, and Grey's River fault systems are too far away to cause damage in Carbon County. If the Chicken Springs fault system in Sweetwater County activates, however, Carbon County could be affected. The Chicken Springs fault system is composed of a series of east-west trending segments in the northeastern corner of Sweetwater County. In 1996, the Wyoming State Geological Survey investigated the Chicken Springs fault system for the U.S. Nuclear Regulatory Commission and the Kennecott Uranium Company. The most recent activation on the system appears to be Holocene in age. Reconnaissance-level studies indicated that the fault system is capable of generating a magnitude 6.5 earthquake (Shepherd Miller, 1996). A magnitude 6.5 earthquake on the Chicken Springs fault system would generate peak horizontal accelerations of approximately 1.85%g at Hanna, approximately 18.5%g at Lamont, approximately 4.8%g at Rawlins, approximately 1.6%g at Saratoga, approximately 3.9%g at Sinclair, approximately 3.4%g at Seminoe Reservoir Dam, and approximately 2.6%g at Pathfinder Reservoir Dam (Campbell, 1987). These accelerations would be roughly equivalent to an intensity VII earthquake at Lamont, intensity V earthquakes at Rawlins and possibly Sinclair, and intensity IV earthquakes at Hanna, Saratoga, Sinclair, Pathfinder Reservoir Dam, and Seminoe Reservoir Dam. An intensity VII event at Lamont would have the potential to cause moderate damage. Rawlins and possibly Sinclair (if felt as an intensity V earthquake) could sustain very light damage, and no damage would occur at Hanna, Saratoga, Sinclair (if felt as an intensity IV earthquake), Pathfinder Reservoir Dam, and Seminoe Reservoir Dam.

A number of unmapped faults also exist in the Washakie Basin area in southern Sweetwater and Carbon Counties. Further field investigation is necessary to determine if any of these faults should be deemed active.

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, Carbon 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, with an average value of magnitude 6.25.

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 6.25 “floating” earthquake, placed 15 kilometers from any structure in Carbon County, would generate horizontal accelerations of approximately 15%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 6.25 earthquake at 15 kilometers from a site will provide a fairly conservative estimate of design ground accelerations.

Probabilistic Seismic Hazard Analyses

The U.S. Geological Survey (USGS) publishes probabilistic acceleration maps for 500-, 1,000-, 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 a new probabilistic acceleration map for the United States (Petersen et al., 2014[3]), but updated state-level maps are not available. A copy of the 2% probability of exceedence in 50 years map of PGA for the U.S. is shown in Figure 5.2.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 5.1.

Based on Figure 5.2, there is a 2% probability of exceedence in 50 years of PGA ranging from 0.14 to 0.30 g in Carbon County. Based upon the 500-year map (10% probability of exceedance in 50 years) (Figure 5.3), the estimated peak horizontal acceleration in Carbon County ranges from approximately 4%g in the southern and southeastern portions of the county to over 6%g in the northern part of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9%g – 9.2%g). Intensity V earthquakes can result in cracked plaster and broken dishes. Rawlins and Saratoga would be subjected to accelerations of approximately 5-6%g and 5%g, respectively, or intensity V.

Based upon the 1000-year map (5% probability of exceedance in 50 years) (Figure 5.4), the estimated peak horizontal acceleration in Carbon County ranges from 6%g in the southeastern corner of the county to over 10%g in the northeastern and northwestern corners of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9%g – 9.2%g) to intensity VI earthquakes (9.2%g – 18%g). Intensity V earthquakes can result in cracked plaster and broken dishes. Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Rawlins and Saratoga would be subjected to accelerations of approximately 9-10%g (intensity V-VI) and 8%g (intensity V), respectively.

Based upon the 2500-year map (2% probability of exceedance in 50 years) (Figure 5.5), the estimated peak horizontal acceleration in Carbon County ranges from approximately 11%g in the southeastern corner of the county to over 20%g in the northeastern portion 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. Rawlins and Saratoga would be subjected to accelerations of approximately 17-18%g (intensity VI-VII) and 14-15%g (intensity VI), respectively.

---

[3] Full reference: Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, Documentation for the 2014 update of the United States national seismic hazard maps: U.S. Geological Survey Open-File Report 2014–1091, 243 p., *http://dx.doi.org/10.3133/ofr20141091*.

As the historic record is limited, it is nearly impossible to determine when a 2,500-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 Carbon County analyses. This conservative approach is in the interest of public safety. Table 5.1 shows the Modified Mercalli Intensity and peak ground acceleration (PGA) (Wald, et al 1999).

Table 5.1 Earthquake Intensity

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

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.

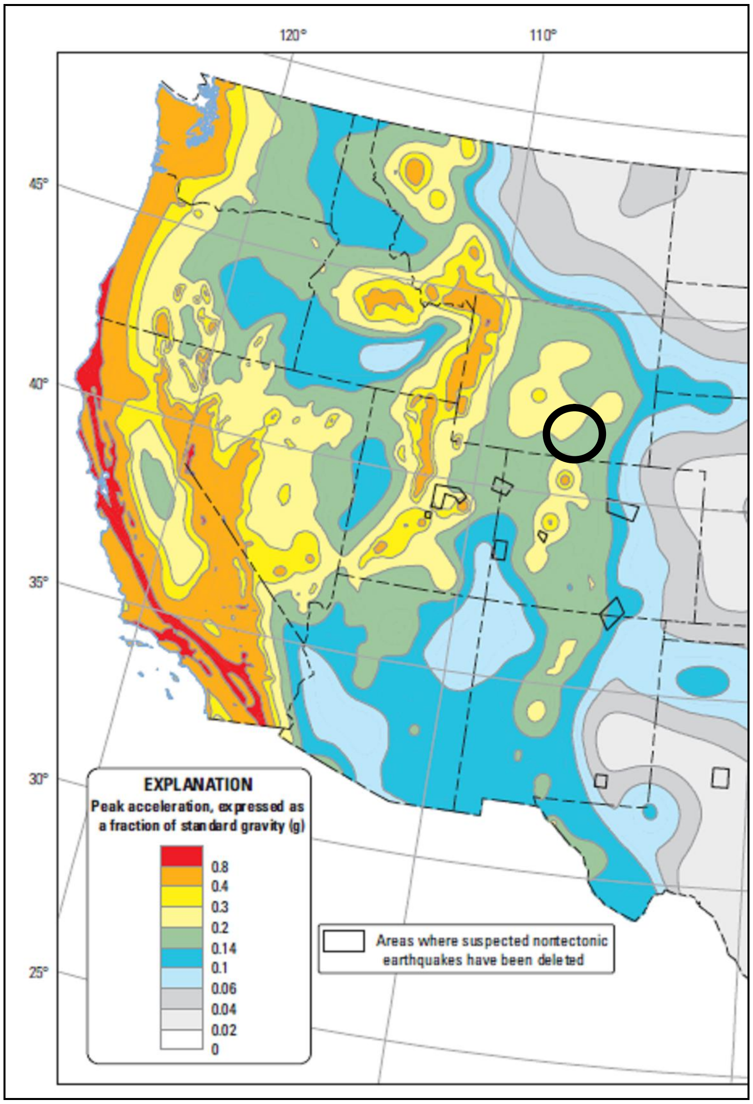


Figure 5.2 Two percent probability of exceedance in 50 years map of peak ground acceleration, Western United States (Carbon County area circled in black)

Source: Petersen et al., 2014

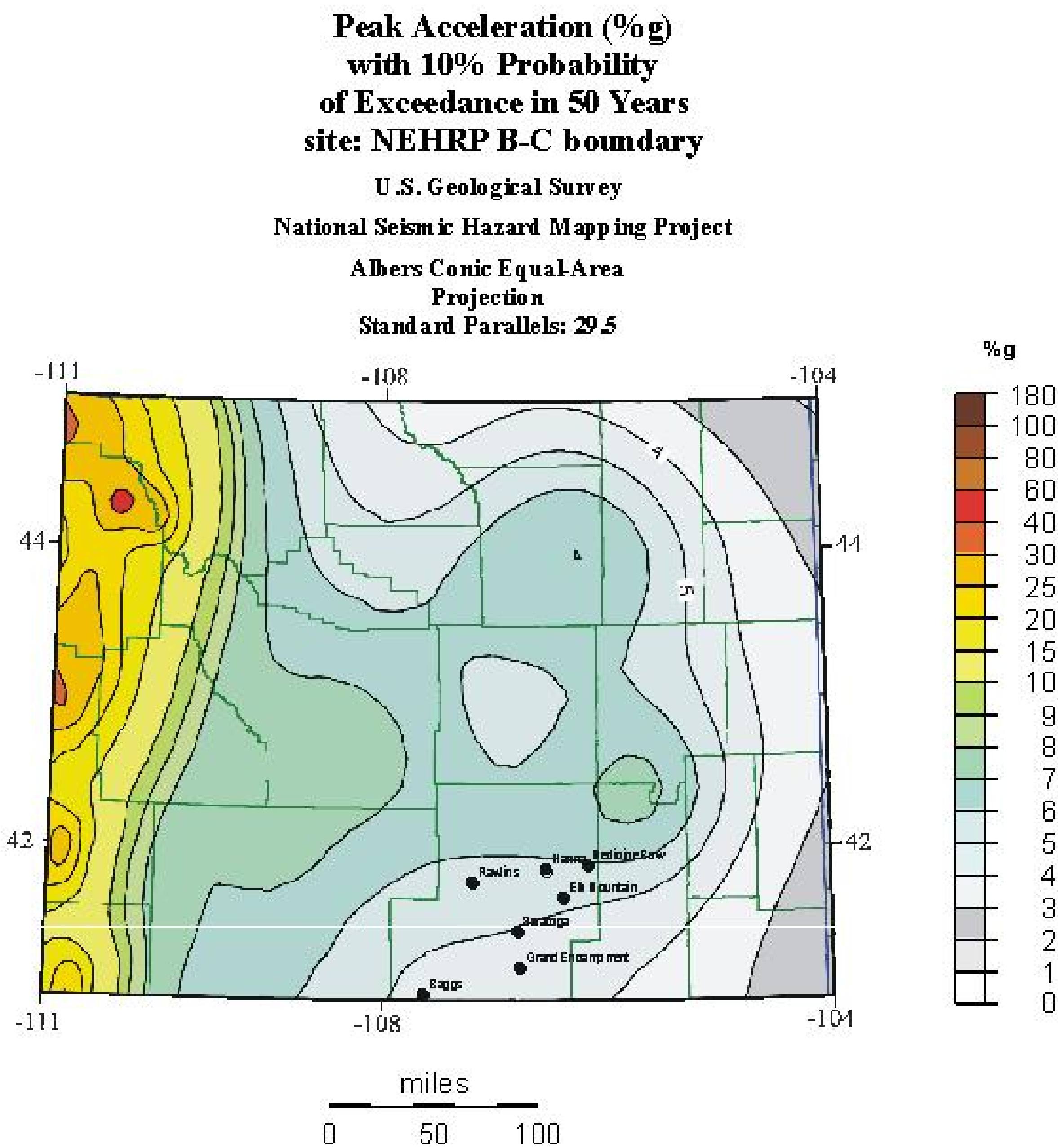


Figure 5.3 500-year probabilistic acceleration map (10% probability of exceedance in 50 years).

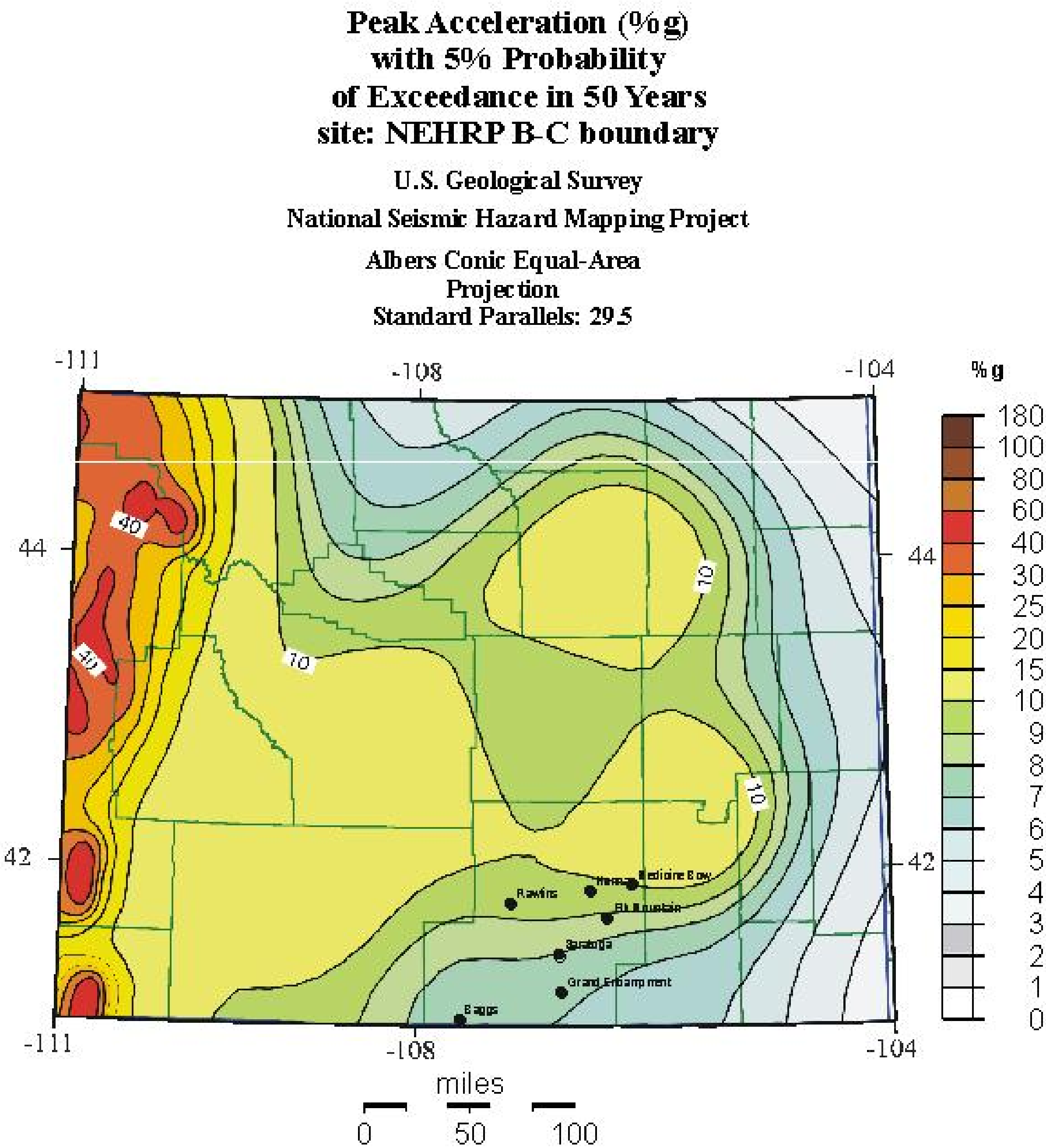


Figure 5.4 1000-year probabilistic acceleration map (5% probability of exceedance in 50 years).

Peak Acceleration (%g)
with 2% Probability
of Exceedance in 50 Years
site: NEHRP B-C boundary

U.S. Geological Survey
National Seismic Hazard Mapping Project

Albers Conic Equal-Area
Projection
Standard Parallels: 29.5

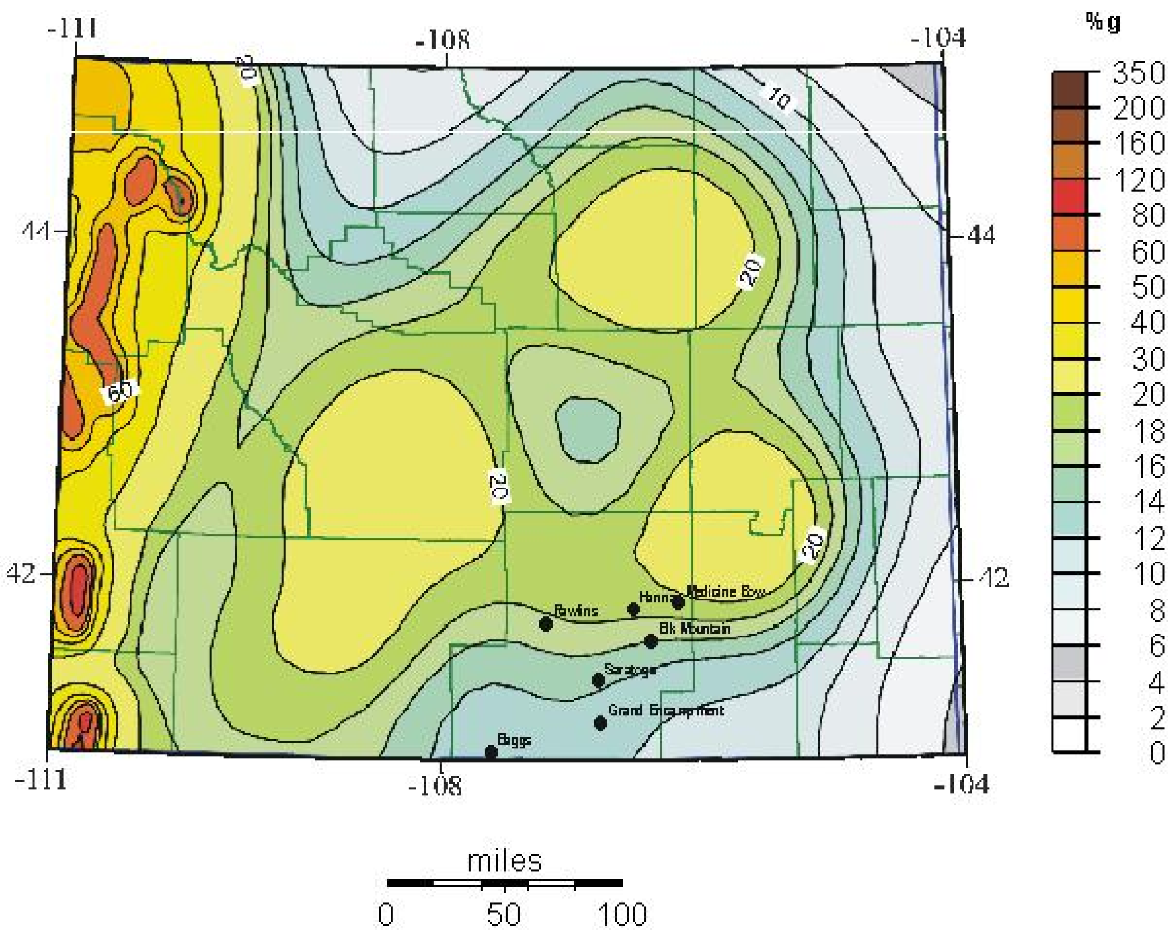


Figure 5.5 2500-year probabilistic acceleration map (2% probability of exceedance in 50 years).

Impacts

There have been over fifty historic earthquakes with a magnitude greater than 2.0 recorded in or near Carbon County. Because of the limited historic record, it is possible to underestimate the seismic hazard in Carbon 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 Carbon County.

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

Intensity VIII Earthquake Areas:

Seminoe Reservoir Dam

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 VII Earthquake Areas:

Elmo
Hanna
Lamont
Medicine Bow
Rawlins
Sinclair
Walcott

In intensity VII earthquakes, damage is negligible in buildings of good design and construction, slight-to-moderate in well-built ordinary structures, considerable in poorly built or badly designed structures such as unreinforced masonry buildings. Some chimneys will be broken.

Intensity VI Earthquake Areas:

Arlington
Baggs
Dixon
Elk Mountain
Encampment
McFadden
Pathfinder Reservoir Dam
Riverside
Saratoga
Savery

In intensity VI earthquakes, some heavy furniture can be moved. There may be some instances of fallen plaster and damaged chimneys.

Future Impacts

In 2011, the Wyoming State Geological Survey (WSGS) conducted an earthquake study involving 16 scenarios around the state using HAZUS. Twelve HAZUS scenarios were based on fault systems across Wyoming suspected of having potential to produce earthquakes. The remaining four studies were based on historic earthquake events, including the 1882 Estes Park earthquake. The authors of the study point out that the odds of an earthquake occurring in the exact same location are very low. However, areas that have experienced seismicity in the past are identified as a potential source of future earthquakes.

Of the 16 studies, five scenarios resulted in damages in Carbon County. Two of these scenarios, the Chicken Springs Fault and the South Granite Mountains Fault, were HAZUS deterministic scenarios (a full description of HAZUS is provided in the following section) and three of these scenarios, Casper 1897, Estes Park 1882, and Laramie Peak 1984, were based on historical earthquake events. The scenario magnitude for the Chicken Springs Fault was 6.5, the magnitude for the South Granite Mountains Fault was 6.8, and the magnitude for the three historical event scenarios was 6.0. The five scenarios are summarized in the following paragraphs.

The Chicken Springs fault system is located in Sweetwater County. The modeled earthquake scenario for this fault system caused damage in Carbon, Fremont, Natrona, and Sweetwater Counties. Scenario results show that very light damage would be expected within 55 miles of the earthquake, as far as Rawlins and Sweetwater Crossing. Table 5.2 summarizes the damage probability to structures in Carbon County as a result of this scenario. The study notes that the Memorial Hospital of Carbon County would experience moderate shaking, but very little damage, if any.

Table 5.2 Percent Damage Probability for Structures in Carbon County – Chicken Springs Fault Scenario

Name	City	PGA (%g)	Slight Damage	Moderate Damage	Extensive Damage
Rawlins FD Station 1	Rawlins	6.97	5.64%	2.07%	0.21%
Rawlins FD Station 2	Rawlins	6.73	5.29%	1.91%	0.19%
Carbon County Sheriff's Dept. HQ	Rawlins	6.96	5.62%	2.06%	0.20%
Rawlins PD	Rawlins	6.94	5.59%	2.05%	0.20%
Wyoming State HP Division H	Rawlins	4.95	2.92%	0.94%	0.08%
Rawlins High School	Rawlins	6.89	5.52%	2.02%	0.20%
Cooperative High School	Rawlins	6.87	5.49%	2.00%	0.20%
Rawlins Middle School	Rawlins	6.87	5.48%	2.00%	0.20%

The study estimates Carbon County would experience $3.320 million dollars in direct economic losses for buildings. The majority of transportation losses for Carbon County would be from damage to airport facilities and highway bridges. Economic loss to utilities was estimated at $882,000 dollars and comes from damages to potable water, wastewater, and natural gas pipelines, and wastewater and natural gas facilities.

The South Granite Mountain fault system is located in Fremont County. The earthquake scenario was modeled at magnitude 6.75. Scenario results show that light damage would be predicted out to 30 miles, including Alcova, Rawlins, and Jeffrey City. Moderate to heavy damage would be expected within 15 miles of the epicenter, which includes Lamont and Muddy Gap. Table 5.3 summarizes the damage probability to structures in Carbon County as a result of this scenario. In addition, the Encampment water plant facility and school could also be affected.

Table 5.3 Damage Probability for Structures in Carbon County – South Granite Fault Scenario					
Name	**City**	**PGA (%g)**	**Slight Damage**	**Moderate Damage**	**Extensive Damage**
Sinclair FD	Sinclair	9.36	7.17%	0.95%	0.05%
Rawlins FD Station 1	Rawlins	8.97	6.56%	0.84%	0.05%
Rawlins FD Station 2	Rawlins	8.90	6.44%	0.82%	0.04%
Carbon County FD	Rawlins	6.96	3.73%	0.40%	0.02%
Hanna FD	Hanna	6.62	3.28%	0.34%	0.02%
Saratoga FS	Saratoga	4.76	1.38%	0.12%	0.01%
Elk Mountain FD	Elk Mountain	4.57	1.23%	0.10%	0.00%
Memorial Hospital of Carbon County	Rawlins	8.73	11.36%	1.21%	0.02%
Sinclair PD HQ	Sinclair	9.34	7.14%	0.94%	0.05%
Carbon County SD HQ	Rawlins	8.92	6.48%	0.83%	0.05%
Rawlins PD	Rawlins	8.89	6.43%	0.82%	0.04%
Wyoming State HP Div. H	Rawlins	6.90	3.66%	0.39%	0.02%
Saratoga PD	Saratoga	4.75	1.37%	0.12%	0.01%
Hanna Marshal's Dept. HQ	Hanna	4.06	0.90%	0.07%	0.00%
Rawlins High School	Rawlins	9.27	7.02%	0.92%	0.05%
Rawlins Middle School	Rawlins	9.26	7.01%	0.92%	0.05%
Cooperative High School	Rawlins	9.06	6.69%	0.87%	0.05%
Highland Hills Elementary	Rawlins	6.02	2.63%	0.26%	0.01%
Sinclair Elementary	Sinclair	5.85	2.45%	0.24%	0.01%
Saratoga Elementary	Saratoga	4.77	1.39%	0.12%	0.01%
Hanna Elementary	Hanna	4.71	1.37%	0.12%	0.01%
Elk Mountain Elementary	Elk Mountain	4.58	1.23%	0.10%	0.00%
H.E.M. Junior High	Hanna	3.95	0.83%	0.06%	0.00%
H.E.M. Senior High	Hanna	3.95	0.83%	0.06%	0.00%

The study estimates Carbon County would experience $8.520 million dollars in direct economic losses for buildings and 985,000 dollars in damages to bridges and airport facilities. Economic loss to utilities was estimated at $5.886 million dollars and comes from damages to wastewater and natural gas pipelines and facilities.

The Casper Area 1897 random event scenario is based on the earthquake that occurred on November 14th, 1897, in Casper, Wyoming. It is the largest recorded earthquake in central and eastern Wyoming and was recorded as an intensity VI-VII event. The earthquake scenario was modeled at magnitude 6.0. Scenario results show that very light damage would be predicted as far away as 46 miles, far enough to reach the northern portion of Carbon County. However, the scenario does not predict any damages to buildings or infrastructure in Carbon County.

The Estes Park 1882 random event scenario is based on the earthquake that occurred on November 7, 1882, in Estes Park, Colorado. It was felt over most of Colorado, the southern half of Wyoming, and northeastern Utah. The earthquake scenario was modeled at magnitude 6.0. Scenario results show that very light damage would be expected up to 45 miles from the epicenter, which includes the very eastern portion of Carbon County. No specific buildings in Carbon County were found at risk for damage, although the scenario predicts 9,000 dollars of loss to buildings in Carbon County in general, but no losses to transportation or utilities infrastructure.

The Laramie Peak 1984 random event scenario is based on the earthquake that occurred on October 18th, 1984, near Esterbrook, Wyoming. It was felt in Wyoming, South Dakota, Nebraska, Colorado, Utah, Montana, and Kansas. It is the second-largest earthquake recorded in eastern Wyoming. The earthquake scenario was modeled at magnitude 6.0. Scenario results show that light to moderate damage would be expected to areas within 31 miles of the epicenter, which includes the northeast corner of Carbon County and Medicine Bow. Table 5.4 summarizes the damage probability to structures in Carbon County as a result of this scenario.

Table 5.4 Damage Probability for Structures in Carbon County – Laramie Peak Scenario

Name	City	PGA (%g)	Slight Damage	Moderate Damage	Extensive Damage
Medicine Bow FD	Medicine Bow	3.64	1.41%	0.39%	0.03%
Medicine Bow Elementary	Medicine Bow	3.64	0.71%	0.05%	0.00%

The scenario predicts Carbon County would have $33,000 dollars in direct economic losses to buildings, and no losses to transportation or utilities infrastructure.

Other HAZUS Studies

HAZUS is a nationally standardized, GIS-based, risk assessment and loss estimation computer program that was originally designed in 1997 to provide the user with an estimate of the type, extent, and cost of damages and losses that may occur during and following an earthquake. It was developed for the FEMA by the National Institute of Building Sciences (NIBS). There have been a number of versions of HAZUS generated by FEMA, with HAZUS-MH (HAZUS – Multi-Hazard) being the most recent release. HAZUS-MH incorporates a flood and wind module with the previously existing earthquake module. Hazus-99 (1999 version) was previously used by the Wyoming State Geological Survey (WSGS).

HAZUS was originally designed to generate damage assessments and associated ground motions based largely upon analysis at the census-tract level. Census tracts average 4,000 inhabitants, with the tract boundaries usually representing visible features. HAZUS-99 calculated a ground motion value for the centroid of a census tract, and applied that value to the entire tract. The calculations are based on United States Geological Survey National Seismic Hazard Maps. In many of the western states, census tracts are very large, and parts of the tracts may be subjected to ground shaking that is considerably different than the value at the centroid. FEMA Region VIII and their subcontractor on HAZUS, PBS&J from Atlanta, have worked closely with the Wyoming State Geological Survey (WSGS) to develop a census-block-based analysis for HAZUS-MH in Wyoming. In fact, Wyoming is the national pilot project for the census-block-based analysis. The block-level analysis is a significant improvement. Census blocks are a subdivision of census tracts. Many blocks correspond to individual city blocks bounded by streets, but blocks – especially in rural areas – may include many square miles and may have some boundaries that are not streets. Ground motion values for Wyoming are now calculated at the centroid of census blocks.

As part of the development of the 2014 State of Wyoming Multi-Hazard Mitigation Plan a HAZUS probabilistic scenario was run for every Wyoming County. The scenario used a 2,500 year return period, and uses the USGS ground shaking data represented in Figure 5.4. The probability of such an event is 2% in 50 years. Carbon County used a driving magnitude of 6.5 associated with the scenario. The results are presented in Tables 5.5-5.7

There are two methods to rank counties to determine where earthquake impacts may be the greatest. Either the loss ratios (Table 5.5) or total damage (Table 5.6) figures can be used. The loss ratio is determined by dividing the sum of the structural and non-structural damage by the total building value for the county. The loss ratio is a better measure of impact for a county as it gives an indication of the percent of damage to buildings. The total damage figure by itself does not reflect the percentage of building damage. Small damage to a number of valuable buildings may result in a higher total damage figure that may be found in a county with fewer, less expensive buildings, with a higher percentage of damage.

Table 5.5 Values at Risk—Earthquakes

County	Capital Stock Losses (Thousands of Dollars)				Loss Ratio (%)	Income Losses (Thousands of Dollars)				Total Loss (Thousands of Dollars)
	Structural	Non-structural	Contents	Inventory		Relocation	Capital-Related	Wages	Rental	Loss
Albany	9,714	36,865	13,946	151	2.32	276	2,717	3,198	4,210	71,078
Big Horn	3,470	12,203	4,647	65	2.43	84	533	694	963	22,660
Campbell	5,116	20,093	9,419	282	1.37	144	1,484	2,013	1,592	40,144
Carbon	7,140	26,320	10,480	170	3.08	190	2,120	2,700	1,810	50,920
Converse	6,054	24,172	9,787	185	4.15	152	984	1,303	1,845	44,482
Crook	836	2,640	896	17	1.04	21	107	139	211	4,867
Fremont	14,890	61,030	24,640	460	3.75	380	2,920	3,940	3,190	111,450
Goshen	2,168	6,982	2,543	69	1.13	57	392	528	623	13,364
Hot Springs	3,038	10,871	4,176	52	4.20	82	799	1,149	969	21,136
Johnson	3,293	13,062	5,514	94	3.40	86	557	648	1,066	24,320
Laramie	13,605	47,839	17,577	233	1.25	406	3,926	4,402	4,976	92,963
Lincoln	65,670	225,594	64,429	2,538	31.08	1,211	8,579	10,359	15,347	391,727
Natrona	36,764	137,379	57,269	1,149	3.99	981	9,890	13,033	12,245	268,911
Niobrara	423	1,585	617	12	1.20	12	72	83	132	2,935
Park	11,430	42,694	15,289	429	2.98	285	5,173	6,217	4,487	86,004
Platte	1,875	6,894	2,697	36	1.60	51	326	418	554	12,850
Sheridan	7,830	29,154	12,057	233	2.09	213	1,898	2,402	2,636	56,423
Sublette	9,654	30,667	9,436	222	8.24	206	2,438	3,052	2,665	58,340
Sweetwater	12,782	50,213	20,753	542	2.84	313	2,180	2,514	3,719	93,017
Teton	92,477	359,169	110,323	2,402	24.72	1,821	37,784	43,975	34,030	681,981
Uinta	39,912	135,111	38,841	1,007	15.84	782	5,888	8,741	11,004	241,284
Washakie	4,115	13,761	5,656	134	3.54	99	904	1,019	1,236	26,925
Weston	897	3,016	1,085	21	0.96	26	147	266	302	5,760

Table 5.6 County Impacts Rated by Loss Ratio

County	Loss Ratio	Total Loss (Thousands of Dollars)
Lincoln	31.08	391,727
Teton	24.72	681,981
Uinta	15.84	241,284
Sublette	8.24	58,340
Hot Springs	4.20	21,136
Converse	4.15	44,482
Natrona	3.99	268,911
Fremont	3.75	53,860
Washakie	3.54	26,925
Johnson	3.40	24,320
Carbon	3.08	37,762
Park	2.98	86,004
Sweetwater	2.84	93,017
Big Horn	2.43	22,660
Albany	2.32	71,078
Sheridan	2.09	56,423
Platte	1.60	12,850
Campbell	1.37	40,144
Laramie	1.25	92,963
Niobrara	1.20	2,935
Goshen	1.13	13,364
Crook	1.04	4,867
Weston	0.96	5,760

Table 5.7 County Impacts Rated by Dollar Loss

County	Total Loss (Thousands of Dollars)	Loss Ratio
Teton	681,981	24.72
Lincoln	391,727	31.08
Natrona	268,911	3.99
Uinta	241,284	15.84
Sweetwater	93,017	2.84
Laramie	92,963	1.25
Park	86,004	2.98
Albany	71,078	2.32
Sublette	58,340	8.24
Sheridan	56,423	2.09
Fremont	53,860	3.75
Converse	44,482	4.15
Campbell	40,144	1.37
Carbon	37,762	3.08
Washakie	26,925	3.54
Johnson	24,320	3.4
Big Horn	22,660	2.43
Hot Springs	21,136	4.2
Goshen	13,364	1.13
Platte	12,850	1.6
Weston	5,760	0.96
Crook	4,867	1.04
Niobrara	2,935	1.2

In summary, it is estimated that if a worse case event occurred in Carbon County, $37,762,000 in building related damage could occur. It is also estimated that over 3% of the buildings would be significantly damaged. The probability of such an event is 2% in 50 years. Though the probability is low, WSGS studies of a possible 6.75 maximum magnitude on the South Granite Mountain fault could generate moderate to heavy damage to Seminoe Reservoir Dam.

Summary

PROPERTY AFFECTED: Medium
POPULATION AFFECTED: Medium
PROBABILITY: Low - Medium
JURISDICTION AFFECTED: All jurisdictions in the county, with slightly higher risk in the northern county including jurisdictions of Hanna, Medicine Bow, and Rawlins.

Chapter VI. Floods

Floods can and have caused significant damage in Carbon County and are one of the more significant natural hazards in the county. They have caused millions of dollars in damage in just a few hours or days. A flood, as defined by the National Flood Insurance Program (NFIP), is a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties from: overflow of waters; unusual and rapid accumulation or runoff of surface waters from any source; or, a mudflow. Floods can be slow or fast rising, but generally develop over a period of many hours or days.

Floods can also occur with little or no warning and can reach full peak in only a few minutes. Such floods are called flash floods. A flash flood usually results from intense storms dropping large amounts of rain within a brief period. Floods can occur for reasons other than precipitation or rapidly melting snow. They can also occur because of ice jams.

Sources of flooding in Carbon County include the North Platte River which flows north through Saratoga; its tributaries (Encampment River) flow through Encampment and Riverside. The Medicine Bow River flows from the east through Medicine Bow and then drains into the North Platte River.

National Flood Insurance Program Participation and Related Information

According to the NFIP Community Status Book Carbon County entered the regular program in 1987. The county's Flood Map is dated 1/16/87 and according to the Community Status Book the area is minimally flood prone and no flood elevations are shown on the map. The table that follows details the NFIP status of the incorporated areas within the county. SFHA stands for Special Flood Hazard Area, or 100-year flood plain.

Table 6.1 NFIP Status

Community	Date of Entry into Program	Current Effective Map Date
County (unincorporated area)	1/16/87	1/16/87
Baggs	8/16/88	8/16/88
Dixon	9/30/87	9/30/87
Elk Mountain	11/04/87	11/04/87
Encampment	In process	In process
Hanna	Not in program, sanctioned 1976	8/22/75
Medicine Bow	12/01/12	12/01/12
Rawlins	12/11/85	No SFHA
Riverside	7/2/87	7/2/87(Minimally flood prone)
Saratoga	10/1/86	10/1/86(Minimally flood prone)
Sinclair	Not mapped	

As of October 31, 2014, there were 64 flood insurance policies in force across all jurisdictions in the county for a total coverage of $12,645,700. As of November 30, 2014 a total of 34 claims had been filed; 21 of these claims were paid for a total of $117,763.75.

The unincorporated part of Carbon County has 17 policies in force for $2,470,100 coverage. Six claims were filed with five claims paid out for $10,929.19 in losses.

The Town of Baggs has 10 policies in force for $2,038,700 coverage. Sixteen claims have been filed with eight claims paid out for $70,932.55 in losses.

The Town of Elk Mountain has seven policies in force for $842,000 coverage. Four claims have been filed with two claims paid out for $6,154.91 in losses.

The City of Rawlins has three policies in force for $1,050,000 coverage.

The Town of Saratoga has 27 policies in force for $6,244,900 coverage. Eight claims have been filed with six claims paid out for $29,747.10 in losses.

According to Jackie Erwin, State of Wyoming National Flood Insurance Program Coordinator, **there are no repetitive loss flood areas in Carbon County**. These are defined as an NFIP-insured structure that has had at least two paid flood losses of more than $1,000 each in any 10-year period since 1978.

The state is in the beginning stages of RiskMAP for Unincorporated Carbon County and all communities within Carbon County to include: Baggs, Dixon, Elk Mountain, Encampment, Hanna, Medicine Bow, Rawlins, Riverside, Saratoga and Sinclair. This study will include revised hydrology and hydraulics and possibly revised base flood elevations (BFE). Most likely there will be areas not currently mapped included in the new study. The flood risk products developed as part of a flood risk project are designed to help communities effectively plan to mitigate flood risk. The multiple discussions throughout the process allow FEMA and its partners to provide guidance to local officials to help them identify mitigation opportunities that work for their community. Discovery Meetings for RiskMAP will begin in early March 2015 and the project is estimated to take 5-7 years to complete.

The Town of Saratoga recently completed a river study entitled "North Platte River Conceptual Design." (September 5, 2014) This study was prepared by the firms Wildland Hydrology and Stantec Consulting. This report presents a conceptual restoration design for approximately 10,750 ft of the North Platte River through the Town of Saratoga and was completed to achieve the objectives of the town and project stakeholders, including design of a self-sustaining, natural, stable river and reducing the flood stage through Saratoga. The results of the assessment indicated that the North Platte River through Saratoga has a high sediment supply from streambank erosion and is unable to transport the sediment load generated from the watershed. The conceptual design proposes to increase the sediment transport capacity, competence, and flow hydraulics.

The flood risk potential for the Town of Saratoga and private land owners along the North Platte River through Saratoga is dependent on the discharge of water and the sediment that is being produced by this 2,840 mi^2 watershed area. The existing channel configuration (a result of previous channel manipulations and dredging that were intended to reduce flood risk through town) promotes aggradation and increases the flood stage through town. The proposed design will help decrease the flood risk through town compared to existing conditions by reducing the width/depth ratio and excess sediment deposition. The largest discharge of record on the river was 16,900 cubic feet per second (cfs) recorded on June 9th, 2011. This flow rate represents an approximate 25-yr flow event. The 100-yr discharge was predicted to be 24,000 cfs. The conceptual design shows a minimal reduction in flood stage of ~0.1 ft at the Highway 130 Bridge and 0.0–0.3 ft flood stage reduction for the 100-yr storm over the entire project reach. The higher frequency floods will also have a slight reduction in flood stage. The biggest flood-reduction advantage is a result of the increased sediment transport capacity. The project will not increase flood stage, but the projected reductions are minimal.

History

The abbreviated flood history in Table 6.2 was in large part derived from the monthly Storm Data reports generated and released by the National Oceanic and Atmospheric Administration's National Climate Center. Other sources are unpublished reports from the Wyoming Office of Homeland Security, newspaper accounts, and periodicals from public libraries. The table represents floods that have caused damage, injuries, or loss of life.

One of the largest floods documented in Carbon County occurred on May 12, 1984, when rain storms combined with snowmelt runoff on the Little Snake River breached a dam. Damage occurred to rural property in Baggs. This was estimated to be greater than the 100-year flood. Additional damaging floods occurred on May 14 and 16 of that year. Many of the documented floods have been associated with dam failures.

Snowfall during the spring of 2008 produced a snowpack that was several hundred percent of normal in the Sierra Madre Mountains of Carbon County. Several warm days in early June caused that snowpack to melt rapidly and produced near-flood conditions in Riverside and Baggs. In Baggs the existing levee through town on the Little Snake River was augmented with sandbags, and property damage was prevented. The North Platte ran high through Saratoga and Riverside but never reached flood stage. A small portion of a campground was inundated in Riverside (the area had no structures or infrastructure at risk) and several fields flooded in the Saratoga area.

In early June, 2010, due to the above average snowfall during the winter and rather wet spring season, reservoirs in the area were quickly filling to capacity. As a result some water had to be released to make room for the expected snow melt during the summer months. The combination of large releases from the reservoirs and excessive snow melt due to the warm temperatures caused the streams and rivers to rise to at or above flood stage. Excessive water from nearby snow melt caused the Medicine Bow River on the southwest side of the Town of Elk Mountain to flood. Houses near the river were sand bagged to prevent flood damage. Excessive snow melt caused the North Platte River through Saratoga to flood the public golf course and Veteran's Island.

Thunderstorms with heavy rain moved across the Snowy Range and Brush Creek area on State Highway 130 between 9 pm and midnight on July 18, 2011. Debris carried down Brush Creek by runoff from the heavy rainfall clogged the drainage culvert at milepost 55.8 on State Highway 130, about 13 miles east of the junction with State Highway 230. As a result, water washed away the pavement around the culvert and created a 25-foot wide, 9-foot deep trench. Four members of a Colorado Springs family died after their van drove into the washout and were swept downstream by the raging creek as they fled flash flooding at a nearby campground shortly after 1 am. The driver of the van managed to escape from the van, which was submerged to its rooftop. Minutes later, the Carbon County emergency manager who responded to the flash flooding, drove his vehicle into the same washout and plunged into the creek. Firefighters rescued both drivers about two hours later, and were transported to a hospital in Rawlins. Both men were treated for their injuries and later released. After floodwaters receded, State Highway 130 between mileposts 36 and 68 was closed for repairs.

Additional impacts from the spring 2011 flood include damage to U.S. Forest Service roads, State Highway 130, and State Highway 70. Highway 130 was washed out and Highway 70 was damaged by debris flow. Highway 70 was permanently rerouted as a result of the damage, which totaled over $1 million.

Table 6.2 Carbon County Flood History

County	Location	Start Date	Deaths	Injuries	Property Damage	Crop Damage	Total Damage	Information
Carbon		5-Apr-1937						Locally heavy rains, accompanied by high temperatures, which caused rapidly melting snow on the 15th, caused considerable flood damage. In the northern portion of Carbon County Sage Creek reached the highest known stage, washing out bridges and carrying away farm buildings.
Carbon	Southeast, Central Wyoming	1-Sep-1938						Some damage was reported from the heavy rains to highways and bridges in the southeast and central portion of the state.
Carbon	Rawlins	4-Jul-1950						Light damage occurred at Rawlins on the 4th when storm sewers were unable to carry off water from a heavy shower, causing flooding of some basements.
Carbon	Baggs	1-May-1952						Local flooding occurred in a few streams where rapidly melting snow in the mountains caused a few streams to leave their banks. The most important flooding occurred at Baggs where Savery Creek backed flood water into the business section of the town.
Carbon	North Platte River, Tributaries near Saratoga, tributaries near Little Snake River	12-May-1984	0	0	$0	$0	$0	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

Table 6.2 Carbon County Flood History

County	Location	Start Date	Deaths	Injuries	Property Damage	Crop Damage	Total Damage	Information
Carbon	Baggs, Savery, Dixon, Little Snake River	14-May-1984	0	0	$5,000,000	$0	$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 of 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.
Carbon	Dixon	16-May-1984	0	0	$0	$0	$0	A greater than 100-year flood caused by snowmelt runoff augmented by an upstream reservoir failure had a discharge of 13,000 CFS.
Albany and Carbon	35NW Laramie	10-Jun-1986	0	0	$225,000	$0	$225,000	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.
Carbon	Near Saratoga	11-Aug-1990	0	0	$2,250	$0	$2,250	Heavy thunderstorm rains of 1- to 3-inches caused flash flooding mainly in the Snowy Range 15 to 20 miles east of Saratoga. Two campgrounds in the Snowy Range had to be evacuated due to high water on creeks and streams.
Carbon	Rawlins	24-May-1996	0	0	$0	$0	$0	Heavy rainfall in a short time caused street flooding in Rawlins. Some roads were closed for a time and some accidents occurred.
Carbon	Baggs	19-May-2008						High temperatures created a rapid melt of mountain snowpack which, in turn, caused the Little Snake River to overflow its banks.

Table 6.2 Carbon County Flood History

County	Location	Start Date	Deaths	Injuries	Property Damage	Crop Damage	Total Damage	Information
Carbon	Elk Mountain	6-Jun-2010	0		$0	$0	$0	Excessive water from nearby snow melt caused the Medicine Bow river on the southwest side of town to flood. Houses near the river were sand bagged to prevent flood damage.
Carbon	Saratoga	7-Jun-2010	0	0	$0	$0	$0	Excessive snow melt caused the North Platte river to flood the public golf course and Veteran's Island.
Carbon	Ryan Park	19-Jul-2011	4	2	$0	$0	$0	Debris carried down by runoff from heavy rainfall clogged a drainage culvert on a small section of Highway 130, resulting in the water washing away the pavement around the culvert shortly after midnight on July 19. Four fatalities occurred when one vehicle drove into the washout, with its driver escaping injury. An emergency vehicle also drove into the washout, but the driver was able to escape.
Carbon	Shirley Basin	29-Jul-2014	0	0	$0	$0	$0	Slow moving thunderstorms produced very heavy rainfall with observed totals of two to four inches. Runoff on saturated grounds caused flash flooding across portions of the county. One to two inches of rain in two hours caused flash flooding of low lying areas in Shirley Basin.
Carbon	Oil Springs	29-Jul-2014	0	0	$0	$0	$0	Slow moving thunderstorms produced very heavy rainfall. Two to three inches of rain in three hours caused flash flooding about five miles east and northeast of Battle Mountain with a few dirt roads washed out.

Impacts

The flood history above shows that damaging floods have occurred occasionally in Carbon County. On average, a damaging flood occurs approximately every five years. Unfortunately, there has been a loss of four lives and two significant injuries caused by floods in the county in the past 30 years.

Other threats that could influence flood frequency and severity is forest health and wildfires. According to the Wyoming Forest Action Plan, 2009 Resource Assessment, the mountain pine beetle populations are increasing in Carbon County. Most of the as of yet unaffected large diameter lodgepole pine forests in these areas are expected to be attacked by mountain pine beetle within the next 2 – 5 years. "The bark beetle epidemic in progress will be a long term problem for fire managers. Fire danger will initially increase due to the standing dead trees. The initial risk will decrease after a few years, but then increase again as the trees begin to fall in large numbers, probably in about 10 years. "

The dead trees left after epidemics are a source of fuel accumulation that will, in time, burn unless removed (http://www.firewisewyoming.com/index.html). FEMA states there can be even greater risk of flooding due to wildfires that burn across a region. Large-scale wildfires dramatically alter the terrain and ground conditions. Normally, vegetation absorbs rainfall, reducing runoff. However, wildfires leave the ground charred, barren, and unable to absorb water, creating conditions ripe for flash flooding and mudflow. Flood risk remains significantly higher until vegetation is restored—up to five years after a wildfire. Flooding after fire is often more severe, as debris and ash left from the fire can form mudflows. As rainwater moves across charred and denuded ground, it can also pick up soil and sediment and carry it in a stream of floodwaters. These mudflows can cause significant damage (http://m.fema.gov/after-wildfire).

Flood of Record for Future Impacts

The May 14, 1984 flood is the most damaging event recorded and considered to be the flood of record for Carbon County. This was estimated to be a 500-year event. As a result of adjusting the dollar losses to a 2014 equivalent, the damage sum is $11.3 million, which can be used as an estimate of the expected damages for future significant flood events in Carbon County.

Flood Vulnerability Analysis

Planning level flood loss estimates were made available for every county in Wyoming with the 2010 update to the Wyoming Hazard Mitigation Plan. FEMA used HAZUS-MH MR2 to model the 100-year floodplain and perform associated building and population risk assessments. HAZUS-MH is FEMA's GIS-based natural hazard loss estimation software. The HAZUS-MH flood model results include analysis for Carbon County, modeling streams draining a 10 square mile minimum drainage area, using 30 meter (1 arc second) Digital Elevation Models (DEM). Hydrology and hydraulic processes utilize the DEMs, along with flows from USGS regional regression equations and stream gauge data, to determine reach discharges and to model the floodplain. Losses are then calculated using HAZUS-MH national baseline inventories (buildings and population) at the census block level.

HAZUS-MH produces a flood polygon and flood-depth grid that represents the 100-year floodplain. The 100-year floodplain represents a flood that has a 1% chance of being equaled or exceeded in any single year. While not as accurate as official flood maps, these floodplain boundaries are available for use in GIS and could be valuable to communities that have not been mapped by the National Flood Insurance Program. HAZUS-MH generated damage estimates are directly related to depth of flooding and are based on FEMA's depth-damage functions. For example, a two-foot flood generally results in about 20% damage to the structure (which translates to 20% of the structure's replacement value). The HAZUS-MH flood analysis results provide number of buildings impacted, estimates of the building repair costs, and the associated loss of building contents and business inventory. Building damage can cause additional losses to a community as a whole by restricting the building's ability to function properly. Income loss data accounts for losses such as business interruption and rental income losses as well as the resources associated with damage repair and job and housing losses.

Potential losses derived from HAZUS-MH used default national databases and may contain inaccuracies; loss estimates should be used for planning level applications only. The damaged building counts generated are susceptible to rounding errors and are likely the weakest output of the model due to the use of census blocks for analysis. In rural Wyoming, census blocks are large and often sparsely populated or developed; this may create inaccurate loss estimates. HAZUS-MH assumes population and building inventory to be evenly distributed over a census block; flooding may occur in a small section of the census block where there are not actually any buildings or people, but the model assumes that there is damage to that block. In addition, excessive flood depths may occur due to problems with a DEM or with modeling lake flooding. Errors in the extent and depth of the floodplain may also be present from the use of 30 meter digital elevation models. HAZUS Level II analyses based on local building inventory, higher resolution terrain models, and Digital Flood Insurance Rate Maps (DFIRMs) could be used in the future to refine and improve the accuracy of the results.

Maps and Results

A series of maps and analysis results were compiled for Carbon County (Figure 6.1 through 6.3). Tables 6.3 and 6.4 contain the results of the HAZUS loss estimation. Building and contents value loss estimates, income-related loss estimates, and displaced population and shelter needs estimates are included in Table 6.3 Flood Loss by Municipality. These loss estimates have been grouped by municipality to demonstrate how the risk varies across the county. Per Capita Loss was calculated using total building loss and Census 2009 estimates to the municipal and county –level population. Percent Building Loss and Percent Contents Loss were calculated using building and contents loss estimates, and HAZUS building and contents exposure data. Table 6.4: HAZUS Loss Estimation Additional Analysis shows these estimates, also grouped by municipality.

The following three maps are provided at the county scale.: the *Flood Hazards* map shows the HAZUS floodplain boundary, the *Flood Depth* map shows HAZUS flood depth data, and the *Building Loss* map shows total building loss, in dollars, by census block. A flood hazard, flood depth, and building loss map were also produced for each jurisdiction except Sinclair because flood hazards have not been mapped there. The jurisdictional maps are available in an attachment to this plan.

According to the HAZUS model output, Carbon County would suffer a total of $41,672,000 in total direct economic loss to buildings and 1,151 people would be displaced in the event of a countywide 100-year flood. There would be a total of 131 damaged buildings, 30 of which would be substantially damaged (>50% damaged). The North Platte River flows north through Saratoga; its tributaries flow through Encampment and Riverside. The Medicine Bow River flows from the east through Medicine Bow and then drains into the North Platte River. The

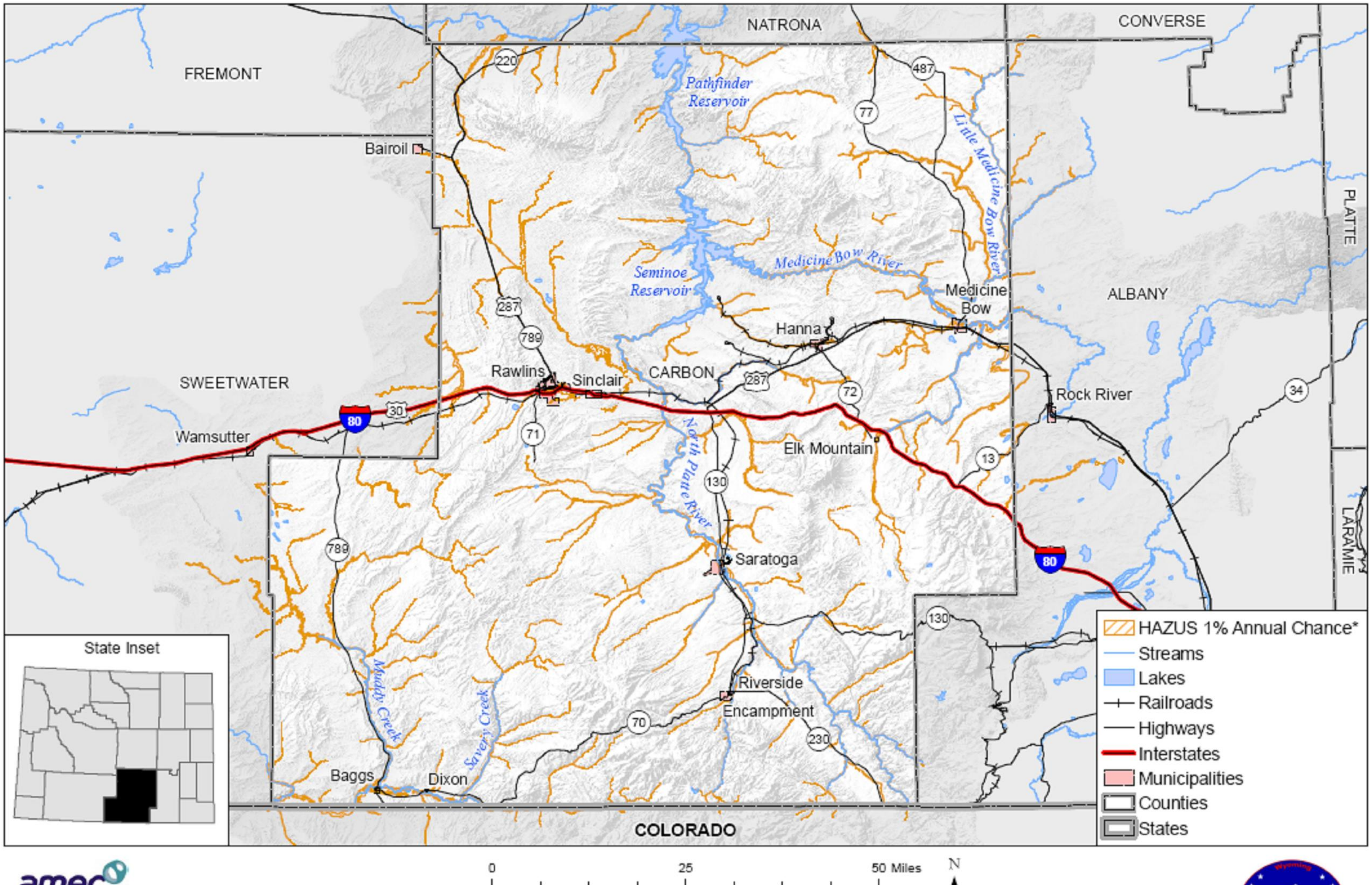
Town of Saratoga would suffer the most damage in the county, with a total direct economic loss for buildings of $24,630,000 and 404 displaced people. The Town of Baggs has the greatest percent building loss (6.6%) and the Town of Saratoga has both the greatest percent contents loss (13.9%) and per capita loss ($13,860) of the jurisdictions in the county. The total county, incorporated and unincorporated, would suffer 1.6% building loss, 3.2% contents loss, and $2,651 per capita loss.

Table 6.3 Flood Loss by Municipality

Municipality	Building Loss (K)	Contents Loss (K)	Inventory Loss (K)	Relocation Loss (K)	Capital Related Loss (K)	Wages Loss (K)	Rental Income Loss (K)	Total Loss (K)	# of Displaced People	# of People Needing Short Term Shelter
Baggs	$1,274	$1,145	$24	$5	$3	$5	$1	$2,457	$78	$15
Dixon	$78	$72	-	-	$1	-	-	$151	$5	-
Elk Mountain	$457	$313	$5	$1	$1	$2	-	$779	$71	$12
Encampment	$2	$6	-	-	-	-	-	$8	-	-
Hanna	$195	$230	$2	-	$2	$4	-	$433	$15	-
Medicine Bow	$792	$516	$6	$4	-	$27	-	$1,345	$80	$41
Rawlins	$3,570	$2,444	$10	$5	$1	$13	-	$6,043	$308	$89
Riverside	$77	$45	-	-	-	-	-	$122	$3	-
Saratoga	$8,413	$15,207	$500	$36	$130	$320	$24	$24,630	$404	$52
Sinclair	-	-	-	-	-	-	-	-	-	-
Unincorporated	$2,944	$2,644	$94	$1	$3	$17	$1	$5,704	$187	$14
TOTAL	**$17,802**	**$22,622**	**$641**	**$52**	**$141**	**$388**	**$26**	**$41,672**	**$1,151**	**$223**

Table 6.4 HAZUS Loss Estimation Additional Analysis

Municipality	2009 Population*	Total Exposure (K)	Building Loss (K)	Building Exposure (K)	% Building Loss	Contents Loss (K)	Contents Exposure (K)	% Contents Loss	Total Loss (K)	Per Capita Loss
Baggs	423	$31,454	$1,274	$19,230	6.6%	$1,145	$12,224	9.4%	$2,457	$5,809
Dixon	82	$10,684	$78	$6,853	1.1%	$72	$3,831	1.9%	$151	$1,841
Elk Mountain	201	$22,956	$457	$14,547	3.1%	$313	$8,409	3.7%	$779	$3,876
Encampment	460	$82,186	$2	$49,644	0.0%	$6	$32,542	0.0%	$8	$17
Hanna	870	$92,086	$195	$59,809	0.3%	$230	$32,277	0.7%	$433	$498
Medicine Bow	269	$25,434	$792	$15,460	5.1%	$516	$9,974	5.2%	$1,345	$5,000
Rawlins	8,791	$868,261	$3,570	$529,259	0.7%	$2,444	$339,002	0.7%	$6,043	$687
Riverside	64	$9,763	$77	$6,171	1.2%	$45	$3,592	1.3%	$122	$1,906
Saratoga	1,777	$274,766	$8,413	$165,202	5.1%	$15,207	$109,564	13.9%	$24,630	$13,860
Sinclair	406	$38,059	-	$24,241	0.0%	-	$13,818	0.0%	-	-
Unincorporated	2,377	$401,046	$2,944	$252,028	1.2%	$2,644	$149,018	1.8%	$5,704	$2,400
TOTAL	**15,720**	**$1,856,695**	**$17,802**	**$1,142,444**	**1.6%**	**$22,622**	**$714,251**	**3.2%**	**$41,672**	**$2,651**



amec

Map compiled 6/2010; intended for planning purposes only
Data Sources: HAZUS-MH MR2, USGS, WYGISC
* Approximate Flood Hazard modeled by FEMA with HAZUS Level 1 utilizing 30 meter DEM

Figure 6.1 Carbon County HAZUS Flood Hazards

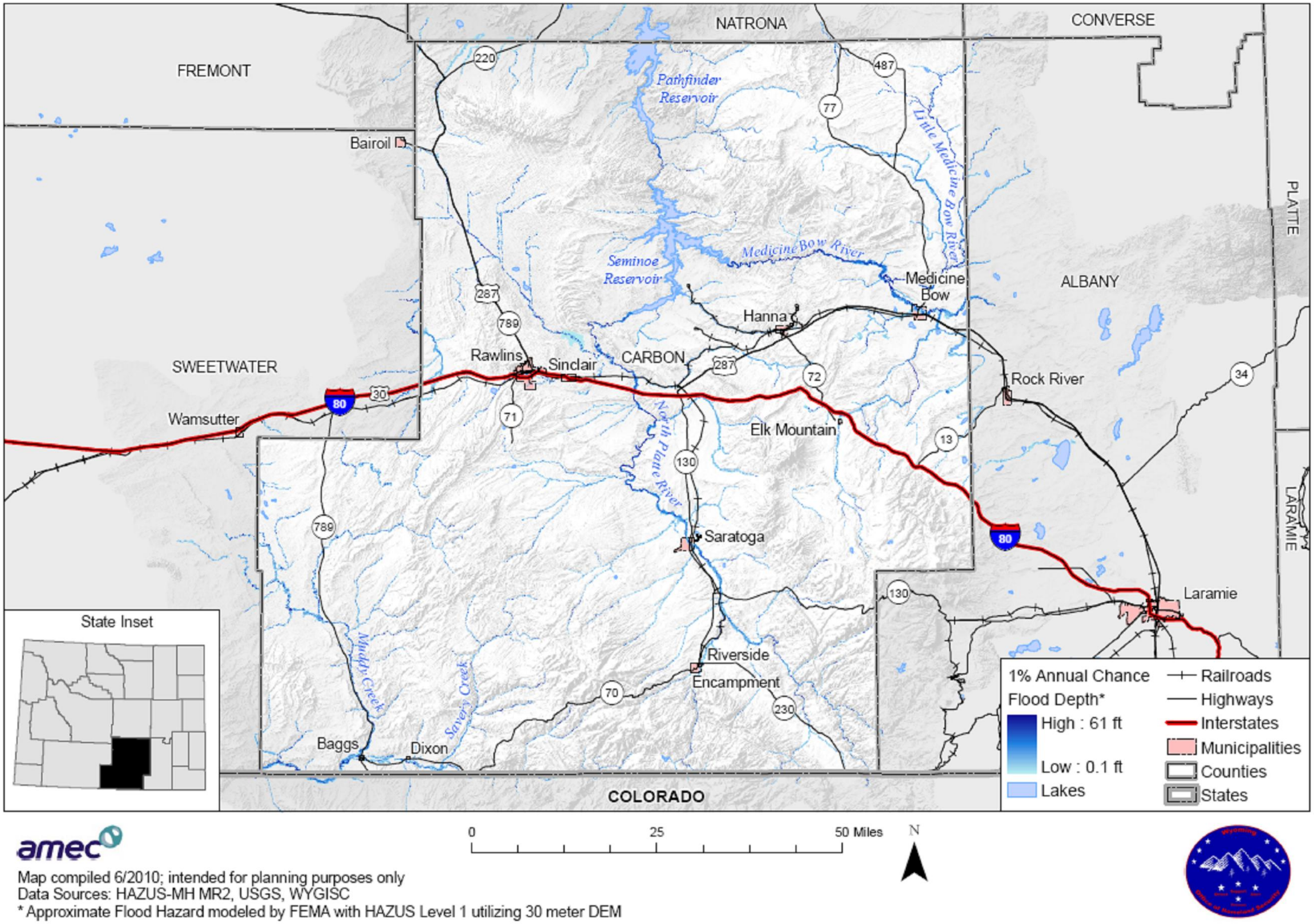
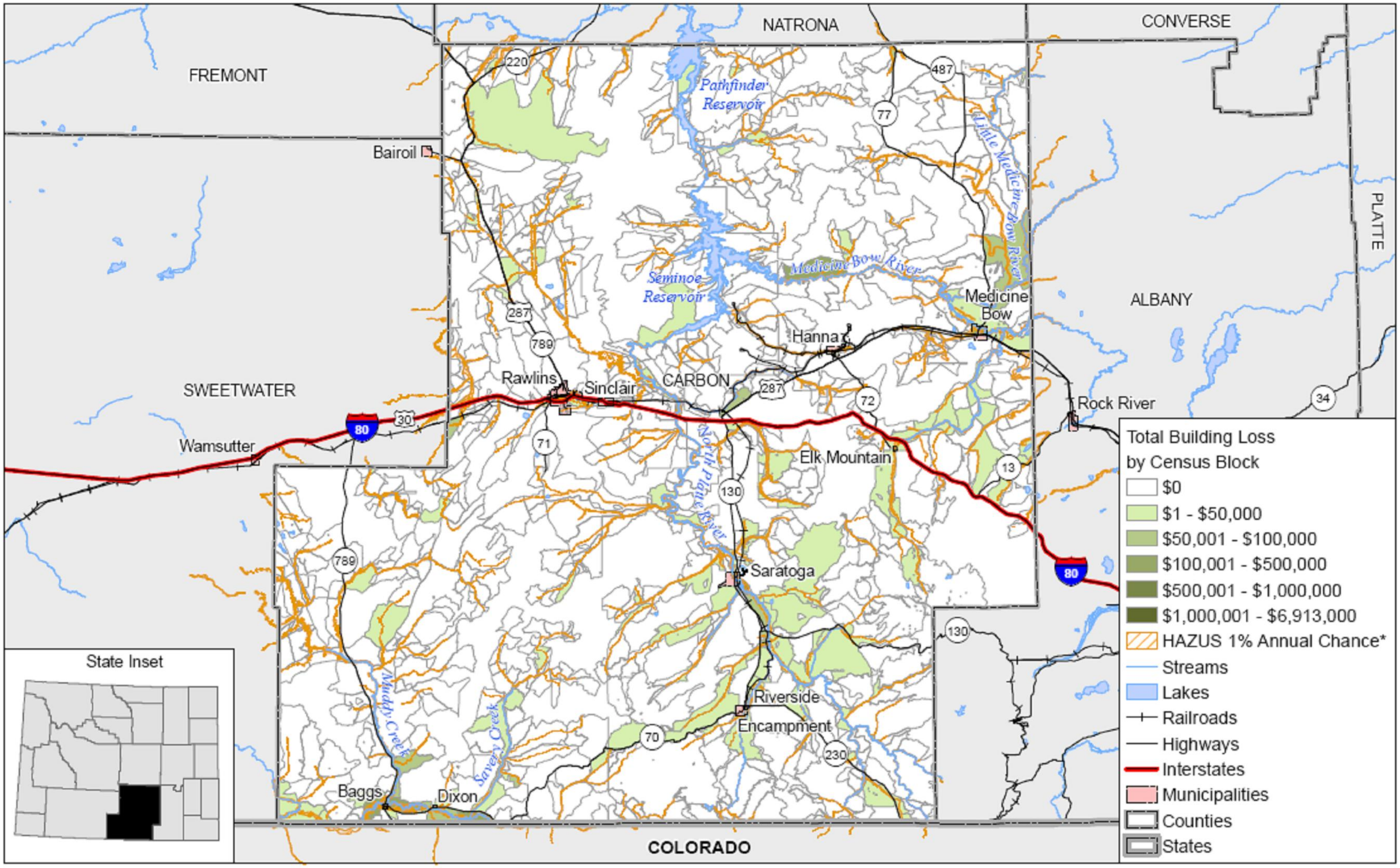


Figure 6.2 Carbon County HAZUS Flood Depth



0 25 50 Miles

N

Map compiled 6/2010; intended for planning purposes only
Data Sources: HAZUS-MH MR2, USGS, WYGISC
* Approximate Flood Hazard modeled by FEMA with HAZUS Level 1 utilizing 30 meter DEM

Figure 6.3 Carbon County HAZUS Building Loss

Future Impacts

Floods are likely to occur in Carbon County in both the unincorporated County and in the six jurisdictions with mapped floodplains. The result of the flood analysis summarizes the values at risk in the floodplain. When a flood occurs seldom does the event cause total destruction of an area. Potential losses from flooding are related to a variety of factors including flood depth, flood velocity, building type and construction.

Future Development

The communities of Baggs, Dixon, Elk Mountain, Medicine Bow, Rawlins, Riverside, Saratoga, and unincorporated Carbon County, participate in the National Flood Insurance Program and have ordinances regulating development in and around floodplain areas.

Some areas in the county may have flood potential that is not mapped, and therefore, development can occur in hazard areas. Growth in the number of residential structures across the county is not a serious concern at present, as the area has lost population since the last plan was prepared; however, the statewide trend is increasing population and the State Hazard Mitigation Plan predicts a population increase in Carbon County. The wind energy industry in Carbon County is also expected to expand over the next few years, potentially adding hundreds of new wind turbines. Therefore, floods may threaten future developments and structures that are built over the next several years or until National Flood Insurance Program mapping is updated through the RiskMAP process which begins in 2015.

Summary

PROPERTY AFFECTED: High
POPULATION AFFECTED: Medium
PROBABILITY: Medium
JURISDICTION AFFECTED: Baggs, Dixon, Elk Mountain, Encampment, Hanna, Medicine Bow, Riverside, Saratoga, portions of unincorporated County

Chapter VII. Hail

Hail causes more than a billion dollars of property damage nationally each year, mostly to crops. The southeast corner of Wyoming lies within the nation's "Hail Alley". Together with adjacent portions of Colorado and Nebraska, this region of Wyoming is battered by more hailstorms than any other part of the United States. Climatological data shows this area of Wyoming averaging five to nine days annually when hail is reported. While Carbon County is not in "Hail Alley", damaging hail storms have still occurred.

History

NOAA defines "damaging hail" as that which has hailstones of one inch or more in diameter. There have been 16 damaging hail storms in Carbon in the last 78 years, which equates to a damaging or severe hail storm roughly every five years. Table 7.1 presents a complete history of damaging hail storms. The data were derived from the monthly Storm Data reports generated and released by the National Oceanic and Atmospheric Administration's National Climate Center. Other sources are unpublished reports from the Wyoming Office of Homeland Security, newspaper accounts, and periodicals from public libraries. The table represents hail storms that have caused damage, injuries, or loss of life, or meet the NOAA criteria for damaging hail.

Table 7.1 Damaging Hail Storms: 1937-2013

Location	Start Date	Magnitude (inches)	Deaths	Injured	Estimated Damage-Property	Estimated Damage-Crops	Information
Leo	7/6/1937						Crops suffered on account of flood and hail. Severe hail occurred over much of the state, particularly in Sweetwater, Carbon, and Washakie Counties, but due to the absence of crops, it resulted in only slight damage.
Leo	7/8/1937						Crops suffered on account of flood and hail. Severe hail occurred over much of the state, particularly in Sweetwater, Carbon, and Washakie Counties, but due to the

Table 7.1 Damaging Hail Storms: 1937-2013							
Location	**Start Date**	**Magnitude (inches)**	**Deaths**	**Injured**	**Estimated Damage-Property**	**Estimated Damage-Crops**	**Information**
							absence of crops, it resulted in only slight damage.
Rawlins	9-May-1972	1.25	0	0	$275,000	$0	Hail up to 2 inches diameter caused damage to roofs, cars, windows, trees, shrubs and a greenhouse.
Shirley Basin	8-Sep-1973		0	0	$275,000	$0	Hail up to 1.5 inches did much damage to this mostly mobile home community along with damage to other structures and cars.
	7/26/1981	1	0	0	0	0	
Rawlins	5/25/1995	1	0	0	0	0	
Rawlins	4/20/2001	1.5	0	0	0	0	
Medicine Bow	7/22/2002	1.5	0	0	0	0	
Hanna	8/27/2002	1.75	0	0	0	0	
Medicine Bow	8/27/2002	1.25	0	0	0	0	
Rawlins	7/2/2008	1.25	0	0	0	0	
Elk Mountain	6/6/2010	1.5	0	0	0	0	
Rawlins	6/6/2010	1.25	0	0	0	0	
Hanna	7/4/2010	1	0	0	0	0	
Elk Mountain	7/4/2010	1	0	0	0	0	
Shirley Basin	7/24/2013	1	0	0	0	0	

Source: 2014 Wyoming Multi-Hazard Mitigation Plan, Appendix K, pg. K-196; NCDC Storm Events Database

Impacts

Hail storms have occurred in every county in Wyoming, although hail damage has only occurred in 21 counties. Sublette and Uinta counties have no recorded hail damage. The total documented hail damage for Carbon County is $550,000 in year of damage dollars and $3,016,272 in 2014 dollars.

Table 7.2 County Rankings by Hail Damage – SHELDUS (1960-2012)						
County	Total Events	Total Injuries	Total Fatalities	Total Property Damage	Total Crop Damage	Total Damage
Albany	4	0	0	$70,000	$0	$70,000
Big Horn	8	1	0	$101,000	$360,000	$461,500
Campbell	25	2	0	$64,188,606	$5,550	$64,194,156
Carbon	3	0	0	$101,000	$500	$100,500
Converse	12	1	0	$117,550	$25,150	$142,700
Crook	27	4	0	$2,893,056	$10,500	$2,903,556
Fremont	11	0	0	$44,000	$122,500	$166,500
Goshen	26	0	0	$3,004,600	$1,351,550	$4,356,150
Hot Springs	3	1	0	$507,500	$2,500	$510,000
Johnson	12	0	0	$541,050	$275,050	$816,100
Laramie	87	3	0	$54,010,000	$728,350	$54,738,350
Lincoln	4	0	0	$110,000	$250,000	$360,000
Natrona	11	1	0	$1,123,700	$100	$1,123,800
Niobrara	11	0	0	$189,550	$5,050	$194,600
Park	15	0	0	$2,215,000	$115,000	$2,330,000
Platte	18	0	0	$284,300	$40,500	$324,800
Sheridan	8	0	0	$655,500	$600	$656,100
Sublette						
Sweetwater	1	0	0	$700,000	$0	$700,000
Teton	5	2	0	$35,000	$5,000	$40,000
Uinta						
Washakie	7	0	0	$1,180,000	$175,000	$1,355,000
Weston	11	0	0	$1,101,606	$0	$1,101,606
TOTAL	309	15	0	$133,172,017	$3,473,400	$136,645,417

Source: 2014 Wyoming Multi-Hazard Mitigation Plan, pg. 126

Future Impacts

Based on past events, damaging or severe hail events occur in Carbon County about once every five years. Based on the past worst-case documented storm damage converted to 2014 dollars it is suggested that $1.4 million, at a minimum, be used as the potential cost of the worst-case future hail storm in Carbon County. Future hail storms will impact private and public property such as cars, roofs, equipment, buildings, and agricultural crops and livestock.

Future Development

Any future development in Carbon County will be at risk to damage from hail. Development in the eastern part of the county would be at higher risk due to the closer proximity to Hail Alley.

Summary

PROPERTY AFFECTED: Medium
POPULATION AFFECTED: Medium
PROBABILITY: Low
JURISDICTION AFFECTED: All jurisdictions in the county

Chapter VIII. Hazardous Materials and Waste

A general definition of hazardous material is: A substance or combination of substances which because of its quantity, concentration, or physical, chemical or infectious characteristics, may either (1) cause, or significantly contribute to, an increase in mortality or an increase in serious, irreversible, or incapacitating reversible, illness; or (2) pose a substantial present or potential hazard to human health or environment when improperly treated, stored, transported, disposed of or otherwise managed.

The U.S. Department of Transportation (U.S. DOT), U.S. Environmental Protection Agency (EPA), and the Occupational Health and Safety Administration all have responsibilities in regards to hazardous materials and waste. Presented below are the various definitions and general responsibilities of each of the agencies.

The U.S. DOT, which has control over transported hazardous materials, uses the following definition: Hazardous material means a substance or material that the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and has designated as hazardous under section 5103 of Federal hazardous materials transportation law (49 U.S.C. 5103). The term includes hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, materials designated as hazardous in the Hazardous Materials Table (see 49 CFR 172.101), and materials that meet the defining criteria for hazard classes and divisions in part 173 of subchapter C of this chapter. The U.S. DOT has nine classes of hazardous material:

- Explosives
- Compressed Gasses: Flammable Gasses; Non-Flammable Compressed Gasses; Poisonous Gasses
- Flammable Liquids: Flammable (Flash Point Below 141 degrees);Combustible (Flash Point 141 degrees – 200 degrees)
- Flammable Solids; Spontaneously Combustible; Dangerous When Wet
- Oxidizers and Organic Peroxides: Oxidizer; Organic Peroxide
- Toxic Materials: Material that is Poisonous; Infectious Agents
- Radioactive Material
- Corrosive Material: Destruction of Human Skin; Corrode Steel at a Rate of 0.25 Inches Per Year
- Miscellaneous

The UEPA also has responsibility for hazardous materials, chemicals, and wastes that have the potential to be released into the environment through stationary facilities. The EPA addresses through the Resource Conservation and Recovery Act (RCRA), the need for facilities with hazardous waste substances to store containers in some kind of containment system. Stationary containers, such as tanks, as well as portable storage containers, such as 55-gallon drums, are required to have a system that will protect the environment from this waste if a leak were to occur. Hazardous waste regulations appear in Title 40 of the Code of Federal Regulations (CFR.) Portable container containment is addressed under Subpart I, Use and Management of Containers (EPA 40 CFR 264.175). Facilities dealing with the storage of hazardous materials may also be required to have containment if they are to meet the Uniform Fire Code (UFC) standards. Within the UFC standards, Section 80, Division III refers to Hazardous Materials Storage Requirements pertaining to containers and tanks and Division IV refers to Spill Containment with regard to hazardous materials.

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires certain regulated entities to report information about hazardous chemicals and substances at their facilities to Federal, state, and local authorities. The objective is to improve the facilities, or government agency's ability to plan for and respond to chemical emergencies, and to give citizens information about chemicals present in their communities. The President has issued Executive Orders to Federal agencies that mandate their compliance with certain EPCRA requirements. Part of EPA's mission is to ensure that Federal facilities comply with these requirements. Sections 301 and 303 of EPCRA mandate the creation of two organizations; The State Emergency Response Commission (SERC) and the Local Emergency Planning Committee (LEPC). Sections 311-312 of EPCRA require facilities to submit material safety data sheets or Tier II forms (lists of hazardous chemicals on-site (above threshold quantities)) to SERC's, LEPC's, and local fire departments.

In addition to EPCRA, there is a Risk Management Program (RMP). When Congress passed the Clean Air Act Amendments of 1990, it required EPA to publish regulations and guidance for chemical accident prevention at facilities using extremely hazardous substances. The RMP Rule was written to implement Section 112(r) of these amendments. The rule, which built upon existing industry codes and standards, requires companies of all sizes that use certain flammable and toxic substances to develop a Risk Management Program, which includes a(n):

- Hazard assessment that details the potential effects of an accidental release, an accident history of the last five years, and an evaluation of worst-case and alternative accidental releases;
- Prevention program that includes safety precautions and maintenance, monitoring, and employee training measures; and
- Emergency response program that spells out emergency health care, employee training measures and procedures for informing the public and response agencies (e.g. the fire department) should an accident occur.

By June 21, 1999, a summary of the facility's risk management program (known as a "Risk Management Plan" or "RMP") was to be submitted to EPA, which will make the information publicly available. The plans must be revised and resubmitted every five years. A listing of the facilities present in Carbon County is presented in Table 8.1 below. The chemicals that are extremely hazardous in Carbon County as a result of the RMP facilities are presented in Table 8.2 below. There are some potentially significant problems that could develop in Carbon County if select chemicals in Table 8.2 are released. No additional information is available for this report because of Homeland Security concerns.

The Risk Management Program is about reducing chemical risk at the local level. This information helps local fire, police, and emergency response personnel (who must prepare for and respond to chemical accidents), and is useful to citizens in understanding the chemical hazards in communities. EPA anticipates that making the RMPs available to the public stimulates communication between industry and the public to improve accident prevention and emergency response practices at the local level.

The Occupational Safety and Health Administration (OSHA), established under the Department of Labor by the OSHA Act of 1970, regulates the storage and use of toxic and hazardous substances as they relate to worker health and safety. OSHA regulations are found in Title 29 of the Code of Federal Regulations (CFR), Part 1910, Subpart H.

Table 8.1 Risk Management Plan (RMP) Facilities in Carbon County

County	Site
Carbon	Bairoil OC CO_2 Plant
Carbon	Big Medicine Bow Unit
Carbon	Colorado Interstate Gas Co. - Rawlins Station
Carbon	Wamsutter LLC Echo Springs Plant
Carbon	Sinclair Wyoming Refinery
Carbon	Wamsutter Stabilization Facility (Carbon County)

Source: The Right-to-Know Network, RTKNET.org, data last released on 12/31/2014, accessed on 2/9/2015

Table 8.2 Hazardous Chemicals in Carbon County

County	Chemical
Carbon	70U00 dimetallic GE betz
Carbon	Absorbent (activated carbon & aluminosilicate)
Carbon	Alcoa F-200
Carbon	Alkylate (gasoline component)
Carbon	Aluminum sulfate
Carbon	Asphalt
Carbon	Bauxite (SRU catalyst)
Carbon	Benzene
Carbon	Betz 20K & 26K (corrosion inhibitor)
Carbon	Betz 8Q106 (rust/corrosion inhibitor)
Carbon	Betz 8Q202 (antioxidant)
Carbon	Carbon dioxide
Carbon	Catalyst, platforming
Carbon	Cement and associated additives
Carbon	Chevron OGA 476 DS (gasoline additive)
Carbon	Citgo PM 840 oil
Carbon	Condensate (hydrocarbon liquid)
Carbon	Control IS3000
Carbon	Control OS 7785
Carbon	Diesel fuel
Carbon	Diesel fuel (in two tanks)
Carbon	Diesel fuel(s)
Carbon	Diethanolamine
Carbon	DN-190 Grace Hydrocracker catalyst
Carbon	DN-3120 Grace Hydrocracker catalyst
Carbon	Drilling mud and associated additives
Carbon	EC1010A Filmer Nalco
Carbon	EC1014A Filmer Nalco
Carbon	EC3044A
Carbon	EC3051A
Carbon	E-Cat (Grace & AKZO)
Carbon	Emulsion breaker (Nalco/Exxon EC2425A & EC2059A)
Carbon	Expedite
Carbon	FCC/poly gasoline
Carbon	Ferric sulfate
Carbon	Flourprotien concentrate (foam) AFFF & XL3
Carbon	Fresh FCC catalyst (Grace & AKZO)
Carbon	Gasolines
Carbon	GE betz 8Q31
Carbon	Gilsonite 350

Table 8.2 Hazardous Chemicals in Carbon County

County	Chemical
Carbon	Glycol ether DM (jet fuel additive)
Carbon	Heavy oils (FCC bottoms, vacuum tower bottoms, resid)
Carbon	Hexane M,O,P
Carbon	Hydrate lime
Carbon	Hydrogen sulfide
Carbon	Hydrogen sulfide/ammonia
Carbon	Hydrotreating catalyst
Carbon	Iron/chromium catalyst (high temp. catalyst on hydrogen plant)
Carbon	Jet fuel /JP-8
Carbon	Light cycle oil
Carbon	Light straight run gasoline
Carbon	Lube oils
Carbon	Methanol 50/50
Carbon	Methyldiethanolamine
Carbon	Nalco EC1005A (neutralizer)
Carbon	Nalco EC100A & EC1030A (corrosion inhibitor)
Carbon	Naphtha
Carbon	Natural gas
Carbon	Nickel catalyst (hydrogen plant)
Carbon	Nitrogen
Carbon	Phosphoric acid
Carbon	Polymerization SPA-2 (cat poly catalyst)
Carbon	Produced hydrocarbons
Carbon	Red dye b midcontinental chemical
Carbon	Refinery fuel gas
Carbon	Reformate
Carbon	Slop r (water-amine-condensate)
Carbon	Soda ash dense (sodium carbonate, anhydrous)
Carbon	Sodium aluminate 45%
Carbon	Sodium hydroxide (caustic soda)
Carbon	Sodium hypochlorite
Carbon	Steam condensate
Carbon	Steam return - line treatment
Carbon	Steamate NA2440 GE betz
Carbon	Sulfur
Carbon	Sulfuric acid
Carbon	Sunoco hydroline H225T
Carbon	Sunoco hydroline H90T
Carbon	Texaco system 3 TFA-4908 (gasoline additive)
Carbon	Toluene
Carbon	Triethylene glycol
Carbon	Unichem 8162 (asphalt additive)
Carbon	Unleaded gasoline
Carbon	Uop platinum catalyst (reformer)
Carbon	Used oil
Carbon	Wastewater and oil
Carbon	Xylene
Carbon	Y-grade product
Carbon	Zinc oxide catalyst (hydrogen plant)

Source: The Right-to-Know Network, RTKNET.org, data last released on 12/31/2014, accessed on 2/9/2015

History

The National Response Center recorded 310 hazardous materials incidents in Carbon County between 1990 and 2014, which averages out to approximately 13 events per year. Sinclair was the nearest town for 156 of these events, which is unsurprising given the presence of the Sinclair Oil Refinery, the Semi-Truck and Trailer Repair, the railroad, and I-80. The majority of the events in or near Sinclair were fixed--as opposed to transportation or mobile, including several incidents at the refinery. The events at the refinery frequently involved equipment failure or malfunction. There was also a handful of storage tank, mobile, pipeline, and railroad incidents in or near Sinclair. Overall, fixed incidents accounted for 182 of the 310 hazmat events in Carbon County.

Impacts

As mentioned above, about 13 hazardous material spills occur every year in the county. There are not readily available data on response and cleanup costs. It is estimated that the costs are many tens of thousands of dollars per year. Life safety is a concern related to transportation incidents that can occur on the I-80, state highway, and the Union Pacific Railroad corridors in the county.

Future Impacts

Hazardous material spills will continue in Wyoming and the rest of the nation. There are some facilities, however, that contain extremely hazardous substances. Those are the facilities that are required to generate Risk Management Plans. An accident resulting in the release of chemicals from those facilities could pose a significant problem to local jurisdictions and the State of Wyoming. Presently I-80 is designated as a corridor for radioactive shipments for many years to come.

Future Development

The potential for growth in Carbon County's energy industry could bring new residents (permanent or temporary) to the county. With more people working in the energy industry, more people are at risk to hazardous materials incidents.

Summary

PROPERTY AFFECTED: Low
POPULATION AFFECTED: Medium
PROBABILITY: High
JURISDICTION AFFECTED: Baggs, Dixon, Encampment, Elk Mountain, Hanna, Medicine Bow, Rawlins, Saratoga, Sinclair, County

Chapter IX. Landslides

Landslides are one of the most common geologic hazards in Wyoming, with some of the highest landslide densities in the country found in the state. The figure below shows mapped landslides in Wyoming.

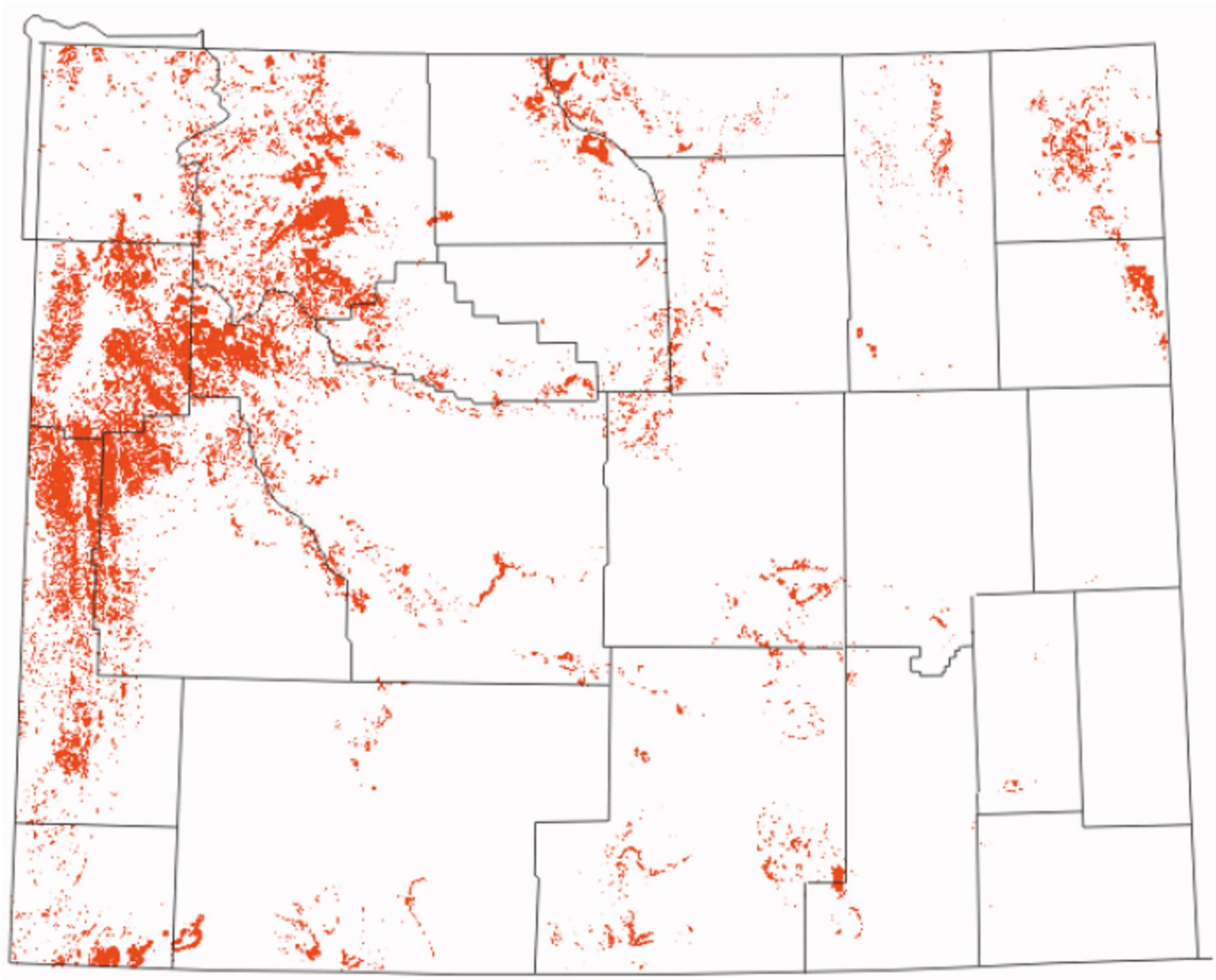


Figure 9.1. Mapped Landslides in Wyoming

There are many types of landslides present in Wyoming. In order to properly describe landslide type, the Geologic Hazards Section developed a landslide classification modified from Varnes (1978) and Campbell (1985). As can be seen in Figure 9.2 there are five basic types of landslides that occur in three types of material. Falls, topples, slides, lateral spreads, and flows can occur in bedrock, debris, or earth. While individual landslide types can occur in nature, most landslides are complex, or composed of combinations of basic types of landslides.

Falls and topples are easy to visualize. In a fall, material detached form a steep slope or cliff descends through the air, and may bounce and roll. In a topple, a mass rotates forward on a pivot point. If a toppling mass pivots far enough, a fall may result.

Slides are characterized by shear displacement along one or several surfaces. Two general types of slides are recognized: rotational and translational. In a rotational slide, the surface of rupture is concave upward, and the mass rotates along the concave shear surface. Rotational slides are usually called slumps, and they can occur in bedrock, debris, or earth. In a translational slide, the surface of rupture is a planar or gently undulatory surface. In bedrock and earth, translational slides are usually called block slides if an intact mass slides down the slope. If rock fragments or debris slide down a slope on a distinct shear plane, the movements are called rock slides or debris slides. It is easy to see that confusion can result by applying the term “slide” to all types of landslides.

Lateral spreads are characterized by lateral extension movements in a fractured mass. Lateral spread movements may occur in bedrock and soil as a result of liquefaction or plastic flow of subjacent materials, or in bedrock without a well-defined basal shear surface or zone of plastic flow. Lateral spreads in bedrock without a well-defined zone of shearing or flow, usually occur on ridge crests.

In general, a flow is a moving mass that has differential internal movements that are distributed throughout the mass. While most flows occur in debris and earth, one type of flow, gravitational sagging, does occur in bedrock. Flows in debris and earth can be cohesive or non-cohesive. Both cohesive and non-cohesive flows are further subdivided by water content and material properties.

Cohesive flows in debris include soil creep, solifluction, block streams, talus flows, and rock glaciers. Soil creep is an imperceptibly slow deformation that continues under constant stress. Solifluction is a slow flow in soil that is often observed in areas with perennially or permanently frozen ground. Block streams are slow moving tongues or rocky debris on steep slopes, and are often fed by talus cones. Talus flows are slow flows that occur in the basal portions of talus slopes. Rock glaciers are not true landslides, but have been included in the classification scheme because they are mass movements composed of coarse debris. Interstitial ice between debris fragments plays a role in the movement of rock glaciers, which are similar in form to a true glacier.

Cohesive flows in earth include soil creep, solifluction, earth flows, and debris laden earth flows. Soil creep and solifluction in earth are similar to those in debris. Earth flows are very slow compared to rapid flows that have a distinct source area, a main flow track, and a lobate depositional area. Debris laden earth flows are flows that appear to be earth flows but are composed of debris. Standard classifications do not recognize debris laden earth flows, but many have been observed in Wyoming. Many of the landslides present in Wyoming have an earth flow component.

Non-cohesive flows in debris include rock fragment flows and debris flows. Rock fragment flows are extremely rapid flows composed of dry to moist rock debris. This type of flow can be initiated by a rock fall, by seismic activity, or by other processes. In some cases, it appears that rock debris has moved on a cushion of air, although other mechanisms may have dominated the process. Rock fragment flows can cause significant destruction in a short period of time. Debris flows are a slurry flow composed of debris and a significant amount of water. They are usually associated with unusually heavy precipitation or with rapid snowmelt. Debris flows commonly follow preexisting drainage ways, and commonly form debris levees along their main flow track.

Debris flows are a significant component of alluvial fans in mountainous areas with the main debris flow deposit having a broad, fairly flat, fan shape. Debris flows are very common in the mountainous areas of Wyoming.

Non-cohesive flows in earth include loess flows, dry sand flows, wet sand flows, rapid earth flows, and mud flows. Loess flows and dry sand flows are rapid to very rapid flows of dry material. Loess flows are usually initiated by seismic activity, and are a fluid suspension of silt in air. Fortunately, none have yet been identified in Wyoming. Dry sand flows usually occur along shorelines or in Aeolian deposits. In Wyoming, most dry sand flows are very small. Wet sand flows occur along river banks or shorelines composed of saturated clean sand. The destabilized sand usually flows into an adjacent body of water. Wet sand flows are not common in Wyoming. Rapid earth flows, also called quick clay flows, are very rapid flows that involve the liquefaction of subjacent material and the entire slide mass. They usually initiate in sensitive materials, such as quick clay, and are not common in Wyoming. Mud flows are slurry flows composed of earth and a significant amount of water. They differ from debris flows only in the size of their component materials.

Most landslides mapped in Wyoming are classified as being complex. For example, many landslides in the state are slump/earth flow complexes. That type of landslide is composed of a slump at its head, with the main body and deposit being an earth flow. Block slides often grade into rock slides, which can further grade into earth flows or debris laden earth flows. Such a movement would be classified as a block slide/rock slide/flow complex.

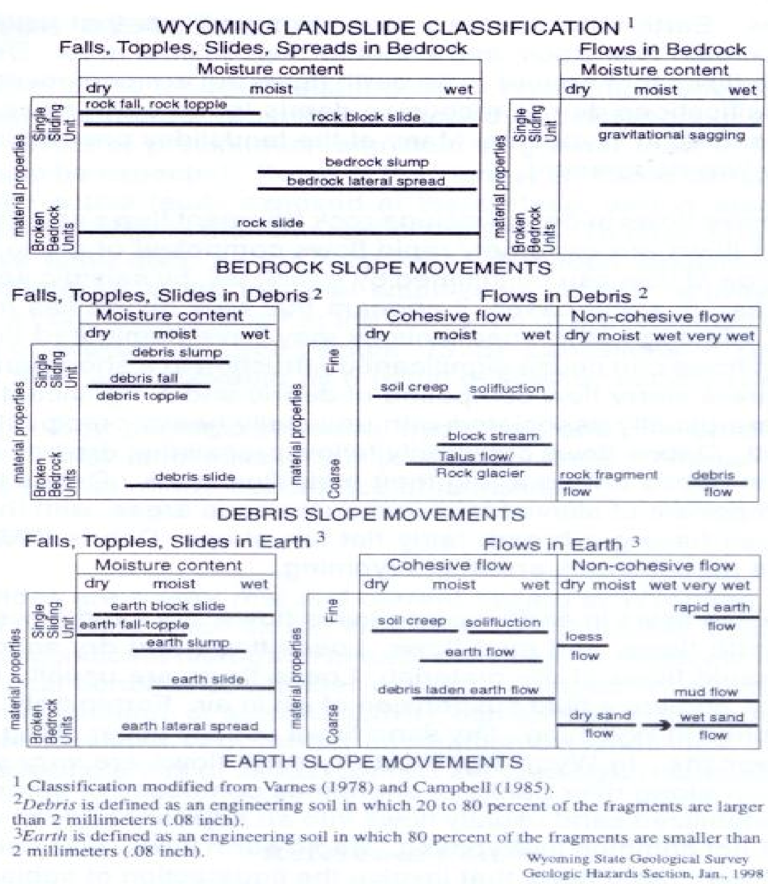


Figure 9.2 Wyoming Landslide Classification

Landslide History and Distribution

Numerous landslides are present in Carbon County. Specifically, landslides are present on the following quadrangles:

Arlington
Baggs
Bates Creek Reservoir
Bear Mountain
Bengough Hill
Bradley Peak
Bridger Pass
Bridger Peak
Browns Hill
Cameron Creek
Carbon
Chalk Hills
Coal Mine Ridge
Coad Mountain
Difficulty
Divide Peak
Dixon
Doty Mountain
Elk Mountain
Elk Mountain SW
Ferris
Fillmore Ranch
Flat Top Mountain
Fourmile Point
Garden Gulch
Grieve Reservoir
Horse Peak
Jack Creek Reservoir
Kennaday Peak
Ketchum Buttes
Kindt Reservoir
La Marsh Creek East
La Marsh Creek West
McCarty Ranch
McFadden
Measel Spring Reservoir
Medicine Bow Peak
Middlewood Hill
Morgan
Moss Agate Reservoir
Mud Springs
Muddy Gap
Overland Crossing
Peach Orchard Flat
Phantom Lake
Pine Grove Ranch
Pine Hill
Pole Gulch
Poison Basin
Rattlesnake Pass
Red Mountain
Rendle Hill
Sand Lake
Savery
Seminoe Dam
Separation Peak
Singer Peak
Smiley Draw
Smith Draw East
Smith Draw West
Squaw Spring
Strouss Hill
Sulphur Springs
T B Ranch
The Q Ranch
T L Ranch
Tullis
Turpin Reservoir
Walker Draw NW
White Rock Canyon
Wild Irish Reservoir
Windy Hill
Young's Pass

The Wyoming State Geological Survey and Carbon County Emergency Management examined all quadrangles, and the following areas were determined to pose a potential hazard to homes, roads, or other facilities.

Arlington Quadrangle: A slump/rockslide/flow complex is present in the northern part of the quadrangle in T19N R78W Sections 17, 18, and 19. If this landslide destabilizes, damage could occur to the nearby road. Slump/flow and blockslide/flow complexes in T19N R78W Section 19 and T19N R79W Section 24 could also damage nearby pipelines if they destabilize. In addition, a blockslide/rockslide complex is located in T18N R78W Section 9. If this landslide activates, it could damage a transmission line that passes through it. Finally, roads in T18N R78W Section 22 could be damaged if the slump/flow complexes in the same section destabilize. Heavy periods of precipitation or significant development could have an effect on slope stability.

Baggs Quadrangle: A shallow blockslide is present in the northern portion of the quadrangle in T13N R91W Sections 5 and 6. If this landslide destabilizes, damage could occur to the road that passes through the blockslide. Slump and slump/flow complexes are present in T12N R91W Section 4. If these landslides activate, they could potentially divert the Little Snake River. Heavy periods of precipitation or significant development could have an effect on slope stability.

Bates Creek Reservoir Quadrangle: Several Quaternary alluvium/debris flow complexes are present in T28N R78W Sections 4 and 5. If these landslides destabilize, damage could occur to the Old Casper-Medicine Bow Road. Heavy periods of precipitation or significant development could have an effect on slope stability.

Bear Mountain Quadrangle: Flows and blockslide/slump/flow complexes are present in T28N R81W Sections 10 and 15. If these landslides destabilize, damage could occur to the road that passes through or near the complexes. Heavy periods of precipitation or significant development could have an effect on slope stability.

Bradley Peak Quadrangle: A large blockslide/slump/flow complex is present in T25N R85W Sections 6, 7, 17, and 18 and in T25N R86W Sections 1, 12, and 13. If this landslide destabilizes, damage could occur to a nearby transmission line. Heavy periods of precipitation or significant development could have an effect on slope stability.

Bridger Pass Quadrangle: Several landslides, including slump/flow, rock fall/rockslide, and rock fall/rockslide/flow complexes are present in T19N R89W Sections 27. If these landslides destabilize, damage could occur to a road that passes through the complexes and/or nearby oil wells. Heavy periods of precipitation or significant development could have an effect on slope stability.

Bridger Peak Quadrangle: Rockslide/flow complexes are present in T14N R86W Sections 26 and 32. If these landslides destabilize, damage could occur to the road that passes through or near the complexes. If the complex in Section 32 destabilizes, it could also dam Lost Creek, causing further damage to the road. Baby Lake Creek could be dammed if the rock fall/rockslide complexes in the southeastern corner of the quadrangle (T13N R86W Section 1; T13N R85W Section 6) destabilize. Heavy periods of precipitation or significant development could have an effect on slope stability.

Browns Hill Quadrangle: Large blockslide/slump/flow complexes are present in the southwestern corner of the quadrangle (T14N R89W Section 31; T14N R90W Sections 24, 25, 35, and 36). If these landslides activate, damage could occur to a secondary road that passes through the complexes. Heavy periods of precipitation or significant development could have an effect on slope stability.

Carbon Quadrangle: Flow, slump/flow, and rockslide/flow complexes are present in T21N R80W Sections 16 and 21. If these landslides destabilize, damage could occur to a nearby road that lies to the east of the complexes. Heavy periods of precipitation or significant development could have an effect on slope stability.

Coad Mountain Quadrangle: A blockslide and a blockslide/slump/flow complex are present in T19N R81W Section 31 and T19N R82W Sections 25 and 36. If these landslides destabilize, damage could occur to the road that passes through the complexes. In addition, structures at Johnson Ranch could be damaged if the blockslide in T18N R81W Section 5 activates. Heavy periods of precipitation or significant development could have an effect on slope stability.

Chalk Hills Quadrangle: Paleocene landslides are present in the northwestern portion of the quadrangle in T28N R77W Sections 29, 30, and 32. If these landslides destabilize, damage could occur to the old Casper Medicine Bow Road. Heavy periods of precipitation or significant development could have an effect on slope stability.

Coal Mine Ridge Quadrangle: A series of slump/flow and rock fall/rockslide complexes are present in T20N R88W Sections 22 and 27. If these landslides destabilize, damage could occur to the nearby road. Heavy periods of precipitation or significant development could have an effect on slope stability.

Dixon Quadrangle: A blockslide and a slump/flow complex are present in the eastern portion of the quadrangle in T13N R90W Sections 22 and 27. If these landslides activate, they could dam Cottonwood Creek. Heavy periods of precipitation or significant development could have an effect on slope stability.

Elk Mountain Quadrangle: A slump is present on the west side of the Town of Elk Mountain in T20N R80W Sections 20 and 29. If this landslide destabilizes, damage could occur to structures in Elk Mountain, either directly or by flooding if the landslide dams or diverts the Medicine Bow River. In addition, a blockslide/flow complex is present in T20N R81W Section 26. This landslide could damage the telephone line that crosses it if it activates. Finally, if the slump in T19N R80W Section 8 destabilizes, damage could occur to the road to the McKee Ranch. Heavy periods of precipitation or significant development could have an effect on slope stability.

Elk Mountain SW Quadrangle: A blockslide/flow complex is present in T19N R81W Section 26. If this landslide destabilizes, damage could occur to a nearby road. In the northeastern portion of the quadrangle, a shallow slump is present in T19N R80W Sections 17 and 20. If this landslide destabilizes, damage could occur to the roads that pass through the slump. One of these same roads could also be damaged if any of the blockslide, flow, or blockslide/slump/flow complexes in T19N R80W Section 32 and 33 and in T18N R80W Sections 4, 5, 9 and 16 destabilize. These landslides could also potentially damage nearby irrigation ditches and dam tributaries of the Medicine Bow River. The Medicine Bow River or its tributaries could also be dammed if the blockslide, blockslide/flow, or slump/flow complexes in T18N R80W Sections 8, 16, 17, and 18 activate. In addition, if the blockslide, flow, slump/flow, flow/debris flow, and blockslide/slump/flow complexes in T18N R80W Sections 6, 7, and 18 and in T18N R81W Sections 1, 2, and 3 destabilize, they could dam Little Pass Creek. Heavy periods of precipitation or significant development could have an effect on slope stability.

Ferris Quadrangle: A road passes through a blockslide in T26N R86W Sections 16 and 17. If the landslide activates, damage could occur to this road. Heavy periods of precipitation or significant development could have an effect on slope stability.

Fillmore Ranch Quadrangle: A rockslide and flows are present in the eastern part of the quadrangle in T18N R90W Section 11. If these landslides destabilize, they could dam

Separation Creek. Heavy periods of precipitation or significant development could have an effect on slope stability.

Grieve Reservoir Quadrangle: Several landslides, including blockslides, slump/flow, and debris flow/alluvial fan complexes, are present in the northern portion of the quadrangle (T13N R88W Sections 5, 6, and 7; T13N R89W Sections 1 and 2). If these landslides destabilize, they could dam Little Sandstone Creek. In addition, a large rockslide/flow/Quaternary alluvium complex is present in T12N R88W Sections 8, 9, 10, and 16. If this landslide activates, damage could occur to State Highway 70 and/or a secondary road. Finally, a blockslide in the southern portion of the quadrangle in T12N R88W Section 16 could dam or divert the Little Snake River if it destabilizes. Heavy periods of precipitation or significant development could have an effect on slope stability.

Kennaday Peak Quadrangle: Numerous landslides are present in the central and western portions of the quadrangle (T17N R81W Sections 4-7, 18-20, 28-30, 32, and 33; T17N R82W Sections 1, 12, and 13; T18N R81W Sections 31-33). If any of these flow/debris flow/Quaternary alluvium, Quaternary alluvium/debris flow, debris flow/flow/Quaternary alluvium, blockslide/slump/flow, slump/flow, blockslide/slump/flow/debris flow, blockslide, flow/debris flow, or slump/blockslide/flow complexes destabilize, damage could occur to the road that passes through or near the landslides. Heavy periods of precipitation or significant development could have an effect on slope stability.

Ketchum Buttes Quadrangle: Blockslides are present in the eastern portion of the quadrangle in T16N R89W Sections 23 and 26. If these landslides activate, damage could occur to the nearby road. Heavy periods of precipitation or significant development could have an effect on slope stability.

La Marsh Creek West Quadrangle: Slump/flow complexes are present in T18N R88W Section 16. If these landslides destabilize, damage could occur to Miller Hill Road. Heavy periods of precipitation or significant development could have an effect on slope stability.

McCarty Ranch Quadrangle: Slump/flow complexes are present in the southern part of the quadrangle in T15N R88W Section 19. If these landslides activate, damage could occur to Browns Hill Road. In addition, Little Savery Creek could be dammed if the slump, flow, blockslide, slump/flow, or blockslide/flow complexes in T15N R88W Sections 18 and 19 and in T15N R89W Sections 11, 13, 14, and 24 destabilize. Blockslide, blockslide/flow, and slump/flow complexes in T15N R88W Sections 16 and 17 could dam or divert Savery Creek if they activate. Heavy periods of precipitation or significant development could have an effect on slope stability.

McFadden Quadrangle: A blockslide is present in the far northwestern portion of the quadrangle in T20N R79W Section 11. If this landslide activates, it could divert the Medicine Bow River. Heavy periods of precipitation or significant development could have an effect on slope stability.

Medicine Bow Peak Quadrangle: A rock glacier/talus flow complex and two rock fall/colluvium complexes are present in T16N R79W Section 19 and T16N R80W Section 24. If these landslides destabilize, they could present a hazard to boaters, fishermen, hikers, or other people using the Lake Marie and Lookout Lake area. Heavy periods of precipitation or significant development could have an effect on slope stability.

Middlewood Hill Quadrangle: A slump and a slump/flow complex are present in T17N R87W Section 19. If these landslides destabilize, damage could occur to the road that runs along the west side of Adams Reservoir. Adams Reservoir and an aqueduct could sustain damage if the shallow slump/flow or the blockslide/flow complexes in T17N R87W Sections 17, 19, and 20 destabilize. An aqueduct in T17N R87W Section 7 could also be damaged if the slump/flow complexes in the same section destabilize. Finally, Sage Creek and Trapper Creek could be dammed if the landslides that are located along these creeks activate. Heavy periods of precipitation or significant development could have an effect on slope stability.

Morgan Quadrangle: A large slump/flow/creep complex is present in the eastern portion of the quadrangle in T17N R78W Sections 10, 11, 14, 15, 22, and 23. If this landslide activates, damage could occur to structures at Sevenmile Lake. Heavy periods of precipitation or significant development could have an effect on slope stability.

Mud Springs Quadrangle: Blockslides and a slump/flow complex are present in the southern portion of the quadrangle in T28N R79W Section 21. If these landslides destabilize, damage could occur to State Highway 487. Heavy periods of precipitation or significant development could have an effect on slope stability.

Muddy Gap Quadrangle: A debris flow/alluvial fan complex is present in T27N R89W Section 1. If this landslide activates, damage could occur to a pipeline that crosses the complex. In addition, several debris flow/alluvial fan complexes are also present along Whiskey Creek in T27N R88W Sections 7 and 18 and in T27N R89W Section 12. If these landslides activate, the creek could be dammed. Heavy periods of precipitation or significant development could have an effect on slope stability.

Overland Crossing Quadrangle: A rock fall/rockslide is located along the North Platte River in T19N R85W Sections 33 and 34. If this landslide destabilizes, it could possibly divert the North Platte River, and possibly flood the Old Johnson Place. Heavy periods of precipitation or significant development could have an effect on slope stability.

Peach Orchard Flat Quadrangle: Blockslides in T13N R91W Section 6 could dam Cottonwood Creek if they destabilize. Heavy periods of precipitation or significant development could have an effect on slope stability.

Phantom Lake Quadrangle: A flow is present in T16N R81W Sections 11 and 14. If this landslide destabilizes, Lincoln Creek could be dammed. Heavy periods of precipitation or significant development could have an effect on slope stability.

Pine Grove Ranch Quadrangle: Slumps are present in the northwestern corner of the quadrangle in T17N R89W Section 1 and T18N R89W Section 36. If these landslides activate, they could dam McKinney Creek. Also, a slump/blockslide complex is present in T17N R88W Sections 33 and 34 and in T16N R88W Section 4. If this landslide destabilizes, damage could occur to the nearby road. Heavy periods of precipitation or significant development could have an effect on slope stability.

Pole Gulch Quadrangle: Several landslides, including slump, slump/flow, blockslide/flow, slump/blockslide/flow, slump/rockslide, and slump/blockslide complexes are present along McKinney Creek in the northern portion of the quadrangle. If any of these landslides destabilize, they could dam the creek. Littlefield Creek could also be dammed if the slump, slump/flow, or blockslide/slump landslides along the creek destabilize. Finally, a slump and a blockslide/flow complex are present in T17N R89W Section 33. If it activates, damage could occur to a nearby road. Heavy periods of precipitation or significant development could have an effect on slope stability.

Rattlesnake Pass Quadrangle: A telephone line runs through the center of this quadrangle. It could be damaged if the flows and debris flow/Quaternary alluvium complex in T20N R82W Section 24 and T20N R81W Sections 20, 21, 28, and 29 destabilize. Heavy periods of precipitation or significant development could have an effect on slope stability.

Red Mountain Quadrangle: Several landslides, including rockslide/flow, surface wash/rockslide, rockslide/Quaternary terrace, and rockslide/debris flow complexes are present in T14N R85W Sections 7, 14, 15, 16, 17, and 18. If any of these landslides destabilize, they could dam Cow Creek. The rockslide/Quaternary terrace complex in Section 17 could also damage Cow Creek Reservoir. In addition, the North Encampment River could also be dammed if the rock fall/talus flow and rock fall/rockslide/talus flow complexes (T14N R85W Sections 33, 34, and 35) destabilize. Heavy periods of precipitation or significant development could have an effect on slope stability.

Sand Lake Quadrangle: A large slump/Quaternary complex is present in T17N R80W Sections 2 and 11. If this landslide destabilizes, damage could occur to the nearby road, either directly or by flooding if the landslide dams a tributary to the Medicine Bow River. The Medicine Bow River itself could be dammed if the flow in T17N R80W Section 23 destabilizes. Heavy periods of precipitation or significant development could have an effect on slope stability.

Savery Quadrangle: A large blockslide/slump/flow complex is present in the northwestern corner of the quadrangle in T13N R90W Sections 11 and 12. If this landslide activates, it could damage the road that crosses through the complex. Heavy periods of precipitation or significant development could have an effect on slope stability.

Seminoe Dam Quadrangle: A debris flow/alluvial fan complex is present in the southeastern portion of the quadrangle in T25N R84W Section 17. If this landslide activates, it could damage Seminoe Road, which passes through the complex. Heavy periods of precipitation or significant development could have an effect on slope stability.

Singer Peak Quadrangle: Slump/flow, rockslide/flow and rockslide/flow/Quaternary alluvium complexes are present in the west-central portion of the quadrangle (T14N R88W Sections 13 and 24; T14N R87W Section 19). If any of these landslides destabilize, they could dam or divert Sandstone Creek. Little Sandstone Creek could also be dammed if the blockslide/flow or slump/flow complexes in T14N R88W Section 36 and T14N R87W Section 31 activate. Heavy periods of precipitation or significant development could have an effect on slope stability.

Smiley Draw Quadrangle: Slumps and a slump/flow complex are present in the northeastern corner of the quadrangle in T15N R90W Sections 33 and 34 and in T14N R90W Section 3. If these landslides destabilize, the South Fork of Cherokee Creek could be dammed. In addition, the road that runs through the western portion of the quadrangle could be damaged if the nearby blockslide, flow/surface wash, or slump/flow complexes (T14N R91W Sections 11, 13, 14, 23, and 26) destabilize. Heavy periods of precipitation or significant development could have an effect on slope stability.

Strouss Hill Quadrangle: A slump/flow complex is present in T17N R78W Sections 12 and 13. If this landslide activates, damage could occur to structures in Section 12. Structures in T17N

R78W Section 24 could also be damaged if the large slump/flow/creep complex in the western portion of the quadrangle (T17N R77W Section 7, 18, 19; T17N R78W Sections 11-14, 23-26, 35, 36) activates. Heavy periods of precipitation or significant development could have an effect on slope stability.

Sulphur Springs Quadrangle: A dry sand flow is present in T17N R90W Section 4. If this flow activates, there is a remote possibility that it could dam or divert Muddy Creek and flood Twentymile Road. In addition, Cow Creek could potentially be dammed if the slump in T17N R90W Section 33 destabilizes. Heavy periods of precipitation or significant development could have an effect on slope stability.

T L Ranch Quadrangle: A rockslide/flow complex is located in the southeastern corner of the quadrangle in T19N R79W Section 10. If this landslide destabilizes, damage could occur to the nearby road. Heavy periods of precipitation or significant development could have an effect on slope stability.

Tullis Quadrangle: Numerous landslides are present along Savery Creek in the western portion of the quadrangle, Big Sandstone Creek in the southern and eastern portions of the quadrangle, and Little Sandstone Creek in the southeastern corner of the quadrangle. If any of these landslides activate, they could dam their respective creek. Heavy periods of precipitation or significant development could have an effect on slope stability.

Turpin Reservoir Quadrangle: A blockslide/flow complex is present in T17N R80W Section 7 and in T17N R81W Sections 1 and 12. If this landslide destabilizes, it could dam nearby Pass Creek. In addition, a slump/flow complex and a blockslide/flow complex are present along North Brush Creek in T17N R81W Sections 26, 33, and 34. If these landslides activate, they could damage nearby roads, either directly or by flooding if the landslide dams the creek. North Brush Creek could also be diverted if the debris flow/alluvial fan complex in T17N R80W Sections 29 and 32 activates. Cassidy Creek could be dammed if the nearby blockslide/Quaternary complex (T17N R81W Sections 26, 35, and 36) destabilizes. Finally, Aztec Creek could be dammed by the flow in T16N R81W Section 3. Heavy periods of precipitation or significant development could have an effect on slope stability.

White Rock Canyon Quadrangle: The West Fork and the East Fork of Wagonhound Creek could be dammed if the nearby blockslides (T19N R80W Sections 13 and 24) and the rockslide/blockslide/flow complex (T19N R79W Section 32), respectively, activate. Wagonhound Creek itself could be dammed if the large blockslide/flow complex in T19N R79W Section 31 and T18N R79W (what should be) Sections 5, 6, and 7 activates. In addition, if the blockslide/flow complex in T18N R80W Sections 14, 15, and 22 destabilizes, it could dam the Medicine Bow River. Heavy periods of precipitation or significant development could have an effect on slope stability.

Wild Irish Reservoir Quadrangle: Blockslide/slump/flow complexes are present in T27N R80W Section 7 and T27N R81W Sections 1 and 12. If these landslides activate, damage could occur to the road that passes through the complexes. Heavy periods of precipitation or significant development could have an effect on slope stability.

Young's Pass Quadrangle: Blockslide, slump/blockslide, and blockslide/slump complexes are present in T27N R88W Sections 1 and 12. If these landslides destabilize, they could dam Cherry Creek. Heavy periods of precipitation or significant development could have an effect on slope stability.

In terms of recent events, a landslide damaged Highway 70 during the spring 2011 floods. The damages totaled $1 million, and the highway had to be permanently rerouted as a result of the damage.

Table 9.1 summarizes landslide exposure in the county. During the 2015 update of this plan a GIS analysis of exposure to landslide hazard areas was performed. There are 58 properties in landslide hazard zones based on this analysis. Most of these properties are unimproved residential vacant land. Mapped landslides for Carbon County are shown on the figure below.

Table 9.1 Landslide Exposure in Carbon County

Property Types	Property Count	Improved Value
Agricultural	18	$191,703
Exempt	10	$0
Res Vacant Land	25	$0
Residential	5	$152,716
Total	58	$344,419

Source: 2010 Census and HAZUS 2.2

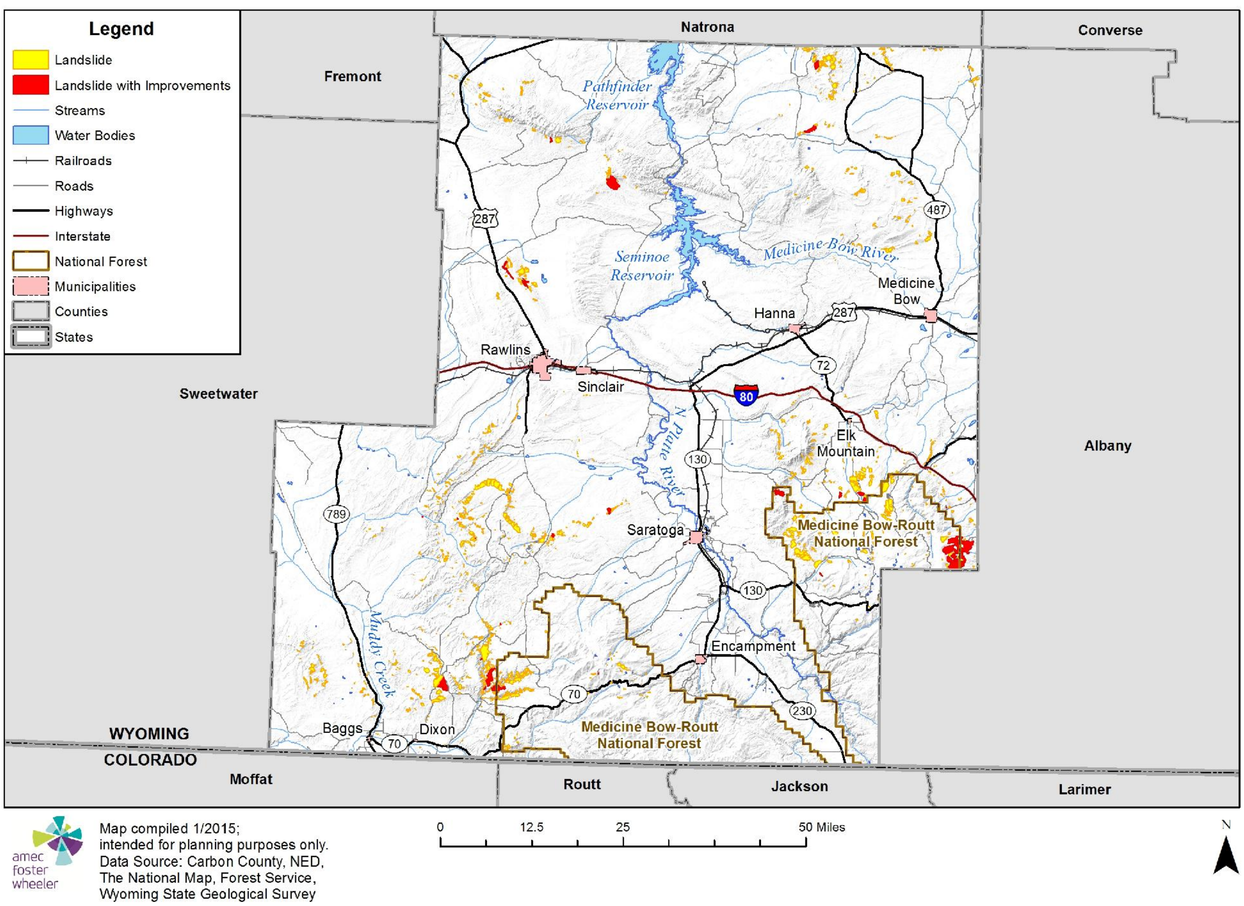


Figure 9.3 Carbon County Landslide Map

Future Impacts

There are three measures of future landslide impacts – historic dollar damages, estimated yearly damages, and building exposure values. There are not enough current data to estimate historic or yearly dollar damages.

The probability of a landslide causing damage in Carbon County is difficult to determine because of the poor historic data. GIS was used to conduct a roads impact analysis. The analysis found that 58 properties with an improved value of $344,419 are potentially at risk to landslide. All of the improved value is attributed to 18 agricultural properties and 5 residential properties. It is unlikely that the entire inventory would be affected by landslides at any one time, but it does give an upper end to the range of possible landslide damage in the county. Heavy periods of precipitation or significant development could have an effect on slope stability in the mapped hazard areas. Based on the geologic studies county roads are likely to experience direct landslide impacts. Secondary impacts could include flooding from landslide dams and power outages where transmission lines may be affected.

Future Development

The severity of landslide problems is directly related to the extent of human activity in hazard areas. There are small landslide areas near Elk Mountain, Baggs, and Dixon. Future development in these areas should be avoided to prevent landslide damage to property or people. Adverse effects can be mitigated by early recognition and avoiding incompatible land uses in these areas or by corrective engineering. Improving mapping and information on landslide hazards and incorporating this information into the development review process could prevent siting of structures and infrastructure in identified hazard areas.

Summary

PROPERTY AFFECTED: Low
POPULATION AFFECTED: Low
PROBABILITY: Medium
JURISDICTION AFFECTED: Elk Mountain, Unincorporated areas

Chapter X. Lightning

Lightning is a sudden electrical discharge released from the atmosphere that follows a course from cloud to ground, cloud to cloud, or cloud to surrounding air, with light illuminating its path. Lightning's unpredictable nature causes it to be one of the most feared weather elements.

Although not as significant in relation to other hazards, lightning still presents a certain danger in Wyoming. Anyone that is caught in an exposed area during a thunderstorm could be at risk to a lightning strike. In Wyoming, outdoor enthusiasts venturing to high and exposed areas should be especially cautious because rapid thunderstorm development with associated lightning can place even the most experienced climbers in jeopardy without warning. Hikers and climbers above the timberline should plan to be off exposed mountain tops and ridges by 1400 Mountain Standard Time (MST) during the summer months to avoid being struck by lightning unless proper shelter is available (Wyoming Climate Atlas).

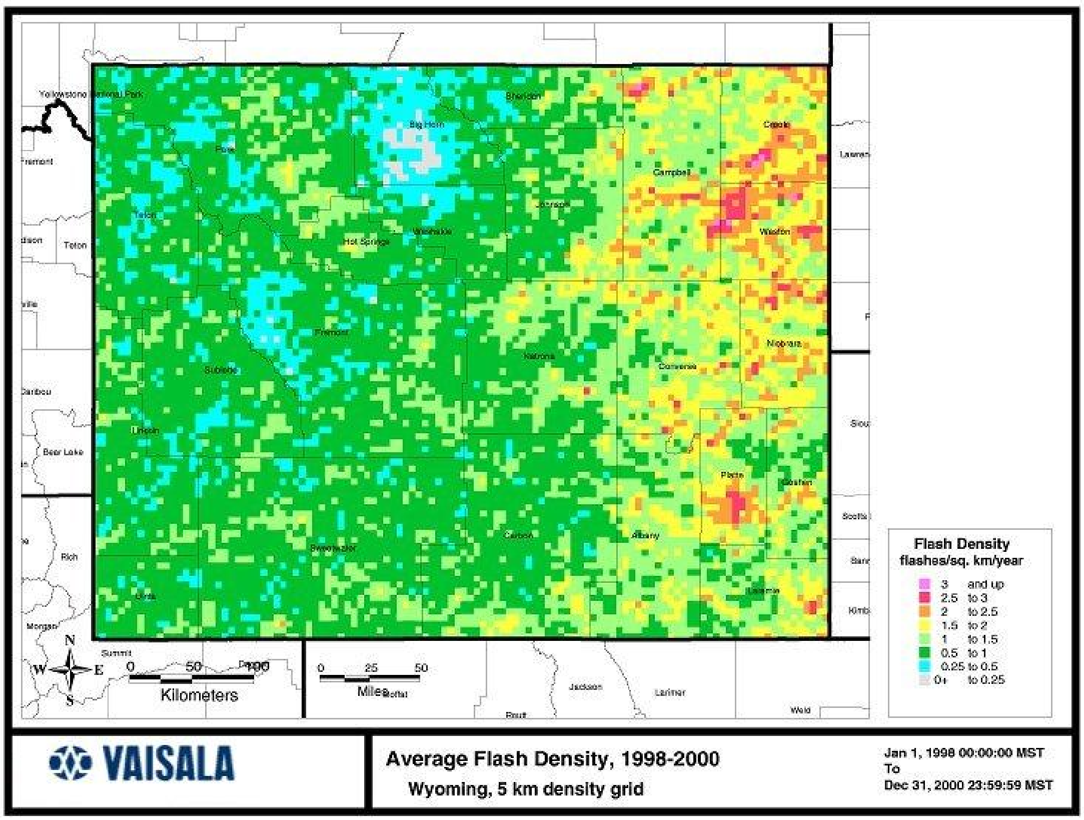


Figure 10.1 Average annual lightning flash density for 1998-2000 over Wyoming. Each pixel represents 5 km^2. Illustration courtesy of Vaisala Inc.

For the period of 1998 through 2000, the Wyoming annual lightning strike frequency is depicted in Figure 10.1. Clearly the eastern plains have more than three times the cloud to ground lightning strikes as does the western half of the state. Platte, Weston, Crook, and parts of Campbell, Niobrara, and Laramie counties are the most active in the state. These values probably vary by 50% in a year depending on whether there is a drought or enhanced monsoonal flow. However, the locations of maximum and minimum strikes do not change much from year to year. In 1998 the state's precipitation average was well above normal, in 1999 near normal, and in 2000 was below normal (Wyoming Climate Atlas).

History

U.S. statistics show that one in 345,000 lightning flashes results in a death and one in 114,000 results in an injury. According to meteorologists at Vaisala, Inc., the odds for an American being hit by lightning sometime in the course of an 80-year lifespan is about 1 in 3,000. Wyoming ranked 36th in number of lightning fatalities, 33rd in injuries, and 40th in property damage from 1959 to 1994 according to the National Oceanic and Atmospheric Administration, National Severe Storms Laboratory (NOAA, NSSL). From 1959 to 2003 lightning was responsible for 26 deaths, 103 injuries, over $3.2 million in property damage, and $22,750 in crop damage in Wyoming. Dollar damage estimates may include damage from associated severe weather, including precipitation and wildland fire.

Table 10.1 includes Wyoming lightning events that have caused deaths, injuries, and damage in Carbon County. Lightning has been responsible for five deaths and five injuries in the county since 1956, and has sparked numerous wildfires. Vaisala data lists Wyoming as 38th in the U.S. for cloud-to-ground lightning flash density with 3.1 flashes per square mile between 1997 and 2011. The same data set showed that Wyoming averaged 300,919 flashes per year between 1997 and 2011.

According to the Vaisala Group and National Lightning Detection Network, Wyoming ranked 38th among the 50 U.S. states, Puerto Rico, and Washington D.C. for overall lightning deaths between 2004 and 2013. Two people died from lightning events in Wyoming during that time frame. This would suggest that lightning is not a major hazard for Wyoming. However, the state had the highest per capita fatality rate within that same time period at 0.38 deaths per million people. Figure 10.2 illustrates the number of lightning fatalities that occurred in each state between 2004 and 2013. Figure 10.3 depicts the lightning fatalities per state weighted by population.

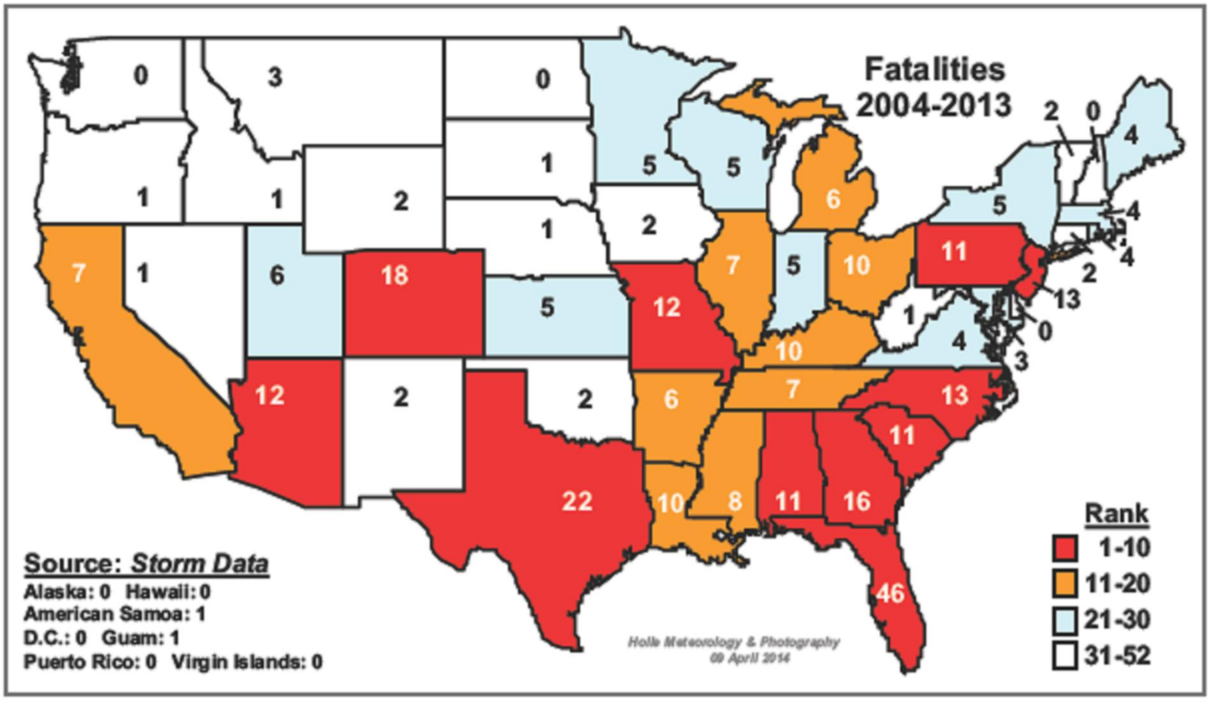


Figure 10.2 Lightning Fatalities by State: 2004-2013

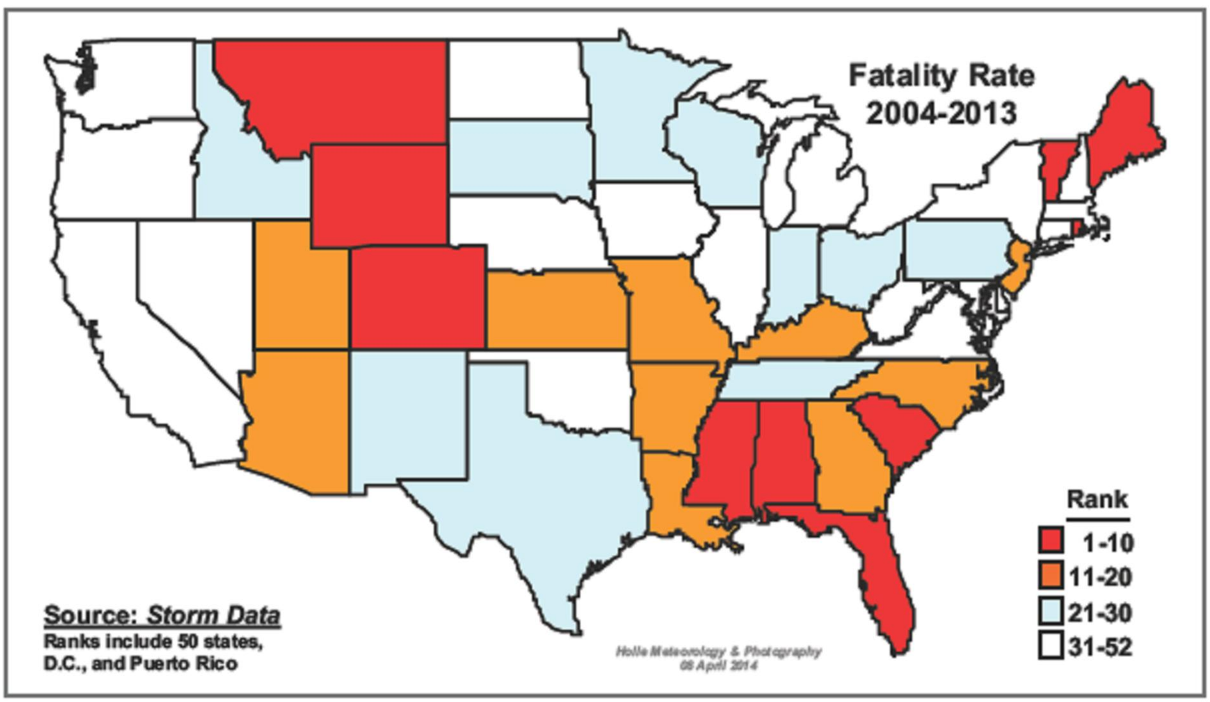


Figure 10.3 Lightning Fatalities Weighted by Population by State: 2003-2014

Table 10.1 Recorded Lightning Events (1956 through 2012)

Location	Date	Deaths	Injuries	Property Damage	Crop Damage	Total Damage (current year)	Total Damage (2014)	Information
South of Elk Mountain	26-Jul-1956	1	0	$0	$0	$275	$2,388	Lightning killed one person south of Elk Mountain in Carbon County.
Baggs	22-Jun-1966	0	1	$275	$0	$275	$2,004	Lightning struck and killed a horse, injuring the rider.
Medicine Bow	15-May-1969	0	1	$275	$0	$275	$1,770	Lightning killed a horse and injured its rider.
Saratoga 33 NE	2-Jun-1976	1	0	$0	$0	$0	$0	Lightning killed a ranch hand on the TA Ranch on Pass Creek Road at about 1500 MST
Medicine Bow 5 SE	30-Jul-1976	1	0	$0	$0	$0	$0	Lightning killed a 13-year-old boy while fishing at Chase Reservoir.
Saratoga	17-Aug-1986	0	0	$0	$6,000	$6,000	$12,928	During the afternoon, a lightning-caused fire burned $6000 worth of baled hay just southeast of Saratoga.
	11-Jul-1994	0	1	$0	$0	$0	$0	Lightning struck a truck's antenna at a fire site near Saratoga. The bolt traveled from the truck to the ground and over to another truck where a sheriff's deputy was sitting slightly injuring the man.
7 E Rawlins	14-Jun-1998	0	1	$0	$0	$0	$0	A motorcycle rider was hit by lightning as he was riding west on Interstate 80. He was struck in the back of the neck and the strike caused him to lose control of his motorcycle and crash into the median. The motorcyclist received a ruptured eardrum and burns to his eyes, chest and shoulder. The victim was taken to the hospital for treatment and released.
15 S Arlington	10-Aug-1998	1	1	$0	$0	$0	$0	A woman was killed by a lightning bolt while hiking in the Snowy Range. A friend that was hiking

Table 10.1 Recorded Lightning Events (1956 through 2012)								
Location	**Date**	**Deaths**	**Injuries**	**Property Damage**	**Crop Damage**	**Total Damage (current year)**	**Total Damage (2014)**	**Information**
								with her was injured. The two were trying to get to lower levels of the mountains after spotting the storm, but the storm caught them in the open.
12 S Encampment	17-Sep-2002	1	0	$0	$0	$0	$0	Lightning struck a tree and woman standing under it at the Pickaroon Campground in Medicine Bow National Forest. F51UT
Encampment	16-Feb-2014	0	0	$3,835	$0	$3,835	$3,835	Loss of instrumentation at water plant due to lightning strike.
TOTALS		**5**	**5**	**$4,385**	**$6,000**	**$10,760**	**$22,925**	

Impacts

Nationwide lightning strikes are routinely monitored by Vaisala, Inc. with accuracies to within a 0.625-mile (1 kilometer) resolution. For the period of 1997 through 2010, the annual lightning strike frequency for the continental U.S. is depicted in Figure 10.4. The approximate area for Carbon County is circled in white in Figure 10.4. Clearly the eastern plains have more than three times the cloud to ground lightning strikes as does the western half of the state. Wyoming's eastern counties have the most lightning activity in the state. Carbon County has a lower rate of incidence.

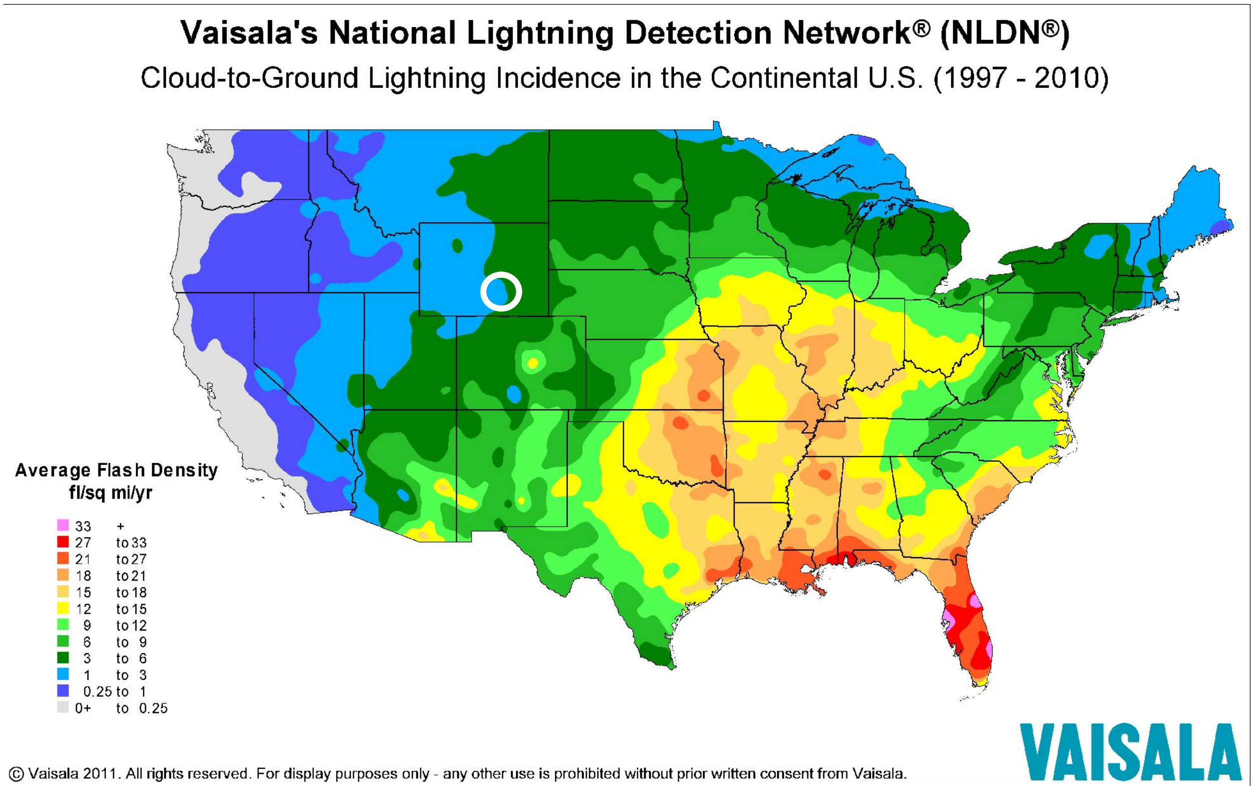


Figure 10.4 Cloud-to-Ground Lightning Flash Density in Continental U.S.: 1997-2010 (Carbon County approximate area circled in white)

Lightning is the leading cause of wildland fires in Wyoming, and is indirectly responsible for millions of dollars of fire damage. Whether in a drought or wet period, Wyoming's hot and windy summers can cause rapid changes to the fire risk over grasslands and forests. Figure 10.5 depicts a 31-year record of lightning-caused wildfires as well as the percent of lightning-induced wildfires. The worst events occurred in July and August 1988, when, according to the U.S. Bureau of Land Management, lightning ignited 29 fires, setting 4,159 acres ablaze. These fires resulted in a total of $780,330 ($1,458,700 in 2010 USD) in damage.

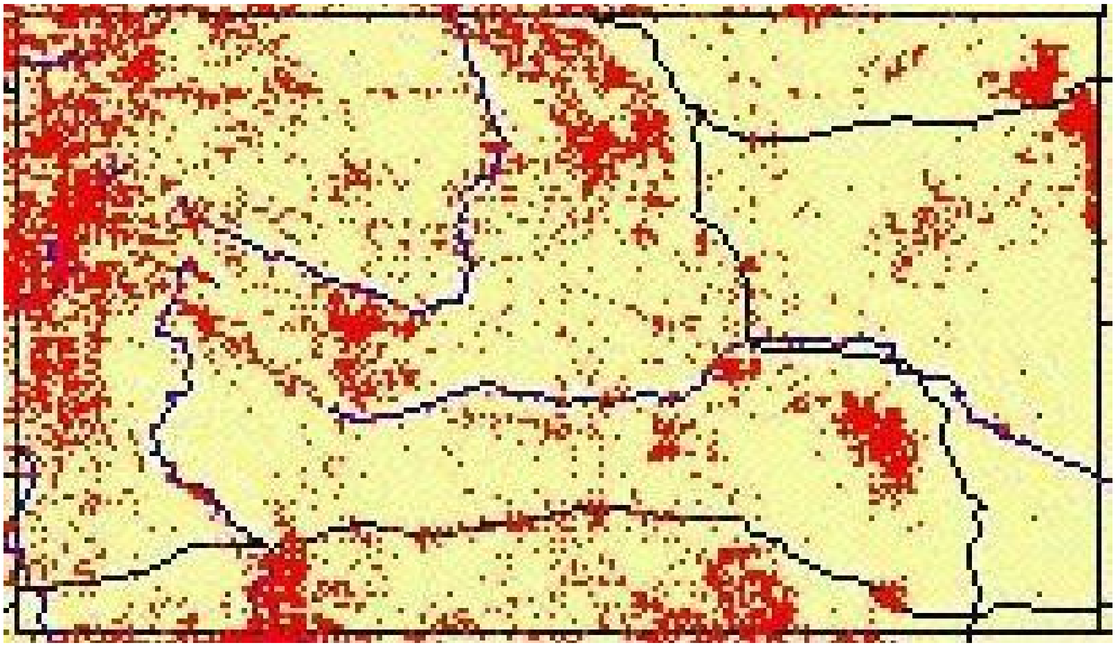


Figure 10.5 Wyoming lightning induced fire source points (1970-2000). Illustration courtesy of Wyoming Climate Atlas.

Historical trends demonstrate that lightning will continue to be the leading cause of wildland fires in the state, and it will maintain dominance in the eastern plains of Wyoming. Given the greater likelihood of lightning in the eastern plains of Wyoming, counties most likely to be impacted by lightning and the potentially resulting wildland fire are Crook, Weston, Niobrara, Goshen, Laramie, Platte, Converse, and Campbell counties. However, as documented in Figure 10.1, all counties in Wyoming are subject to lightning.

Due to the nature of lightning, those at greatest risk for life-threatening lightning hazard impacts fall within two categories: those working outside or enjoying outdoor activities and those in poor health who rely on electricity. Outdoorsmen are susceptible to direct lightning strikes and/or to wildfire started by lightning. Individuals reliant on electricity to meet day-to-day health needs, such as those reliant on oxygen machines for example, may be impacted by lightning because of lightning-caused power outages. Both of these groups are susceptible to serious injury or death.

Future Impacts

Future impacts from lightning are difficult to determine because of the erratic nature of storms. Carbon County will remain susceptible to lightning strikes, based on the history of past events. A damaging lightning event occurs once every 5.6 years in the county. Impacts to persons and property are likely to remain isolated, however. Outdoor workers and outdoor enthusiasts will remain susceptible to lightning strikes. Lightning caused wildland fires may result in more extensive damage.

Future Development

Lightning caused wildland fires may result in more extensive damage. Additional impacts exist to property located in areas susceptible to wildland fire, which is addressed in the “Wildland Fire” chapter in this plan. While Wyoming’s population continues to grow, as documented by the 2010 census, development has no impact on locations where lightning may strike, but potentially increases the exposure of people and property to lightning impacts.

Summary

PROPERTY AFFECTED: Low
POPULATION AFFECTED: Low
PROBABILITY: High
JURISDICTION AFFECTED: All jurisdictions in the county

Chapter XI. Mine Subsidence

Underground coal mining began in Wyoming during the 1860s. Many of the early coal mines were not designed and constructed well. Many were also shallow, and often had minimal ground support in the form of mine timbers. As a result the underground pillars can fail. If enough pillars fail, the caprock in the mine will collapse. The effect of the collapse reaches the surface in some cases. If the effect of the collapse reaches the surface, a subsidence pit or trough forms. Not all subsidence from mining is due to poor design, however. Most underground mines eventually have roof failures due to lack of maintenance and continuous loading of the unsupported rock layers overhead. In some cases the pillars were pulled as mining retreated from an area. In other cases fires occurred in the mines, resulting in a loss of strength in the pillars and caprock.

History

Significant areas in Wyoming have abandoned underground mines present (Figure 11.1). Mining subsidence has been threatening select areas of Wyoming since the onset of mining in the 1860s. Due to the long history of underground mining in the state, many more undermined areas have subsided than most people imagine. A written history of mine subsidence in or near urban areas was published in the *Governor's Workshop on Mine Subsidence* proceedings held on October 31, 1986 at the University of Wyoming.

The WSGS generated a report for each county in Wyoming on abandoned underground coal and hard rock mines that have been identified. Mining sites and subsidence have been reported through multiple avenues including the US Geological Survey, Wyoming Geological Survey, US Forest Service personnel, BLM personnel, hunters, and other private individuals. The Abandoned Mine Lands Division (AML) of the Wyoming Department of Environmental Quality (DEQ) have recorded and actively pursued mitigation of mined out areas throughout the state. One mitigation activity includes generating GIS layers of mined out sites. Two mining GIS inventory projects have been completed, one in 2001 and the other in 2004, wherein staff physically visited and geolocated mined out areas. The AML has accurately mapped approximately 3,000 of the nearly 4,000 reported abandoned mining sites. A high-level map showing numbers of abandoned mines in areas around the state is below. More detailed, local information is available through the AML upon request.

According to the WSGS report significant subsidence problems have occurred in Carbon County in Hanna and Elmo. A map showing documented subsidence is shown in Figure 11.1 and Figure 11.2. Detailed mining maps of the Hanna and Elmo area are provided in Figures 11.3 and 11.4 taken from a report titled *Overview of Coal Mine Subsidence in Wyoming* by James C. Case of the WSGS.

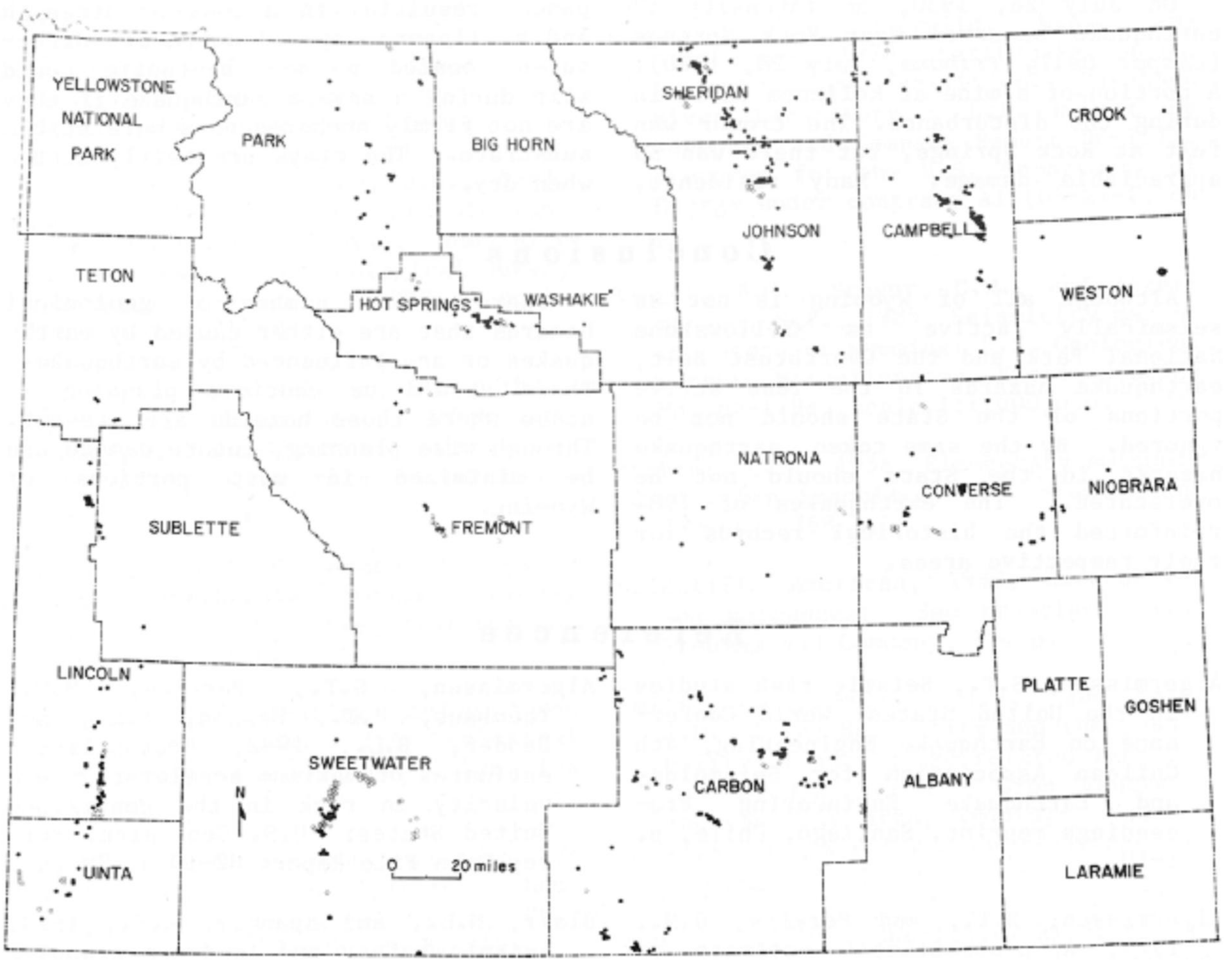


Figure 11.1 Mined-out areas and mine subsidence in Wyoming. Gray areas represent mined-out areas with subsidence. Solid areas represent mined-out areas with no known subsidence.

Source: 2011 Wyoming Multi-Hazard Mitigation Plan

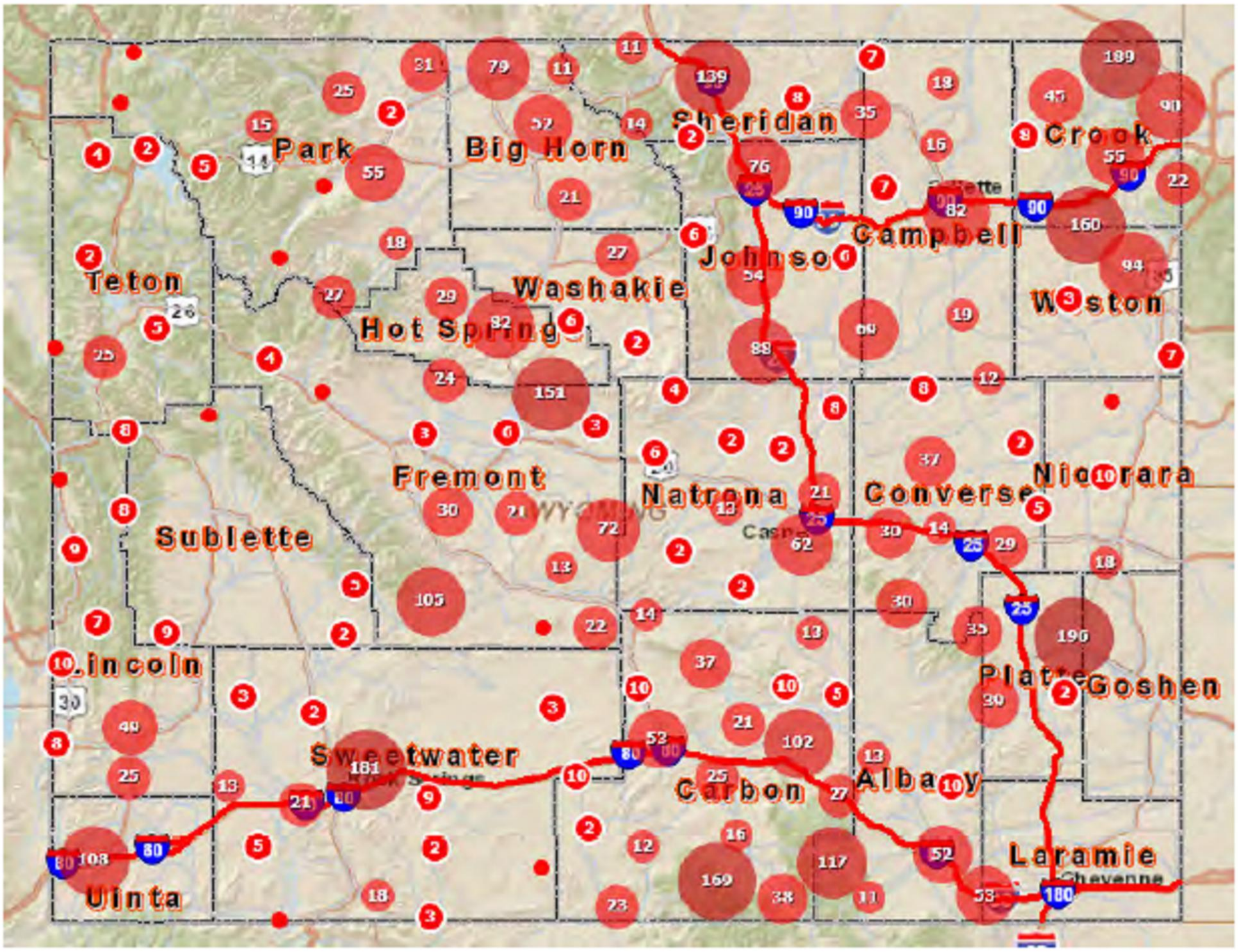


Figure 11.2 Mined-out areas and mine subsidence in Wyoming (cont.)
Source: 2014 Wyoming Multi-Hazard Mitigation Plan

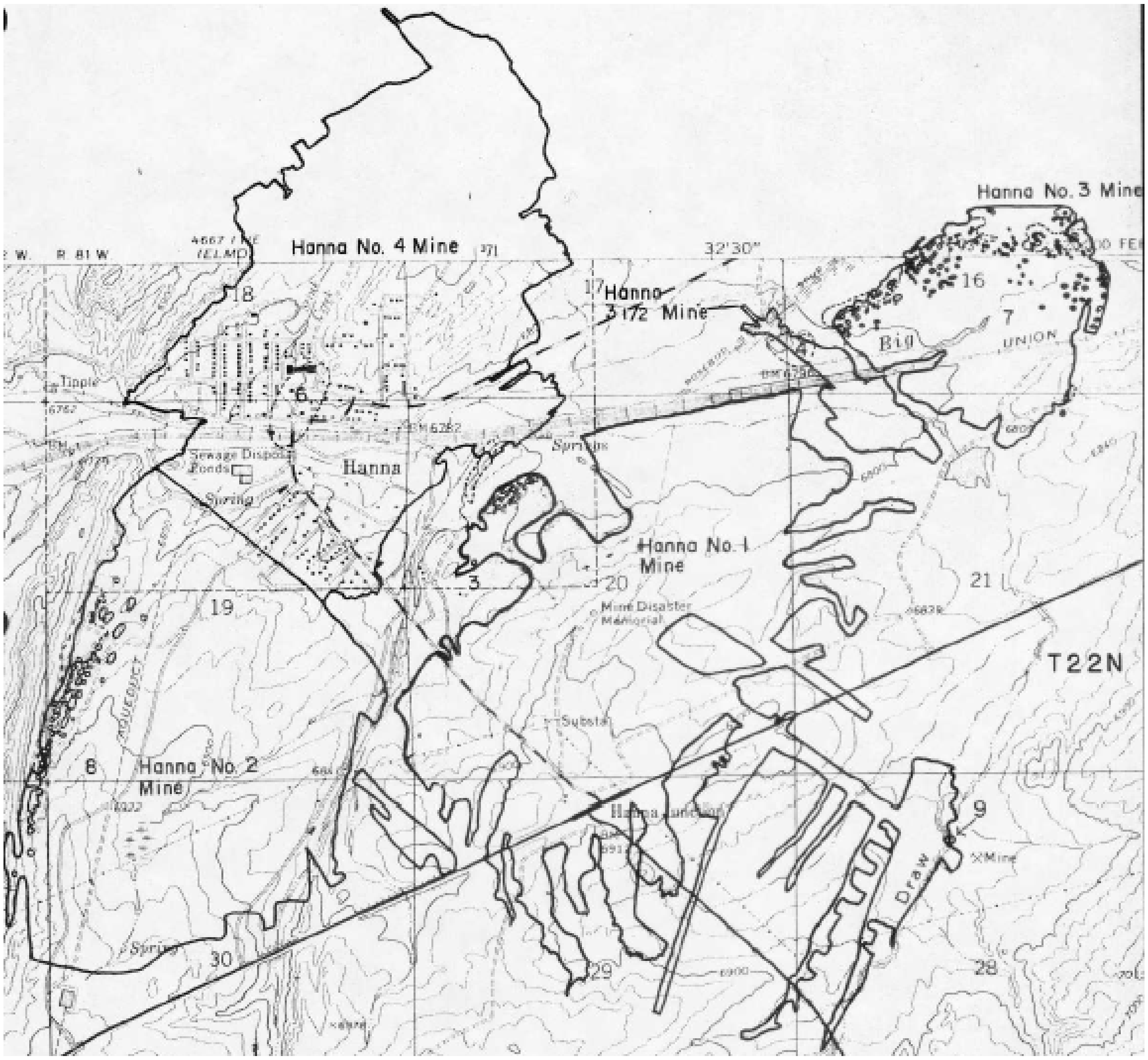


Figure 11.3 Mined-out areas and subsidence near Hanna

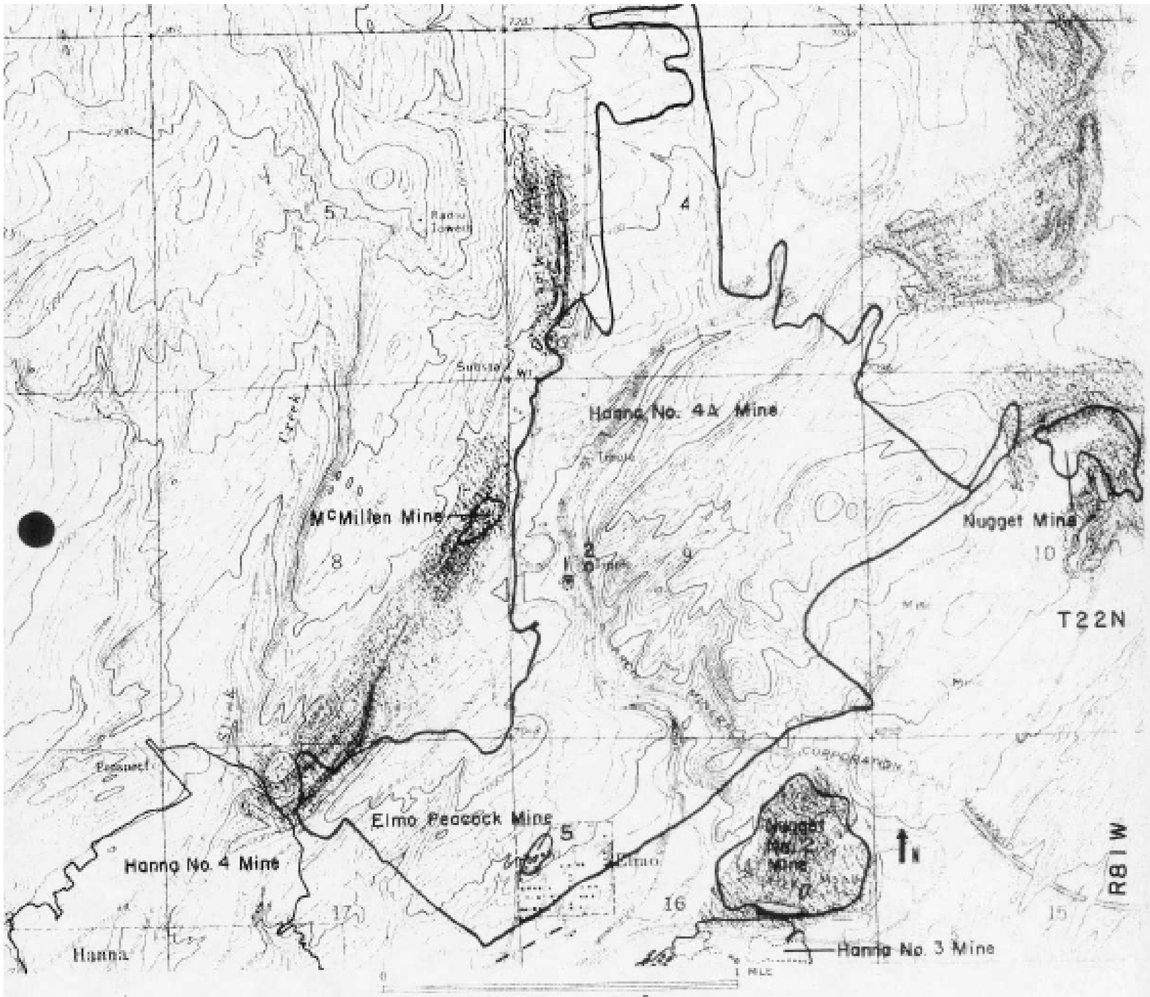


Figure 11.4 Mined-out areas and subsidence near Elmo

Subsidence has been associated with these mines since 1955. The numbers below correspond to the numbers on the Hanna and Elmo maps and provide more detail on the subsidence problems in the area.

Number	Date	Description of Subsidence
1	1955	A 300 to 400 foot wide pit that was 10 to 20 feet deep opened up just after the Hanna 4A mine was closed in 1954. The collapse destroyed a tipple above it. It was felt that the collapse was due to the effects of excessive precipitation in the area.
2	1983	Arch Mineral Corporation's tipple was deformed and tilted due to subsidence. Drilling in the area showed a 30-foot void at a depth of 200 feet.
3	1984	A subsidence pit opened near the High School in July, 1984.
4	Post-1947	There is evidence of continuous subsidence in this area that overlies the Hanna 3 1/2 mine. 1947 aerial photos shows no evidence of ponding or troughs. Later photos do show evidence of ponding.
5	1980s	A pit opened up under a driveway in Elmo. It is probably associated with the Peacock Mine.
6	Unknown	An area of continuous subsidence is suspected in the vicinity of the old High School.
7	Unknown	A major zone of subsidence pits is present over the Hanna No. 3 Mine.
8	Unknown	A major zone of subsidence pits is present over the Hanna No. 2 mine. It is suspected that many occurred shortly after the cessation of mining.
9	Unknown	A large pit/mine entrance was present in this area. A stream was flowing into the opening in 1981.

Figure 11.5 Subsidence Problems near Hanna and Elmo

The State Mine Inspector's Reports from 1888-1948 indicated a number of problems in the Hanna area mines that could affect future stability. These included pillars removed in portions of the mines (Hanna No. 2) and several fires and explosions (Hanna No. 1, 3, 3 1/2). In 1903 169 men were killed in a mine explosion. Five years later 59 men were killed in a series of fires and explosions in the mine in 1908. A large cave-in some 60 feet in length was found near the east entrance after the fire was extinguished.

Mined-Out Areas in Carbon County

Underground Coal Mines

There are numerous abandoned underground coal mines in Carbon County. Although some may have been reclaimed, no development should be allowed at the sites until it can be shown that reclamation has occurred and that the reclamation has been successful. The coal mines below are organized by topographic quadrangle.

Arlington Quadrangle:
Cottontail Mine – T18N R78W Section 2

Bolten Ranch 15' Quadrangle:
McCord Prospect – T19N R85W Section 19
Peck Mines – T19N R85W Section 19
Unnamed mine – T19N R86W Section 13
Unnamed mines (3) – T19N R86W Section 14
Unnamed prospect – T19N R85W Section 19

Bradley Peak Quadrangle:
Fieldhouse Prospect – T25N R86W Section 23
Unnamed mine – T25N R85W Section 20
Kronkheit Mine – T25N R85W Section 17

Bridger Pass 15' Quadrangle:
Nebraska Mine – T20N R88W Section 6

Bull Springs Quadrangle:
Pettingrew Mine – T25N R89W Section 30
Unnamed mine – T25N R89W Section 29

Carbon Quadrangle:
Carbon #1 Mine – T22N R80W Sections 26, 27
Carbon #2 Mine – T22N R80W Sections 26, 35
Carbon #3 Mine – T22N R80W Sections 26, 27
Carbon #5 Mine – T22N R80W Section 14
Carbon #6 Mine – T22N R80W Sections 26, 27
- The Carbon mines are near a pipeline. Reclamation should be confirmed.
New Garey Mine – T21N R80W Section 32

Como East Quadrangle:
Carbon #4 Mine – T22N R80W Section 14
Carbon #5 Mine – T22N R80W Section 14

Como West Quadrangle:
Carbon #5 Mine – T22N R80W Section 14
Sampo Mine – T22N R81W Section 2

Cottonwood Rim Quadrangle:
Carbondale Mine – T13N R87W Section 7
Stemp Springs Mine – T13N R88W Section 13

Dana Quadrangle:
Dana Mine – T21N R82W Section 5; T22N R82W Section 32
-This mine is near a railroad line. Reclamation should be confirmed.
Vanguard No. 2 Mine – T22N R82W Section 18
-This mine is near a road. Reclamation should be confirmed.

Difficulty Quadrangle:
Coulter Mine – T24N R81W Section 35

-This mine is near the Medicine Bow River. Reclamation should be confirmed.

Doty Mountain 15' Quadrangle:
Corlett Opening – T16N R92W Section 4
Muddy Bridge Mine – T15N R92W Section 12
Robertson Mine – T17N R90W Sections 3-5
-This mine is near a road and Muddy Creek. Reclamation should be confirmed.

Elk Mountain Quadrangle:
Carbon County Mine – T21N R80W Section 32
Elk Mountain prospect – T20N R80W Section 6
Finch Mine – T21N R80W Section 32
Gebhart Mine – T21N R80W Section 32
Johnson Mine – T21N R80W Section 32
Old Garey Mine – T21N R80W Section 32
Unnamed mine – T20N R80W Section 4
Unnamed mines (2) – T20N R80W Section 6
Unnamed mines (2) – T21N R80W Section 32
West Mine – T21N R80W Section 32
Wilson #2 Mine – T21N R80W Section 32

<u>Elmo Quadrangle</u>: * All mines in this quad are near roads. Confirm reclamation.
Elmo Peacock Mine – T22N R81W Section 16
-This mine is near railroad line. Reclamation should be confirmed.
Hanna No. 3 Mine – T22N R81W Section 16
Hanna No. 4 Mine – T22N R81W Sections 17 and 18
Hanna No. 4a Mine – T22N R81W Sections 3, 4, 9, 10, 16, 17; T23N R81W Section 33
-This mine is near railroad lines.
McMillen Mine – T22N R81W Section 8
Nugget Mine – T22N R81W Section 10
Foote Creek Lake Quadrangle:
Burn Right Mine – T21N R78W Section 24

Grieve Reservoir Quadrangle:
Linde Opening – T12N R88W Section 8
- A road was built over the mine opening. Reclamation should be confirmed.

Halfway Hill Quadrangle:
Carbon No.1 – T22N R80W Section 26
Carbon No. 2 – T22N R80W Sections 26, 35, 36
Carbon No. 6 – T22N R80W Section 26
Carbon No. 7 – T21N R80W Section 1; T22N R80W Section 36
- All mines in this quadrangle are near pipelines. Reclamation should be confirmed.

Hanna Quadrangle:
Hanna No. 1 Mine – T22N R81W Sections 16, 19, 20, 21, 28, 29
Hanna No. 2 Mine – T22N R81W Section 19, 30; T22N R82W Sections 24, 25
Hanna No. 3 Mine – T22N R81W Sections 7 and 21
Hanna No. 3 ½ Mine – T22N R81W Section 16, 17, 21
Hanna No. 4 Mine – T22N R81W Sections 17-20
Unnamed mine adit – T22N R81W Section 28

*All mines in this quadrangle are near U.S. Highway 30/287, other roads, and railroad lines. Reclamation should be confirmed.

Lone Haystack Mountain Quadrangle:
Miller prospect –T23N R85W Section 18

McFadden Quadrangle:
Sprague Mine – T20N R78W Sections 21, 28

Muddy Gap Quadrangle:
Old Speger Mine – T27N R89W Section 8
Unnamed prospect – T27N R89W Section 17

Overland Crossing Quadrangle:
Larsen Mine – T19N R85W Section 28
Moomaw and Everist Mine – T19N R85W Section 21
Petty Mine – T19N R85W Section 26
Phillips Mine – T19N R85W Section 35
Ream and Ramsey Mine – T19N R85W Section 26
Sehorn Mine – T19N R85W Section 26
Unnamed mines (2) – T19N R85W Section 21
Unnamed mines (2) – T19N R85W Section 28
Unnamed mines (2) – T19N R85W Section 35
Unnamed mine – T19N R85W Section 36
* The mines in Sections 21 and 28 are near the North Platte River. Confirm reclamation.

Pats Bottom Quadrangle:
Crane Mine – T23N R84W Section 26
Prospect Mine – T22N R84W Section 2
Unnamed mines (2) – T22N R84W Section 25
* The Crane Mine and the unnamed mines are near the North Platte River and Seminoe Reservoir.

Pierce Reservoir Quadrangle:
King Mine – T19N R77W Section 7
Monarch Mine – T19N R77W Section 7
Terry Mine – T19N R77W Section 18
* All mines in this quadrangle are near a pipeline. Reclamation should be confirmed.

Poison Basin Quadrangle:
Cedar Hills Mine Group – T13N R92W Section 32
Jack Rabbit Mine Group – T12N R92W Section 5; T13N R92W Section 32
Matt Mines – T12N R92W Section 4
Poison Basin Mines – T12N R92W Section 4
Teton Mine Group – T13N R92W Section 31
* Poison Buttes Road crosses near or through Jack Rabbit Mine, Poison Buttes, and Matt Mines. Reclamation of these mines should be confirmed.

Rawlins Peak 15' Quadrangle:
Pine Bed Mine – T21N R89W Section 26
Unnamed mine – T21N R89W Section 21

Unnamed mine – T21N R89W Section 24
Unnamed mine – T21N R89W Section 25
* The mines in Sections 24-26 are near a railroad line. Reclamation should be confirmed.

Savery Quadrangle:
Angier Mine – T12N R89W Section 6
Beeler Mine – T12N R89W Section 5
Company Bank Mine – T12N R89W Section 9
Darling Mine – T12N R89W Section 5
Easom Mine – T12N R89W Section 8
Pioneer Mine – T12N R89W Section 8
* Mines listed above are near either Savery Creek or roads. Reclamation should be confirmed.
Unnamed mine – T13N R89W Section 32

Schneider Ridge Quadrangle:
Unnamed mine – T24N R82W Section 8
Unnamed mine – T24N R83W Section 11

Seminoe Dam SW Quadrangle:
Miller Mine – T25N R85W Section 35
O'Brien Spring Mine – T24N R85W Section 9

Tenmile Spring Quadrangle:
Vanguard No. 1 Mine – T22N R82W Section 8
Vanguard No. 2 Mine – T22N R82W Section 18
Vanguard No. 3 Mine – T22N R82W Section 7; T22N R83W Section 12

T L Ranch Quadrangle:
Black Diamond No. 1 Mine – T21N R79W Section 32
Black Diamond No. 2 Mine – T21N R79W Section 32
Johnson Mine – T20N R79W Section 6
Kent Mine – T20N R80W Section 2
Unnamed mine – T20N R80W Section 2
Unnamed mine – T21N R79W Section 34

Walcott Quadrangle:
Buckley and Ryan Mine – T21N R84W Section 14

Wild Horse Mountain Quadrangle:
Burlington prospect – T24N R86W Section 26
Penn Wyoming Mine – T25N R85W Section 20

Whiskey Peak Quadrangle:
Muddy Gap Mine – T27N R89W Section 6
Speger prospect – T27N R89W Section 6

Underground Hard Rock Mines

There are a few abandoned underground hard rock mines and prospects in Carbon County. Although several have been reclaimed, no development should be allowed at the sites until it can be shown that reclamation has occurred and that the reclamation has been successful. The hard rock mines below are organized by topographic quadrangle. Approximate locations from: Hausel, W.D., 1997, Copper, lead, zinc, molybdenum, and associated metal deposits of Wyoming, Wyoming State Geological Survey Bulletin 70, 229 p.

Arlington Quadrangle:
Albion Mine – T18N R78W Section 27
Little Ella-Senator Stewart Mine – T18N R78W Sections 16 and 21
Richmond Mine – T18N R78W Section 27
Unnamed adit – T18N R78W Section 5
Unnamed mine – T18N R78W Section 27

Barcus Peak Quadrangle:
Golden Clover Mine – T14N R82W Section 26

Blackhall Mountain Quadrangle:
Beaver group adit/shafts – T13N R83W Sections 14 and 23

Bradley Peak Quadrangle:
Apex adit – T26N R85W Section 32
Deserted Treasure adits – T25N R85W Section 6
Junk Creek Mine – T26N R85W Section 20
Penn Mine – T25N R85W Section 6
Sunday Morning Mine – T26N R85W Section 29
Sunday Morning prospect – T26N R85W Section 29
The King Mine – T25N R85W Section 6

Bridger Peak Quadrangle:
Batchelder Mine – T14N R86W Section 18
Doane-Rambler Mine – T14N R86W Section 25
Echo Property shaft – T14NR86W Sections 9, 15, and 16
Ferris-Haggarty Mine – T14N R86W Section 16
Island City Group shaft – T14N R86W Sections 3 and 10
Leighton-Gentry/Jack Creek Mine – T14N R86W Section 5
Meta Mine – T15N R86W Section 25
Rex Prospect – T14N R86W Section 24
Unnamed mine and prospects – T14N R86W Section 24
Unnamed mine and prospects – T14N R86W Section 35

Coad Mountain Quadrangle:
M & M's Elk Mountain Mine – T19N R82W Sections 22, 23, and 26

Divide Peak Quadrangle:
Bridger Mine – T15N R87W Section 2
Hub prospect – T15N R87W Section 6

Dudley Creek Quadrangle:
Broadway Mine – T13N R83W Section 32
Cascade Mine – T13N R84W Section 12

Encampment Quadrangle:
Copper Schist Mine – T14N R84W Section 12

Eureka shaft – T14N R84W Section 22
Finley Mine – T14N R84W Section 22
King of the Camp prospect – T14N R83W Section 36
Kurtz-Chatterton Mine – T14N R84W Section 29
Purgatory Gulch Mines – T13N R84W Section 1; T14N R84W Section 36
Tennant property Mine – T14N R84W Sections 21 and 22
Unnamed adits – T14N R84W Section 23
Unnamed adits – T14N R84W Section 24
Unnamed adits – T14N R84W Section 34
Unnamed shafts – T14N R84W Section 24
Unnamed shaft – T14N R84W Section 26
Unnamed prospects – T14N R84W Sections 26, 35, 36

Ferris Quadrangle:
Spanish Trails prospect #8 – T26N R86W Section 5
Unnamed shaft – T26N R86W Section 5

Fletcher Peak:
Anaconda Mine/North Fork Group/Homestake prospect/Three Forks Group – T12N R86W Sections 11-14
Itmay Mine – T13N R86W Section 14
Prospect 9999 – T13N R86W Sections 15 and 16
Standard Mine – T13N R86W Section 12
Unnamed mine – T13N R86W Section 11

Gunst Reservoir Quadrangle:
Unnamed shaft – T14N R83 Section 20

Indian Rocks Quadrangle:
Newton group – T14N R85W Sections 13 and 24

Keystone Quadrangle:
Unnamed shafts (2) – T15N R80W Section 35

Morgan Quadrangle:
Clare B. (Morgan) Mine – T18N R78W Section 34
Cooper Creek adit – T17N R78W Section 3
Copper Queen Mine – T18N R78W Section 27
Emma G. Mine – T18N R78W Section 34
Rip Van Winkle Mine – T18N R78W Section 27
Silver Queen Mine – T18N R78W Section 34
Silver King prospects – T18N R78W Section 34

Overlook Hill Quadrangle:
Natures Mint Mine – T14N R80W Section 30
Unnamed adit – T15N R81W Section 35

Red Mountain Quadrangle:
Bonita prospect – T15N R85W Sections 25 and 36
Charter Oak Mine – T15N R85W Section 24
Continental group adit/shaft – T14N R85W Section 18

Copper Rock group – T14N R85W Sections 27 and 28
Gertrude Mine – T14N R85W Section 28
Hercules Mine – T14N R85W Section 29
Hidden Treasure Mine – T14N R85W Section 28
Newton group – T14N R84W Sections 18 and 19
Portland Mine – T14N R85W Section 30
Rambler Mine – T14N R85W Section 30
Section 8 Mine – T14N R85W Section 8
Sun-Anchor and Sweet claims – T14N R85W Section 34
Unnamed mine – T14N R85W Section 25
Unnamed shaft – T14N R85W Section 25
Unnamed mines (3) – T14N R85W Section 29

Sharp Hill Quadrangle:
North Spring Creek prospect – T15N R86W Section 10
Unnamed mine – T15N R86W Section 13

Singer Peak Quadrangle:
Buckeye Lode – T14N R87W Section 11
Syndicate Mine – T15N R87W Section 26
Unnamed mine – T15N R87W Section 27

Solomon Creek Quadrangle:
Century Mine – T13N R85W Sections 32 and 33
Hinton-Verde Mine – T13N R85W Section 32
Sun-Anchor and Sweet claims – T13N R84W Section 6
Unnamed mine – T12N R85W Section 15
Unnamed mine – T13N R85W Section 33

Spanish Mine Quadrangle:
Done Moving prospect – T26N R86W Section 5
Mathilda Jane Mine – T26N R86W Section 6
Spanish Mine – T26N R86W Section 6
Spanish Trails #1 prospect – T26N R86W Section 6
Spanish Trails #4 adit – T26N R86W Section 6
Spanish Trails #4 prospect – T26N R86W Section 6
Unnamed shaft – T26N R86W Section 6

Seminoe Dam Quadrangle:
Long Creek area shaft – T26N R85W Section 26

Trent Creek Quadrangle:
Big Creek (Bonanza, Cox) Mine – T13N R81W Sections 8, 9
Platt Mine – T13N R81W Section 9
Unnamed mine – T12N R81W Section 7
Unnamed shaft – T13N R82W Section 16

Impacts

There has been property and infrastructure damage associated with mine subsidence in Wyoming communities. The dollar amounts of the damage are not readily available. Underground coal fires can also happen in abandoned mines.

An indirect measure of the impacts is the existing cost of mitigating the hazards. The Wyoming Abandoned Mine Lands (AML) Program at Wyoming Department of Environmental Quality (DEQ) has spent $303.4 million through 2013 mitigating the effects of mine subsidence alone, as part of the abandoned mine reclamation program. If any of the above mines are found to be unreclaimed and appear to pose a hazard to the public, the Abandoned Mine Lands Program at the Wyoming Department of Environmental Quality should be contacted.

Future Impacts

Although many areas of the state have already had mitigation projects designed to reduce or remove the impacts from underground mining and subsidence, subsidence may still occur in some areas. The dollar impact is difficult to predict.

Future Development

Businesses seeking to lay pipelines, electrical transmission lines, develop a well site, or build another type of business structure in an area subject to subsidence hazards are typically referred to the AML during the environmental review process. This contact helps ensure new, developing infrastructure can be routed around problem areas, or if more efficient and possible, the area can be mitigated for subsidence hazards before structures or individuals are exposed to the hazard.

Locations where mine subsidence may occur are located throughout the state in both populated and unpopulated areas. Development in locations where mine subsidence occurs certainly has the potential to impact individual homes or neighborhoods. While it is believed all mined out areas in Wyoming have been mapped, it is unknown if all locations of potential subsidence have been located. The uncertainty regarding the locations of more potential subsidence areas means there is the possibility development may occur in a subsidence-prone location without the knowledge of contractors or developers prior to development. Given this fact, there is no way to determine with certainty the likelihood development will occur in a subsidence-prone location. Therefore, it is difficult to put a risk factor to this hazard as it relates to development within Wyoming's borders.

Summary

PROPERTY AFFECTED: Low
POPULATION AFFECTED: Low
PROBABILITY: Medium
JURISDICTION AFFECTED: Hanna/Elmo, unincorporated areas in the county

Chapter XII. Snow Avalanches

Wyoming is one of the top-ranking states for avalanche hazard because of its rural character and mountain recreation. Skiers, snowboarders, and snowmobile operators are most commonly associated with avalanche hazards. However, motorists and others not engaging in recreation are also at risk of being caught in an avalanche. An avalanche is defined as a large mass of snow, ice, earth, rock, or other material in swift motion down a mountainside or over a precipice (Merriam-Webster). In the case of this evaluation, avalanche medium refers to snow.

An avalanche occurs when the stress (from gravity) trying to pull the snow downhill exceeds the strength (from bonds between snow grains) of the snow cover. There are four ingredients of an avalanche: a steep slope, a snow cover, a weak layer in the snow cover, and a trigger. About 90% of all avalanches start on slopes of 30-45 degrees; about 98% of all avalanches occur on slopes of 25-50 degrees. Avalanches release most often on slopes above timberline that face away from prevailing winds (leeward slopes collect snow blowing from the windward sides of ridges.) Avalanches can run, however, on small slopes well below timberline, such as gullies, road cuts, and small openings in the trees. Very dense trees can anchor the snow to steep slopes and prevent avalanches from starting; however, avalanches can release and travel through a moderately dense forest.

The Medicine Bow/Centennial Range and Sierra Madre mountains in southern Carbon County, due to their steep terrain, high elevations, and winter snows, experience avalanches every winter. Generally the avalanches occur in remote areas and have little impact, except when unwary backcountry travelers get caught and buried.

History

Avalanche fatalities provide the best indicator for locations of where events occur and what populations are most threatened. According to Colorado Avalanche Information Center statistics for the past 64 years (1950-2014), Wyoming ranks sixth among the eight states with the most avalanche fatalities. Wyoming avalanche deaths composed 7.5% of total avalanche deaths in the U.S. from 1950 through 2014 (Figure 12.1).

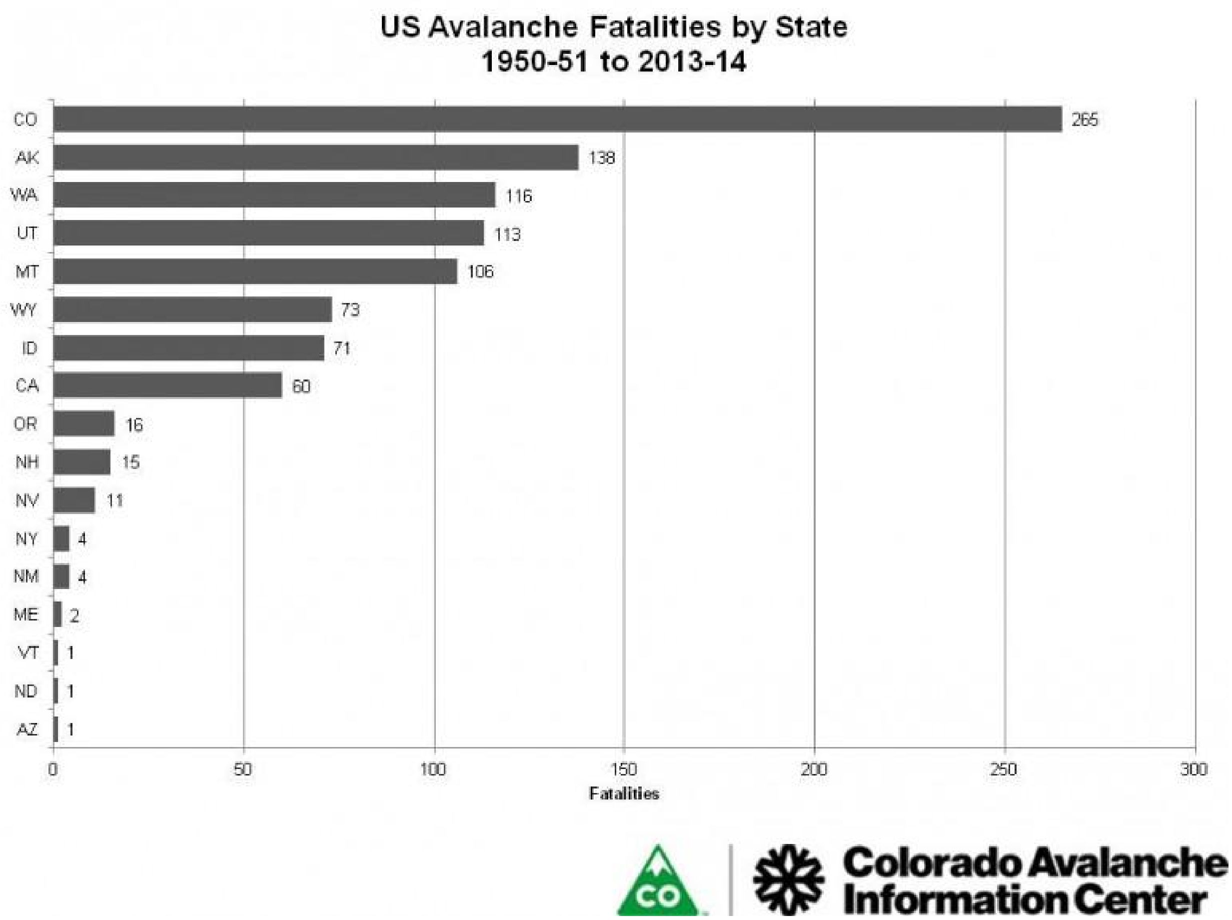


Figure 12.1 Chart highlighting Wyoming as the fifth most at-risk U.S. state for fatalities from avalanches. Figure adapted from the USDA Forest Service, Utah Avalanche Center.

Since 1913, there have been over 85 fatalities from avalanches with the majority resulting from individuals partaking in mountain recreation, most predominantly backcountry skiers (Figure 12.2). Although deaths occur primarily in the backcountry, motorists, residents, and workers in high angle, avalanche-prone terrain must be aware of the danger; at least five individuals have perished this way. In Figure 12.3 it is apparent that the majority of fatalities occurred in western Wyoming, in particular the Teton area. This area presents an increased population of outdoor enthusiasts; an increased population engaging in extreme winter sports; and the high angle, avalanche-prone character of the terrain.

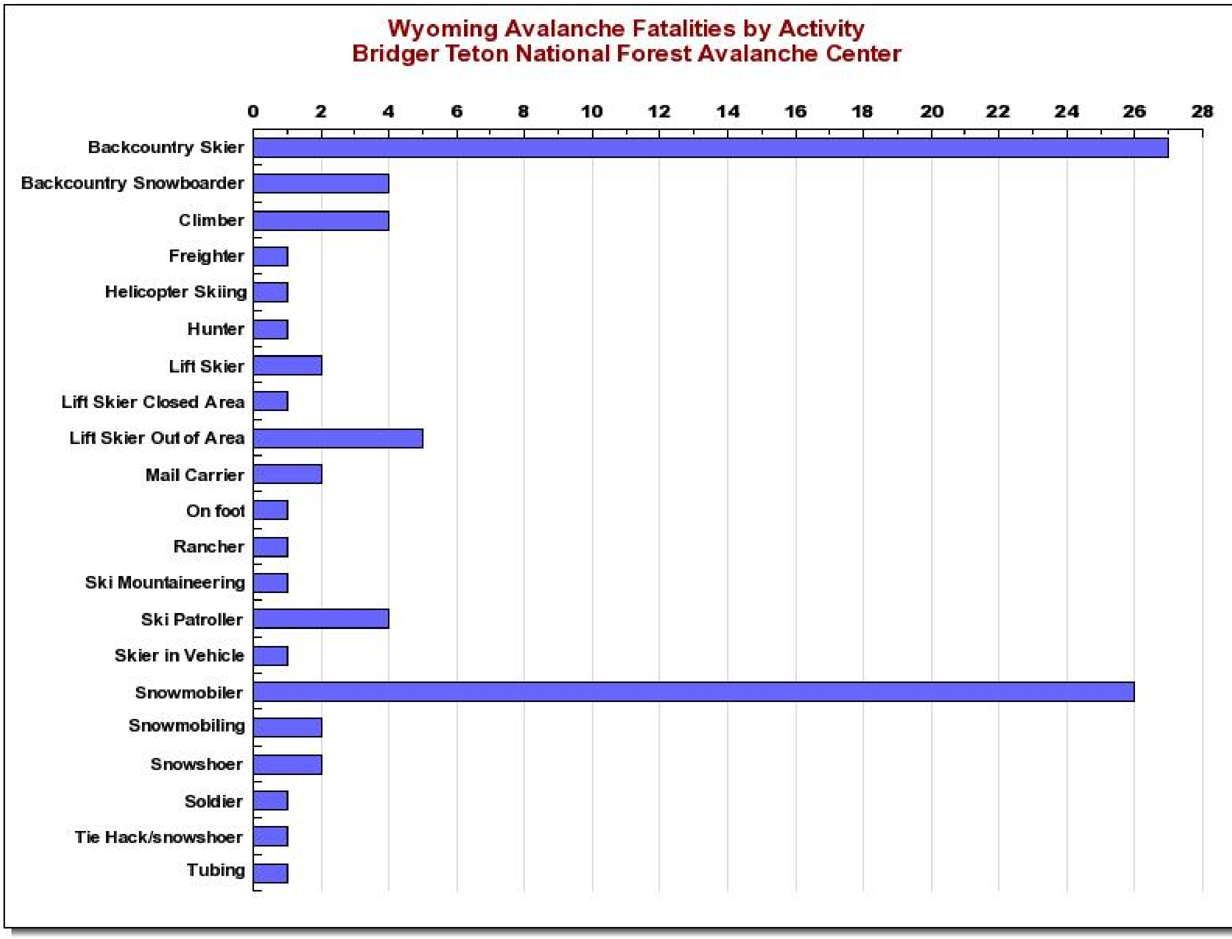


Figure 12.2 Wyoming avalanche fatalities by activity (1913-2014). Graph from the Bridger-Teton National Forest Avalanche Center.

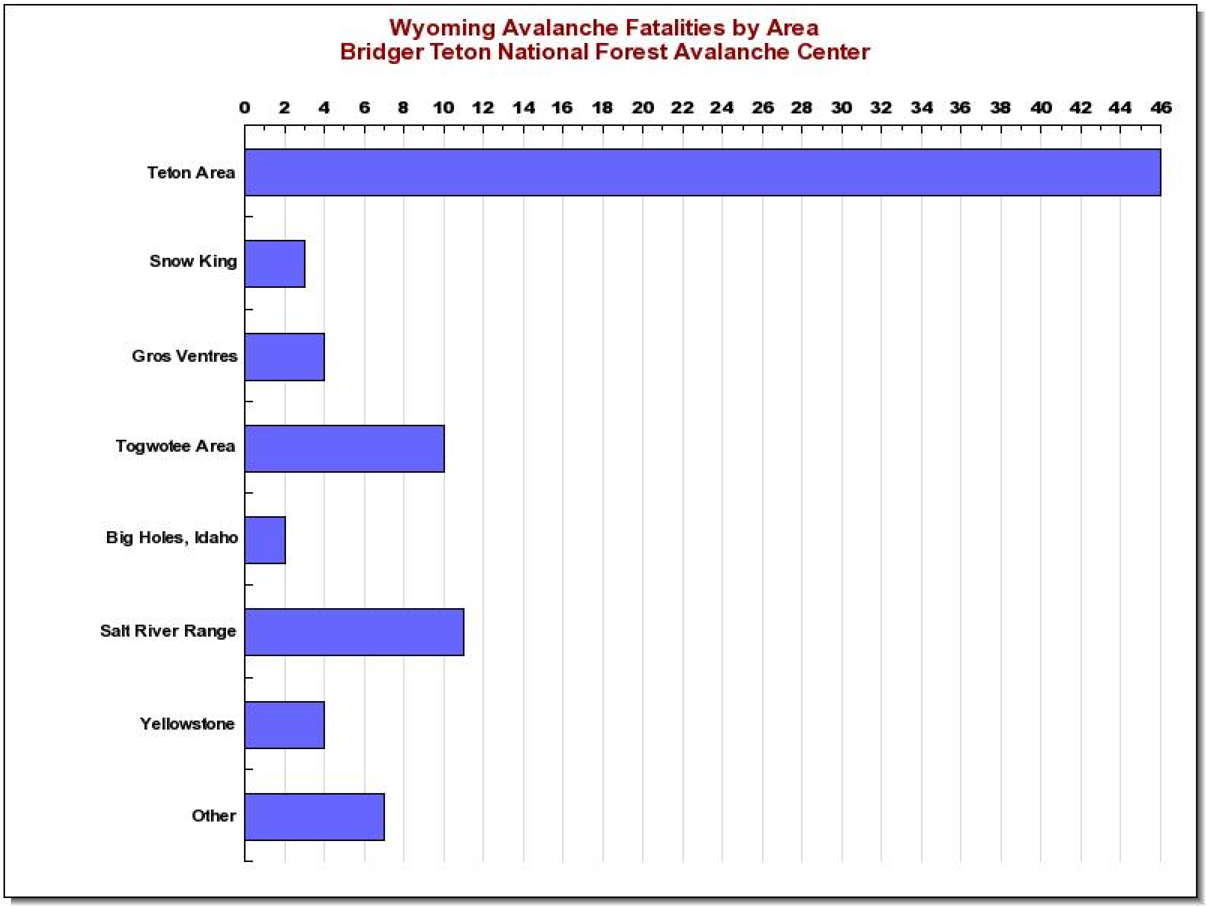


Figure 12.3 Wyoming avalanche fatalities by location (1913-2014). Graph from the Bridger-Teton National Forest Avalanche Center.

Western Wyoming and Teton County in particular have achieved notoriety nationwide for their avalanche hazard susceptibility. Carbon County has had four deaths in the past thirty years, with details on the incidents provided in Table 12.1. Figure 12.4 shows the locations of the incidents.

Table 12.1 Carbon County Fatal Snow Avalanche Events

Date	Age	County	Location	Activity/Travel
09 February 1985		Carbon	Rock Creek Knoll, Snowy Range	Backcountry skier
11 January 1998	21	Carbon	Battle Lake, Sierra Madre Range	Snowmobiler
26 December 2002		Carbon	West side of the Snowy Range	Snowmobiler
02 January 2008	44	Carbon	French Creek, Snowy Range	Snowmobiler

Source: Bridger Teton National Forest Avalanche Center

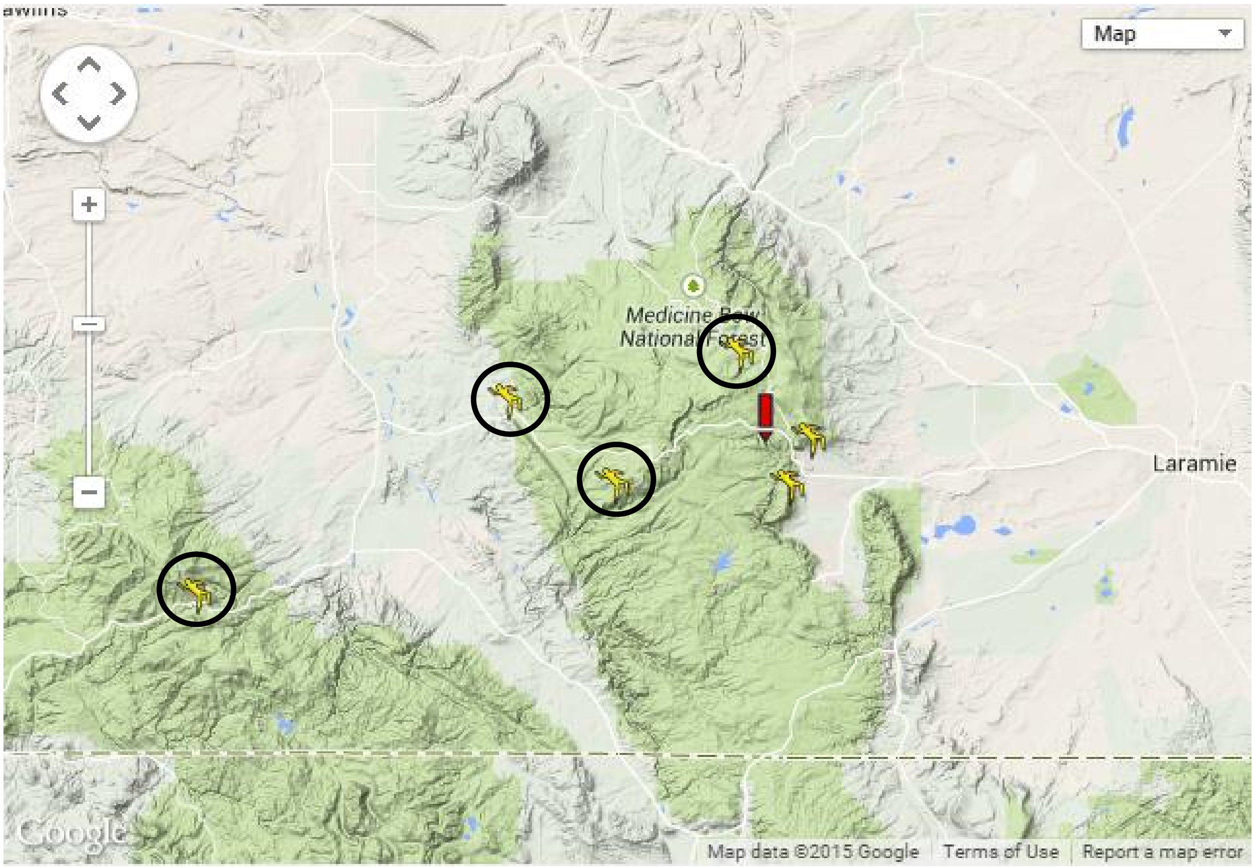


Figure 12.4 Wyoming avalanche fatalities. Map from the Bridger-Teton National Forest Avalanche Center (Carbon County incidents circled in black).

Impacts

Avalanches cause two primary hazards—road blocks and death or injury. Since 1994 there has been a trend of at least one fatality per year in Wyoming. Fatalities are the best-documented impact related to avalanches and are significant simply because of the nature of the hazard. Time is of the essence when a person is buried in an avalanche. Victims buried more than 30 minutes rarely survive. Most that do survive are dug out within 15-30 minutes, and these survivors are often aided by personal locator beacons and prepared backcountry partners that are also equipped with shovels and beacons. Furthermore, there are costs associated with “search and rescue” and removal of the injured or deceased.

Road blocks are another major concern where roads intersect an avalanche path. The major costs associated with road blocks are snow removal and traffic diversion, which both necessitate personnel and equipment. Another less frequent issue is the costs associated with rescuing motorists if they were involved in the avalanche. History and costs for avalanche road blocks are currently unavailable.

Future Impacts

Because avalanches are generally a backcountry hazard in mountainous areas and do not typically occur in populated areas, there is limited risk to significant portions of the population. The one segment of the population most vulnerable to avalanche danger is individuals taking advantage of winter recreation opportunities in the mountains, especially skiers, snowboarders, and snowmobilers. Skiers and snowboarders recreating within developed areas are less vulnerable to avalanche hazards, as ski area staff ensure known avalanche hazard areas within their boundaries are mitigated utilizing various methods. Those most vulnerable are those drawn to recreate outside developed ski areas where mitigation efforts may or may not be taken.

Given the popularity of winter recreational activities it is likely that backcountry travelers will continue to encounter avalanches in southern Carbon County. Based on historic events, avalanche fatalities occur once every 7.5 years.

Future Development

Avalanche vulnerability could increase with future development and population growth as there will be a higher number of people driving on roadways and taking part in backcountry recreation. It is unlikely that risk to structures will increase as long as future development is planned outside of avalanche hazard zones.

Summary

PROPERTY AFFECTED: Low
POPULATION AFFECTED: Low
PROBABILITY: High
JURISDICTION AFFECTED: County

Chapter XIII. Tornadoes

Wyoming, lying just west of “tornado alley,” is fortunate to experience fewer intense tornadoes than its neighboring states to the east. However, tornadoes remain a significant hazard in the state. Tornadoes are the most intense storm on earth having been recorded at velocities exceeding 315 mph. The phenomena results in a destructive rotating column of air ranging in diameter from a few yards to greater than a mile, usually associated with a downward extension of cumulonimbus cloud. Tornadoes are classified by their intensity by using the Fujita (F) Scale, with F0 being the least intense and the F6 being the most intense (Table 13.1).

Table 13.1 Fujita Scale of Tornado Intensity

Fujita Scale	Wind Speed	Damage
F0	40-72	Light
F1	73-112	Moderate
F2	113-157	Considerable
F3	158-206	Severe
F4	207-260	Devastating
F5	261-318	Incredible
F6	319-379	Inconceivable

The weakest intensity, F0, tornadoes describe more than half of Wyoming’s past tornadoes. The strongest tornado in Wyoming was an F4 with winds between 207 and 260 mph. The tornado was the highest elevation F4 tornado every documented. This tornado occurred in Teton County on July 21, 1987 and resulted in $500,000 in damages.

According to the Wyoming Climate Atlas, the State of Wyoming ranked 25th in the number of annual tornadoes (10), 33rd in fatalities (6 deaths per million people), 37th in injuries, and 36th in property damage ($49,339,505) (figure from Wyoming State Geological Survey) in the U.S. from 1950-1994 (excerpted from the Wyoming Climate Atlas). According to the Storm Prediction Center, Wyoming averaged 12 tornadoes and less than one death per year between 1981 and 2010. From 1950 to 2011, 619 tornadoes were reported in Wyoming. The combined damage in dollars from these events was $158 million.[4]

Tornado statistics, especially prior to the 1970s, must be viewed as incomplete since many twisters must have occurred without being witnessed. Wyoming's open rangelands experience little, if any, damage from these storms so many go unreported. In the 1990s, the Internet and Doppler radar increased the public's awareness of tornadoes with the potential of more being observed and reported. However, the trend in annual tornadoes has decreased by one third since 1976 and appears to have coincided with a major hemispheric weather pattern shift, despite the increased reporting based on Doppler radar vortex (circulation) signatures (excerpted from the Wyoming Climate Atlas).

History

Table 13.2 summarizes the history of damaging tornado events in Carbon County from 1950 to 2014.

[4] Methodology is based on . Kevin M. Simmons, Daniel Sutter and Roger Pielke. Normalized tornado damage in the United States: 1950-2011. Environmental Hazards, 2013, Vol. 12, No. 2, 132-147, http://sciencepolicy.colorado.edu/admin/publication_files/2012.31.pdf, accessed February 12, 2015.

Table 13.2 Carbon County Damaging Tornado Events: 1950-2014

Location	Date	Deaths	Injuries	Property Damage	Crop Damage	Total Damage	Fujita Scale	Information
Medicine Bow Mountains	16 Jul 1953	0	0	0	0	0		A tornado was reported in the Medicine Bow Mountains on the 16th. The storm did not affect a populated area, and other than uprooting a few trees, no damage was done.
	20 Jul 1958	0	0	30	0	30	F1	
	9 Jun 1960	0	0	0	0	0	F0	
	29 May 1964	0	0	0	0	0	F1	
Ryan Park	15 Jun 1966	0	0	$27,500	0C	$27,500	F1	Tornado touched down on Barrett Ridge and Ryan Park, 14 miles southeast of Saratoga, primary damage to forest, minor damage to a shed and some trailers at Ryan Park trailer park.
Encampment 15 SW	15 Jul 1967	0	0	$0	$2,750	$2,750		A tornado touched down in the Hayden Division of the Medicine Bow National Forest, damage to trees.
Saratoga 22 E	2 Jul 1976	0	0	$0	$275,000	$275,000	F2	A tornado touched down early in the afternoon in forest on Medicine Bow Mountains. It destroyed about 245 acres of prime timber, an estimated 3.75 million board feet. The area is about 1 mile south of Turpin Reservoir.
	14 Aug 1979	0	0	0	0	0	F0	
	14 Jun 1982	0	0	30	0	30	F0	
	14 Jun 1982	0	0	30	0	30	F0	
	14 Jun 1982	0	0	30	0	30	F0	
	14 Jun 1982	0	0	30	0	30	F0	
	25 May 1995	0	0	0	0	0	F0	
Seminoe Dam	6 Jun 1997	0	0	0	0	0	F0	
Fort Fred Steele	8 Jun 1997	0	0	0	0	0	F0	
Rawlins	Aug 10 1997	0	0	0	0	0	F0	

Impacts

Although counties have been effected to lesser and greater extents by tornado intensity, frequency, and damage, they nevertheless have struck every county in Wyoming, thus proving to be a considerable danger. In 2014 dollars, Carbon County ranks 7th out of 23 counties for reported damage (Table 13.3).

Table 13.3 Tornado Damage by County in 2014 USD (1907 - 2003)

County	Damage
Laramie	129,600,327
Goshen	10,124,467
Campbell	10,056,895
Crook	4,983,675
Niobrara	2,644,622
Fremont	1,766,632
Carbon	1,348,179
Big Horn	1,263,559
Natrona	1,168,827
Platte	1,163,073
Teton	1,030,427
Park	849,959
Converse	349,205
Sweetwater	348,605
Sheridan	326,135
Weston	314,524
Washakie	218,872
Albany	163,162
Lincoln	78,135
Hot Springs	59,822
Johnson	27,115
Uinta	26,458
Sublette	0
TOTAL	167,912,674

Table 13.4 Tornado Events by County (1950 - 2013)	
County	**Number of Events**
Laramie	107
Campbell	84
Goshen	73
Converse	40
Platte	40
Natrona	33
Crook	32
Niobrara	31
Big Horn	29
Weston	23
Albany	22
Sweetwater	20
Johnson	19
Fremont	18
Carbon	15
Sheridan	11
Park	8
Washakie	7
Lincoln	6
Hot Springs	4
Sublette	3
Uinta	3
Teton	1
TOTAL	629

Source: Tornado History Project

Future Impacts

Historical data demonstrates that the most critical area of the state for tornado hazard is the eastern one third, with the five most threatened counties being Laramie, Campbell, Goshen, Converse and Platte. The five least threatened counties include Teton, Uinta, Sublette, Hot Springs, and Lincoln (Table 13.4). Laramie, Campbell, Goshen, Crook, and Niobrara are the five counties that have received the most damage, while Sublette, Uinta, Johnson, Lincoln, and Hot Springs have the sustained the least damage.

Tornadoes will continue to occur in Carbon County. Based upon the historic record, one will occur every four years on average. The worst case historic tornado resulted in $1,144,155 damage in 2014 dollars. This should be considered to be the low end for maximum damage from a future event.

Future Development

Increased population and development can mean greater damage in the event a tornado strikes. Above-ground energy related development (wind turbines and oil and gas wells) could be subject to damage from tornadoes. Tornado shelters and basements become more important the greater the population in order to help prevent loss of life in the event of a tornado.

Future residential development would benefit from including basements and/or tornado shelters in new structures to help protect life safety.

Summary

PROPERTY AFFECTED: Medium
POPULATION AFFECTED: Medium
PROBABILITY: Medium
JURISDICTION AFFECTED: All jurisdictions in the county

Chapter XIV. Wildland Fires

Carbon County, because of its semi-arid climate and rural character, is vulnerable to catastrophic wildland fires, and, of all the fires in Wyoming, over 50% involve wildland areas. As defined by the National Interagency Fire Center (NIFC), a “wildland fire” is any non-structure fire, other than prescribed fire, that occurs in the wildland. Before discussing wildland fire hazard in Carbon County, some key terms should be defined. The term “wildland/urban interface” or WUI is widely used within the wildland fire management community to describe any area where buildings are constructed close to or within a boundary of natural terrain and fuel, where high potential for wildland fires exists. “Aspect” refers to the direction in which a slope faces. “Fuel” consists of combustible material, including vegetation, such as grass, leaves, ground litter, plants, shrubs, and trees that feed a fire.

A number of factors have resulted in an increase in the risk of wildland fire to life and property. As the population and the wildland/urban interface increases, so does the risk of wildland fire hazard. The past 100 years of forest fire suppression has led to heavy vegetation growth and thus greatly increased the potential fuel-load for a wildfire to burn. As the wildland/urban interface has grown into these densely packed forests, the potential for catastrophic wildland fires has increased as well. In addition, many areas of the west including Carbon County are experiencing large scale mountain pine beetle infestations. Pine beetle causes timber stand mortality, providing yet more fuel. Finally, climate change has had the effect of lengthening the fire seasons, with fires starting earlier and the season lasting longer. According to John Rutherford, the Carbon County Fire Warden, County fire resources respond to an estimated 600 calls per year as of 2009. Many of these are extrications necessitated by vehicle accidents during the winter months. The Rawlins Division of the Carbon County Fire Department had 2002 callouts in 2013 and 154 callouts in 2014.

Wyoming’s Forest Action Plan identifies fire in the wildland-urban interface (WUI) as a threat that is significant and expanding. Fire in the WUI impacts suppression strategies, tactics, costs, and also potentially firefighter and public safety. Lands in the WUI are often desirable for housing development due to amenities such as forests or other vegetation which in turn present a hazard to the development. The Forest Action Plan also identifies strategies and tactics to help reduce the risk of wildfire in the WUI. Increased areas of WUI are prompting policy makers and fire management organizations to respond to the need to mitigate wildfire risk.

Wyoming wildland fires are managed and supported to varying extents through cooperative efforts by the:

- Bureau of Land Management (BLM),
- Geospatial Multi-Agency Coordination (GeoMAC),
- Wyoming Fire Academy,
- Wyoming Wildland Fire Plan Action Team,
- National Park Service (NPS) Fire Management Program,
- US Fish and Wildlife Service (FWS) Fire Management Branch,
- National Interagency Fire Center (NIFC),
- Bureau of Indian Affairs (BIA) Fire and Aviation Management ,
- USDA Forest Service (USFS) Fire and Aviation Management,
- Wyoming State Fire Marshalls Office
- Wyoming Office of Homeland Security (WOHS)
- Wyoming State Forestry Division, and
- County and Local Fire Departments/Districts

In the past, the principal action plan for the state was the Wyoming Wildland Urban Interface Hazard Assessment produced by a joint venture of the Wyoming State Forestry Division, USFS, BLM, NPS, and other interested parties, with the BLM hosting the data. This is a Geographic Information System (GIS)-based mapping mission building on The Front Range Redzone Project in Colorado—the first fire-hazard mapping program of its kind. The Assessment maps fire hazard incorporating population density against slope, aspect, and fuels. The mapping analysis evaluates areas of varying wildfire vulnerability. The final output produces a Risk, Hazard, and Value (RHV) map displaying areas of concern (Redzones) for catastrophic wildland fires (Figure 14.3). The Wyoming Wildland Urban Interface Hazard Assessment builds on the work of earlier hazard methodologies and provides new and updated data to further enhance accuracy and scale.

Currently, the Wyoming Forest Action Plan and the Western Wildfire Risk Assessment are considered the primary strategic plans that address wildland fire management in the state. Additionally, the Wyoming Interagency Cooperative Fire Management and Stafford Act Response Agreement outline areas of cooperation and coordination with respect to fire prevention, readiness, detection, fuels management, suppression, information sharing, communications, and reimbursement for shared resources. The agreement is produced through a joint venture of the U.S. Bureau of Land Management (BLM); National Park Service, Intermountain Region; Bureau of Indian Affairs, Rocky Mountain Region (BIA); Fish and Wildlife Service, Mountain Prairie Region; U.S. Department of Agriculture, Forest Service Rocky Mountain and Intermountain Regions; and the Wyoming State Board of Land Commissioners, Office of State Lands and Investments, and Wyoming State Forestry Division.

The agreement is implemented at the county and local levels through Annual Operating Plans (AOP's). This Plan is between the USDI Bureau of Land Management (BLM) High Desert District, Wyoming State Forestry Division (WSFD), USDA Forest Service (USFS) Medicine Bow/Routt National Forest and Thunder Basin National Grasslands, USDI Fish and Wildlife Service, and Carbon County. In addition to local resources, these State and Federal resources fight fires in the county, either assisting local resources in the case of the state, or having primary responsibility on federal lands in the cases of the BLM and FS. In some cases, County equipment and volunteers may be the first resources on scene for federal fires.

According to the Wyoming Forest Action Plan, 2009 Resource Assessment, the mountain pine beetle populations are increasing in southern Albany and Carbon Counties. Most of the large diameter lodgepole pine forests in these areas are expected to be attacked by mountain pine beetle within the next 2 – 5 years. Mountain pine beetle susceptible hosts as small as five inches in diameter are currently being attacked and subsequently killed. Forest stand conditions combined with favorable weather conditions allowed mountain pine beetle populations to increase in both southern Wyoming and northern Colorado.

“The bark beetle epidemic in progress will be a long term problem for fire managers. Fire danger will initially increase due to the standing dead trees. The initial risk will decrease after a few years, but then increase again as the trees begin to fall in large numbers, probably in about 10 years. “

The dead trees left after epidemics are a source of fuel accumulation that will, in time, burn unless removed (http://www.firewisewyoming.com/index.html).

Table 14.1 County Fire Divisions

#	Location	Apprx # volunteers	Capabilities	# County Apparatus
1	Rawlins	15 City Vol. 11 City Paid 27 Co. Vol	Extrication, Hazmat, Search and Rescue, Structural and Wildland	15 FF, 2 Hazmat Trailers, 1 Hazmat Truck
2	Hanna	10-12	Search and Rescue, Structural and Wildland	6
3	Saratoga	32	Extrication, Hazmat, Search and Rescue, Structural and Wildland	9
4	Rock Creek	8	Structural and Wildland	4
5	Medicine Bow	12	Extrication, Limited Hazmat, Structural and Wildland	3
6	Elk Mountain	14	Extrication, Hazmat, Medical First Response, Search and Rescue, Structural and Wildland	5
7	Muddy Gap	5	Structural and Wildland	3
8	Baggs	8	Extrication, Structural and Wildland	8
9	Encampment	15	Extrication, Limited Hazmat, Search and Rescue, Structural and Wildland	5
10	Ryan Park	15	Extrication, Limited Hazmat, Structural and Wildland	4
11	Sinclair	4	Structural, Medical Response, Hazmat	2 City Refinery 3 + Hazmat Trailer

Source: LEPC

The towns and county work together in most of the communities, sharing fire stations, apparatus, volunteers, and equipment. The county has a Fire Warden, Deputy Warden, and Assistant Chief that are paid part-time.

History

The Wildland fire history for the State of Wyoming has been compiled in the Wyoming Multi-Hazard Mitigation Plan from various state and federal sources. Unfortunately the data does not provide detail to the county level. Table 14.2 lists some of the fires that have been started by lightning in Carbon County. Fires also start in the oil patch, under power lines, along the railroad and Interstate, and from other human causes. Table 14.3 and Figure 14.1 summarize the county's fire history for additional events that occurred between 1980 and 2012.

Table 14.2 Recorded Wildfire Events (1988 through 2003)

County	Location	Date	Deaths	Injuries	Estimated Property Damage	Estimated Crop Damage	Total Estimated Damage (current year USD)	Total Estimated Damage (2004 USD)	Information
Carbon	Saratoga	17-Aug-1986	0	0	$0	$6,000	$6,000	$10,221	During the afternoon, a lightning-caused fire burned $6000 worth of baled hay just southeast of Saratoga.
Park, Teton, Carbon, Sweetwater, and Natrona		1-Jul-1988	0	0	$364,430	$0	$364,430	$575,719	During the month of July, at least 59 fires were started by lightning from mostly high-based thunderstorms that produced little rainfall. These included very large forest fires such as the Clover Mist Blaze in Yellowstone National Park and the Lost Fire over the Big Horn Mountains of northern Wyoming. On a week-by-week basis, the breakdown of lightning fire is as follows. Before and including the 2nd, fourteen lightning fires were started. During the 10th through the 16th, 18 such fires were reported. From the 17th through the 23rd, there were eight fires. Between the 24th and 30th, ten lightning blazes occurred. Finally, on the 31st, there were four fires. According to the BLM for Wyoming, 3,644.3 acres were torched with an estimated lost resource value of $364,430. This does not include the fires started by lightning in Yellowstone National Park because this information is not yet available.
Park, Teton, Converse, Sweetwater, Lincoln and Carbon		7-Aug-1988	0	0	Same as 1 August 1988	$0	$0		With the continuation of the hot, dry weather, at least 29 fires were started by lightning during the month of August. The thunderstorms that were responsible for the ignitions were generally high-based and produced little rainfall. Most of these fires were relatively small, less than 100

Table 14.2 Recorded Wildfire Events (1988 through 2003)									
County	**Location**	**Date**	**Deaths**	**Injuries**	**Estimated Property Damage**	**Estimated Crop Damage**	**Total Estimated Damage (current year USD)**	**Total Estimated Damage (2004 USD)**	**Information**
									acres. However, the Dorn #2 fire, located in Washakie County, on August 14th, grew to 1514 acres. The largest blaze was the Fern Fire, located in Yellowstone National Park. That fire occurred on August 5th. The Fern Fire torched 2000 acres before it burned into the Clover Mist blaze (another fire ignited by lightning during the previous month of July). On a week-by-week basis, the breakdown of lightning fires is as follows. From the 1st to the 6th, there were 10 such blazes. Between the 7th and 13th, another 10 lightning fires occurred. During the 14th to the 20th, 6 fires were reported. Finally, from the 21st through the 2nd, there were 3 blazes. According to the BLM for Wyoming, 4,159 acres were torched with and estimated lost resource value of $415,900.

Table 14.3 Total Estimated Acres Burned by Year (1980-2012)

County	Year	Total Estimated Acres Burned
Carbon	1980	38.0
Carbon	1981	211.2
Carbon	1982	48.0
Carbon	1983	767.5
Carbon	1984	55.0
Carbon	1985	694.9
Carbon	1986	14.5
Carbon	1987	806.7
Carbon	1988	884.8
Carbon	1989	43.7
Carbon	1990	542.3
Carbon	1991	6.0
Carbon	1992	260.5
Carbon	1993	2,931.1
Carbon	1994	328.0
Carbon	1995	19.0
Carbon	1996	443.5
Carbon	1997	3,798.0
Carbon	1998	2,471.5
Carbon	1999	9,723.0
Carbon	2000	4,179.9
Carbon	2001	11,941.7
Carbon	2002	10,461.2
Carbon	2003	449.0
Carbon	2004	311.4
Carbon	2005	62.2
Carbon	2006	70.9
Carbon	2007	285.7
Carbon	2008	15.6
Carbon	2009	9.9
Carbon	2010	445.2
Carbon	2011	1,924.8
Carbon	2012	13,096.9
	Total	**67,341.6 acres**

Source: Carbon County, NED, GeoMAC 2012, USGS

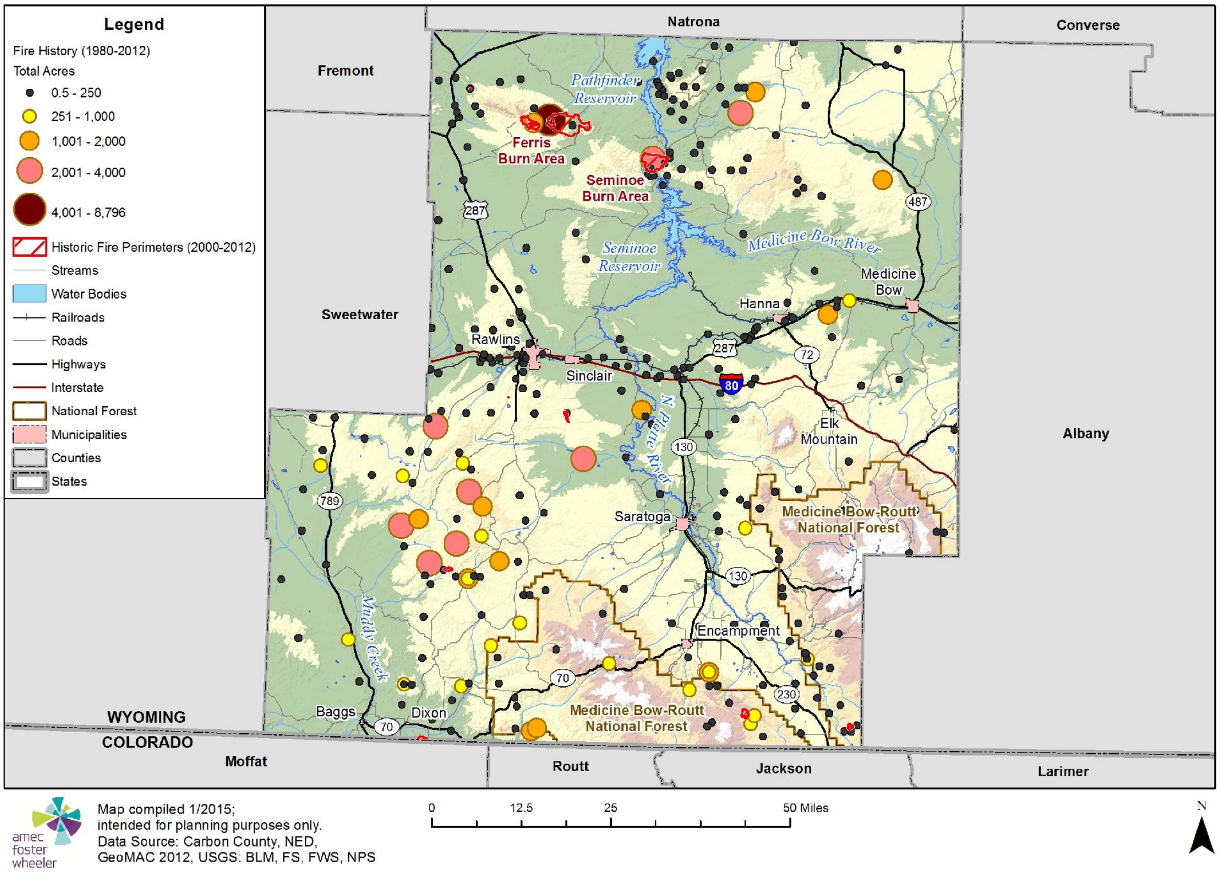


Figure 14.1 Carbon County Wildland Fire History (1980-2012)

Impacts

GIS is a tool that is used to compare, capture, input, output, store, manipulate, analyze, model, and display spatial data. In the case of the Wildland Urban Interface Hazard Assessment, wildfire hazard vulnerability is determined by comparing values such as slope, vegetation, housing density, and aspect. The following is from the *Wyoming Wildland Urban Interface Hazard Assessment Methodology*—a report written by the Wyoming State Forestry Division:

The Wildland Urban Interface Hazard Assessment uses three main layers to determine fire danger—Risk, Hazard, and Values. The following lists include the data used to create each of the three layers.

1. Risk – Probability of Ignition
    a. Lightning Strike density
    b. Road density
    c. Historic fire density
2. Hazard – Vegetative and topological features affecting intensity and rate of spread
    a. Slope
    b. Aspect
    c. Fuels – Interpreted from GAP Vegetation information.
3. Values – Natural or man-made components of the ecosystem on which a value can be placed.
    a. Housing Density – Life and property

4. Non-flammable areas Mask – a mask was created to aid in the analysis for areas that will not carry fire such as water and rock areas. These areas show in the final assessment as a zero value for hazard.

The county has been successful in obtaining grant funds to carry out wildland hazard fuel reduction projects on private lands in the Ryan Park area and Elk Mountain areas, south of Rawlins, and east of Savery. Landowners who sign up get reimbursed to clear their own property and/or hire a contractor to do the work. (John Rutherford, County Fire Warden) The federal agencies are pursuing fuel management projects on their lands adjacent to interface and other areas.

There is no County-wide Community Wildfire Protection Plan. The statewide Wildland Urban Interface Hazard Assessment and its resultant outputs serve two primary purposes: assisting in prioritizing and planning mitigation projects and creating a communications tool to which agencies can relate to common information and data. With the mapping analysis evaluating areas of varying wildfire vulnerability, the final output will result in a Risk, Hazard, and Value (RHV) map displaying areas of concern (Redzones) for catastrophic wildland fires. The Redzone map for Carbon County is below. According to the map the towns of Rawlins and Saratoga are within the Redzone.

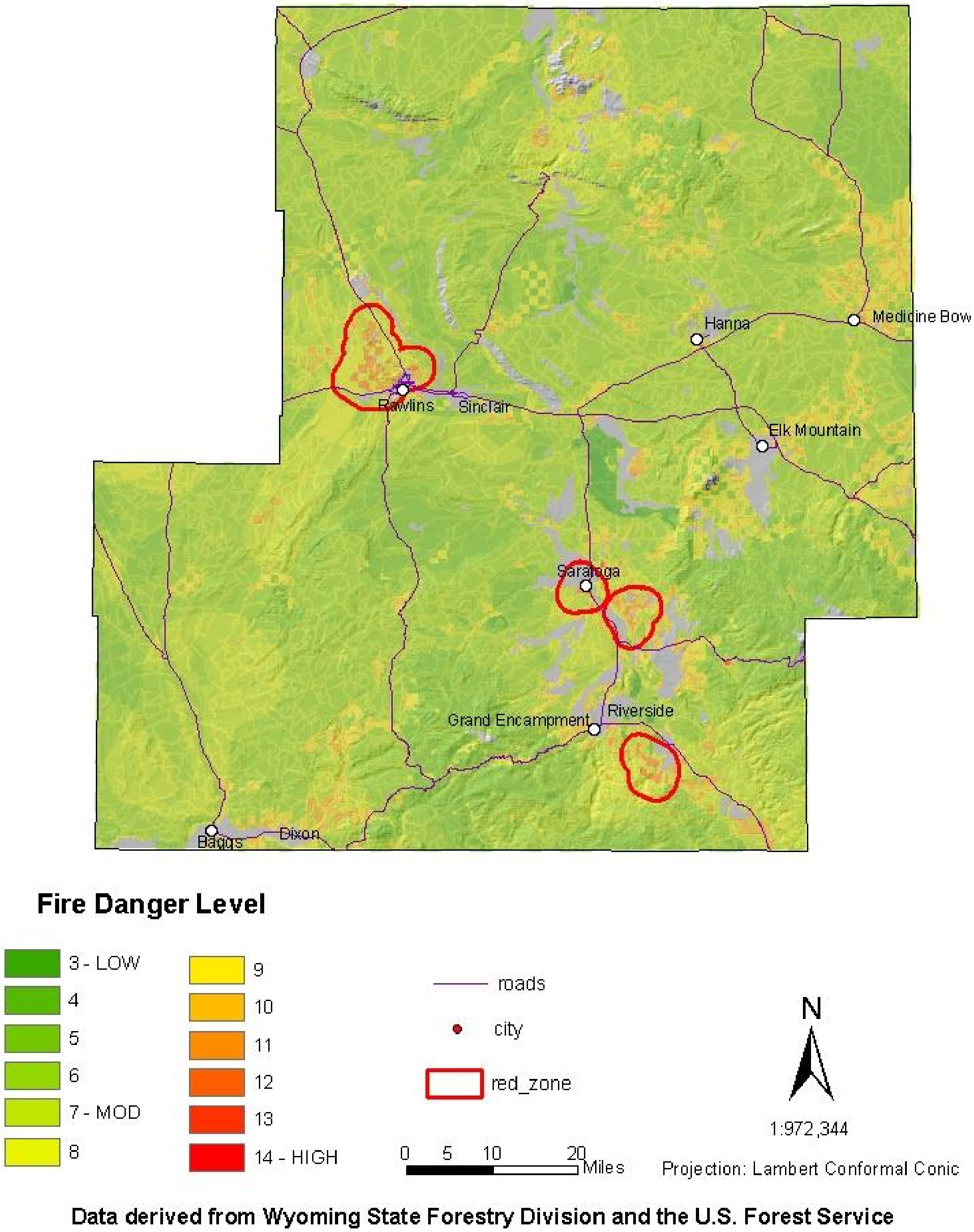


Figure 14.2 Carbon County Wildland Fire Base Map with Redzones (Wyoming Wildland – Urban Interface Hazard Assessment)

Another method of estimating potential future impact is to determine the value of structures that are located within Redzones, or wildland fire building exposure values. Wildland fire building exposure value is the value of buildings that can be potentially damaged by wildland fire in an area.

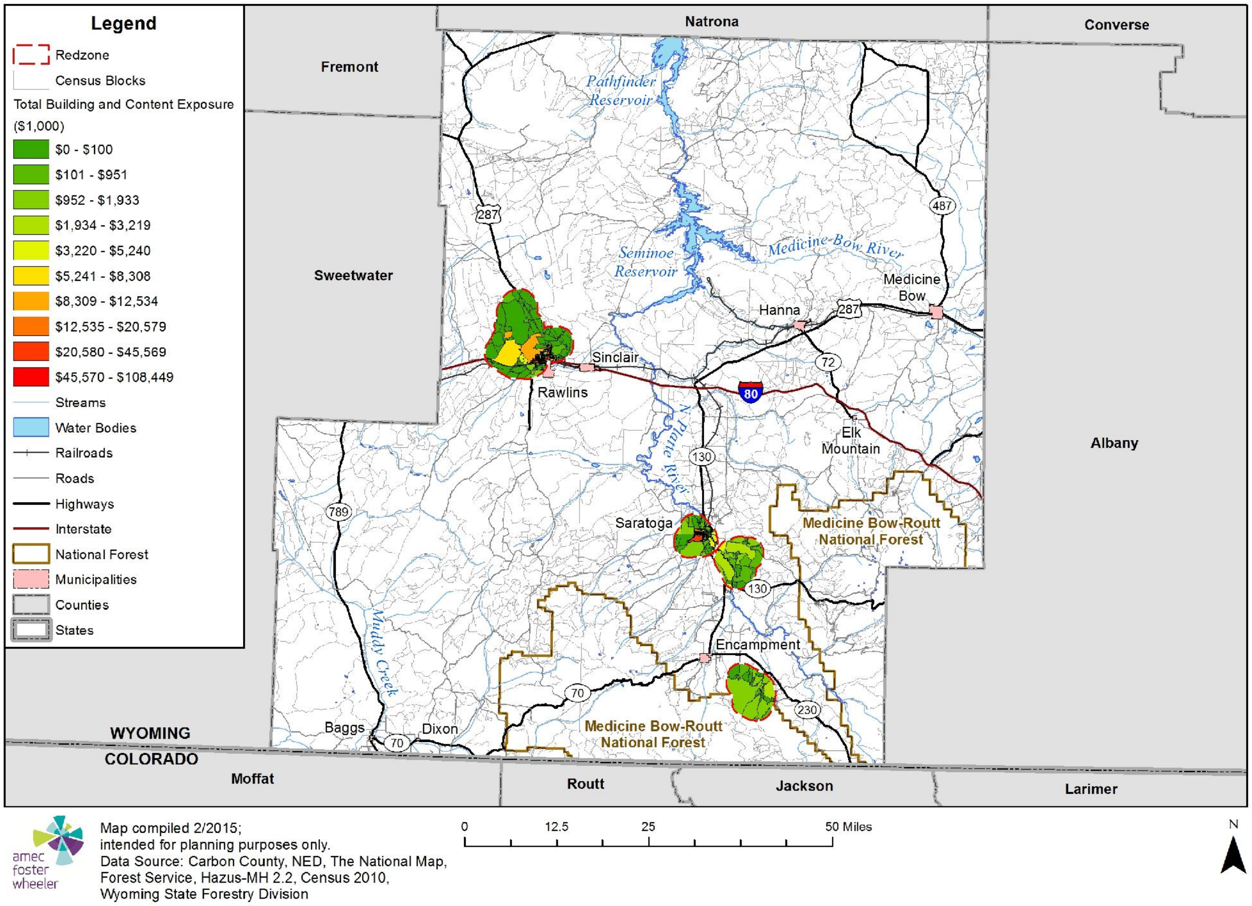


Figure 14.3 Carbon County Wildland Fire Critical Hazard Area Building Exposure Values (thousands of dollars)

Future Impacts

Wildfires occur somewhere within the county on an annual basis. Based on GIS analysis, Carbon County has $2,145,809,000 in combined building and contents exposure value potentially at risk to wildland fires (2010 Census and HAZUS 2.2). Though it is not likely that the areas at risk will simultaneously face a completely destructive event, this figure provides the upper end of what could be affected. Taking geographic considerations into effect, the figure is most likely to be one-tenth or less of this figure for any one event. Smoke from wildland fires can also affect public health if the event is either extremely intense and/or sustained over a period of time. It is difficult to put a dollar figure on the potential effects of wildland fire on human health.

Future Development

Throughout Wyoming there remains potential for future home construction in more than 400 square miles of undeveloped, forested private lands adjacent to fire-prone public lands. Carbon County has 52.2 square miles that meet this definition (2014 Wyoming Multi-Hazard Mitigation Plan, pg. 207). Building homes in these high-risk areas would put lives and property in the path of wildfires.

Beetle-killed timber in the Sierra Madre Range, southern Carbon County

Summary

PROPERTY AFFECTED: High
POPULATION AFFECTED: Medium
PROBABILITY: High
JURISDICTION AFFECTED: County-wide including potential smoke impacts; Rawlins and Saratoga considered within the Redzone.

Chapter XV. Wind

Wind is the movement of air from areas of high pressure to areas of low pressure, or can be the result of microbursts associated with temperature variations in the atmosphere, usually associated with thunderstorms or dry thunderstorms. Wind, because of its constant presence in Wyoming, is taken in stride by the population and often overlooked as a hazard. In retrospect, wind is a damage-causing hazard and warrants review in Carbon County's hazard mitigation plan.

History of Wind and Impacts

Located in Wyoming's "wind zone", Carbon County is in a gap in the Rocky Mountains that acts as a funnel that concentrates westerly winds as low pressure and storm fronts pass through. It is the short-lived but strong wind gusts associated with thunderstorms and dry microbursts that tend to cause damage in the county.

SHELDUS reports only those high wind incidents causing losses. Incidents between 1960 and 2012 are reflected in the map above. Wind events reported in SHELDUS number 1,067 events, or one third (33%) of the loss causing events in Wyoming. Though high in number of events, losses from wind events represent only 3% of costs to Wyoming residents from hazards, or just under $13 million.

The National Climatic Data Center's online database lists 356 high wind and thunderstorm wind events of at least 40mph in the county between 1950 and 2014. The National Weather Service's criteria for issuing a high wind advisory is sustained winds of at least 40 mph or gusts of at least 58 mph. Three of the NCDC events had associated damage and are described in Table 15.1.

Table 15.1 Damaging Wind Events

Date	Damage	Description
02 Aug 1995	$5,000	Thunderstorm winds damaged a shed and broke some windows in Hanna.
14 Apr 2000	$100,000	A wind gust to 70 mph blew out windows in about 35 vehicles on the east side of Rawlins, WY.
20 Apr 2001	$50,000	Strong thunderstorm wind gust (65 knots) rolled a mobile home 3 times in Echo Springs, resulting in 3 injuries, 35 Miles West South West of Rawlins
29 Dec 2011	$8,670	Roof of Grand Encampment Opera House damaged. Grand Encampment Business Park also damaged.

Future impacts

Gusty thunderstorm or microburst winds will likely continue to occur in Carbon County and will possibly result in isolated property damage in developed areas.

Future Development

Wyoming's high winds are becoming a positive economic development factor as renewable wind energy is being developed around the state. Future development such as buildings and infrastructure will need to continue to follow building codes and design criteria for high winds.

Summary

PROPERTY AFFECTED: Low
POPULATION AFFECTED: Low
PROBABILITY: Medium
JURISDICTION AFFECTED: All jurisdictions in the county

Chapter XVI. Windblown Deposits

Windblown deposits are fine-grained materials such as sands and silts that are mobilized by wind. Wyoming has some of the most significant windblown deposits in the U.S. Strong winds can mobilize and significantly move sand or silt grains in much of Wyoming. Many of the mapped deposits in Wyoming are somewhat stabilized, but a significant number are still active. The Seminoe Dune Field extends from the Seminoe Reservoir to the west for approximately 30 miles and is approximately 15 miles wide at its widest point.

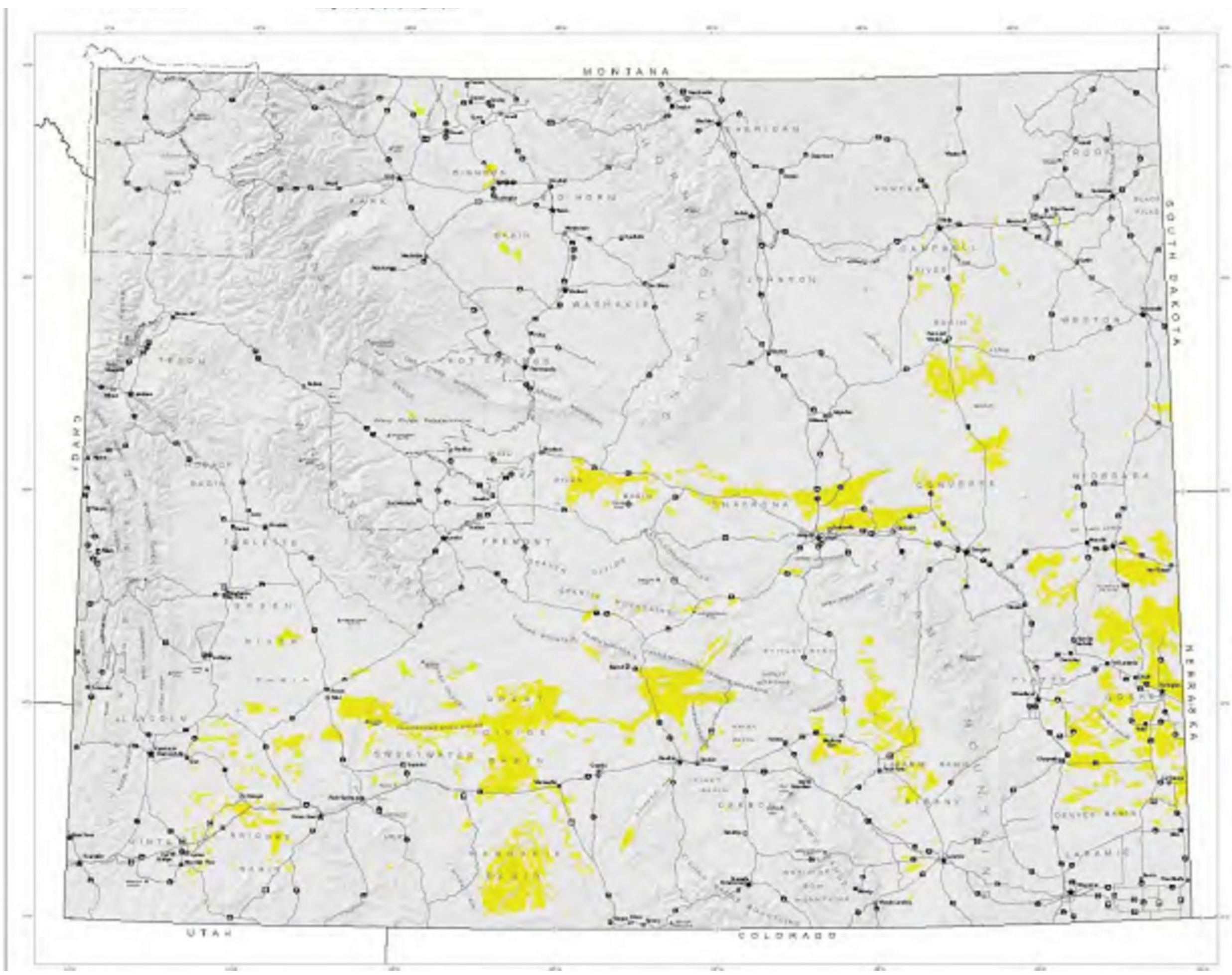


Figure 16.1 Wyoming Windblown Deposits

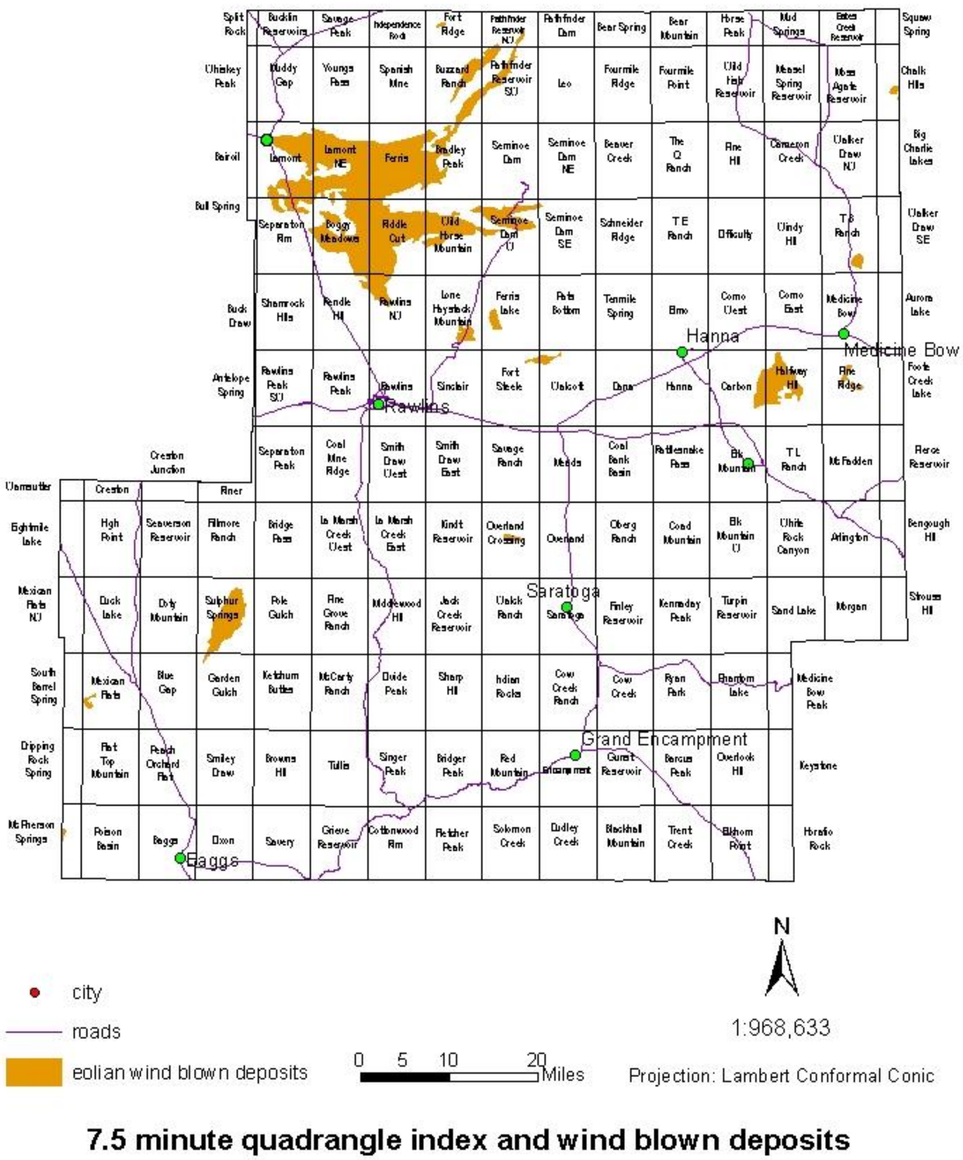


Figure 16.2 Carbon County Windblown Deposits

History

Carbon County's location in the "wind zone," where a gap in the Rocky Mountains funnel and concentrate westerly winds, makes windblown deposits more likely to cause damage because of the force of the wind carrying the deposits. However, there is no well-documented history of problems associated with windblown deposits in Carbon County or the rest of Wyoming.

Impacts

If stabilizing vegetation is stripped from the surface because of some form of development, previously stable dunes may mobilize and encroach on human development. In the Casper area dunes have moved onto subdivision properties, temporarily closed roads, and impinged on homes. The problems were easily fixed, and no significant dollar losses have been associated with windblown deposits. Further, there is no recent history of the recreating public requiring search and rescue in Wyoming dune areas utilizing public assets.

Future Impacts

As development continues in Wyoming and Carbon County, more land is disturbed. Currently stabilized dunes may be disrupted, leading to nuisance problems with windblown deposits. Because the level of damage has been historically low and the cost of damage is not expected to increase, it is believed that development in Wyoming has a limited impact of the risk presented by windblown deposits. Due to the limited nature of damage generated by windblown deposits, it is also believed the vulnerability of Wyoming residents is limited.

Future Development

Windblown deposit maps should be considered when development is planned. Windblown deposits can inhibit transportation, affect agricultural lands and contribute to dust storms. Windblown deposits could temporarily block roads in the vicinity of Seminoe Reservoir, but at present the area is sparsely developed.

Summary

PROPERTY AFFECTED: Low
POPULATION AFFECTED: Low
PROBABILITY: Medium
JURISDICTION AFFECTED: All jurisdictions in the county

Chapter XVII. Winter Storms & Blizzards

Severe winter storms affect far more people in Wyoming than their summer counterparts, even though they are inherently less violent. Severe snowstorms are so extensive that they usually require a day or two to cross and completely exit the state. Blizzard conditions bring the triple threat of heavy snowfall, strong winds and low temperatures. Poor visibility and huge snowdrifts are major hazards caused by blowing snow. These storms disrupt work, make travel difficult or impossible, isolate communities, kill livestock by the hundreds or thousands and sometimes leave human fatalities in their wake.

Fortunately, the simultaneous combination of heavy snowfall, strong winds, and low temperatures are fairly rare, even in Wyoming. In some places, however, such as southeastern Wyoming, strong winds often lift snow crystals from the ground in quantities large enough to produce hazardous ground blizzards without accompanying snowfall.

Data show that Lake Yellowstone and Lander lead the state in frequency of major snowstorms with an average of about five such days per year. The time of year when they receive these storms, however is quite different. At Lake Yellowstone and throughout most of western Wyoming, major snowstorms strike most often in the mid-winter months. In Lander and most other parts of the state (excluding the high mountains) major snowstorms hit with greatest frequency in March and April. The springtime snowstorm peak is particularly destructive for ranchers because it coincides with calving and lambing seasons. Notable early winter storms have hit Carbon County in October.

History

The winter storm history in Carbon County extends from 1871 to present. Based on the data Carbon County has a winter storm of significance once every 2.4 years. There have been a few winter storms in the county that have caused great damage, economic impact, and brought about change in livestock practices. A history of storms that caused damage, significant closure of highways, and/or impacts to the livestock industry between 1871 and 2013 is in Table 17.1. An additional 97 winter storm events were recorded in NCDC. These events did not have any damage estimates or event details, so they are not included in Table 17.1. Instead, Table 17.2 summarizes the number of winter storm events per year. The dataset did not return any events prior to 2009, though the entire NCDC database from 1950 to 2014 was searched.

Particularly bad storms occurred in 1886, 1949, 1980, 1996 and 1997. The data were derived from the monthly Storm Data reports from National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC). Other sources are unpublished reports from the Wyoming Office of Homeland Security, newspaper accounts, and periodicals from public libraries. The winter of 2007-08 was particularly bad for frequent winter storms. Numerous storms were severe enough and with enough blowing and drifting snow to required closure of the Interstate. The emergency shelter was opened five times during this winter for stranded motorists and other needing shelter.

The winter of 2008 was particularly bad, with numerous severe winter storms and high winds. Interstate 70 was closed repeatedly, forcing shelters to be opened to accommodate stranded and vulnerable people. The storms also shut down access to oil fields.

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
Cheyenne to Rock Springs to Fort Washakie	02-Dec-1871	26-Feb-1872					A blizzard began on the evening of December 2nd and lasted two days, affecting the entire length of the tracks across Wyoming. A train was stranded by snowdrifts blocking the tracks. Work trains were sent out from both the east and the west ends to clear the tracks. However, the winds continued to blow so severely that the tracks were blown full of snow and closed almost as fast as they were cleared. Finally, after several days of strenuous efforts, both work crews and the hungry passengers reached safety but the pattern for the next three months was set. Drifts went up to 15 feet high.
Statewide	28-Feb-1905	1-Mar-1905	Several	Several		Loss of 50% of livestock operations	The winter of 1886-1887 was the earliest severe economic disruption. The snow that winter came early and grew very deep. Then, a freak thaw turned much of this to water. As cold weather moved back in, this froze into a crust of ice, which prevented cattle getting through to the forage underneath. These conditions, accompanied by blizzard of unusual severity, caused a loss of over 50 percent among the state's livestock operations. The snow was six feet deep on the level between Mountain Home and Woods Landing. On February 12, 1887 the storms were still raging over the state, and the snow was packed so hard that stages could drive over it. Trains were stalled on their tracks. The winter of 1886-1887 sounded the death knell of the open range cattle business as it had been during previous years. The real disaster to cattlemen had been in the winter of 1886, which has been called "The Equalizer". My father a boy of 8 at the time recalls that spring of 1887. In certain sheltered area he and companions amused themselves stepping from one carcass to another without ever setting foot to the ground.
Statewide	11-Jan-1888	13-Jan-1888	great loss of life			Thousands of cattle	This blizzard covered a number of states. The combination of strong winds, snow and rapid temperature drops made it very dangerous. Loss of life was great and thousands of cattle died.
Statewide	25-Mar-1931	28-Mar-1931	2				This blizzard covered several states. Temperatures dropped rapidly. Strong winds drifted snow badly, blocking highways for several days. Two people died in

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							Wyoming.
Eastern and central Wyoming	2-Jan-1949	20-Feb-1949	17		$9,000,000	Livestock losses were great	Most significant blizzard in Wyoming's history. Snowfall measured up to 30 inches, with drifts 20 to 30 feet high. Within 24 hours of the storm initiation, all bus, rail, and air traffic was halted. There were thousands of stranded motorists and rail passengers. Thirty-three hundred miles of state highway lay in the storm area, there was an estimated loss of 15% of the state's cattle. Seventeen people perished, along with 55,000 head of cattle and more than 105,000 sheep. As the storm continued, Wyoming cities began to run out of food in the stores. Several other blizzards followed the first. "It is estimated from reports of field men that 4194 people received aid through the Interior Department operations; that 104,839 cattle and 421,479 sheep were relieved; and that help was given to 994 ranches. A total of 12,894 miles of roads and feed lanes were opened; 1457 tons of food, fuel, and other supplies were hauled over opened roads; 26,604 tons of feed was hauled over opened roads or made available; and the total number of operated machine hours, for snow moving equipment only totaled 18,310. Wind speeds were 30 to 78 mph with an average of 55 mph. Temperature was below zero. Funding: $200,000 initial relief, later an additional $500,000, federal government turned over $125,000. Out of the $700,000 appropriated, more than $450,000 was returned. Damage and cost: Highway department normally spent $265,000 for snow removal, this storm generated costs of $618,029.50; total economic loss is estimated at more than $9 million. Time spent: December through March snow removal equipment spent 139,000 hours; man-hours amounted to 201,000 hours. Cost of these operations to the government is estimated at $169,550.64, with a unit total cost of approximately $13.15 per mile of road opened and approximately $9.25 per operated hour of snow moving equipment.
Statewide	25-Mar-1950	27-Mar-1950	1				Heavy snow and strong winds covered much of several states, including Wyoming. Snowfall up to 60 inches fell in Wyoming. There was widespread damage to power

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							lines and many cars and trains were stranded. Drifts were up to 16 feet and one person died in the state.
Statewide	18-Feb-1955	20-Feb-1955	4				This blizzard covered several states, including Wyoming. Up to 11 inches of snow fell with winds to 65 mph and temperatures below zero. There were 4 deaths in Wyoming.
Statewide	22-Mar-1957	25-Mar-1957					Heavy snow fell over several states, including Wyoming. Drifts were from 10 to 25 feet deep and many motorists were trapped in cars or snow bound in towns.
Statewide	28-Oct-1961		5	4	$27,500	$0	Snow accompanied by high winds began early afternoon and continued through the evening. Three people were killed and four were injured in auto accidents caused by low visibility. Two hunters were lost and died in the storm.
All of Wyoming	15-Sep-1965	17-Sep-1965	0	0	$2,750,000		A cold wave moved over the state the evening of the 15th and caused considerable damage to crops, trees, power and phone lines, stopped much of the transportation by closing roads, caused an estimated 5% shrinkage in marketable livestock and a few death losses in livestock. Temperature dropped quite low for so early in the season and the heavy (18"-22") band of snow from the southwest part of the state to the northeast part was by far the heaviest so early in the season.
Southern half	2-Apr-1968	3-Apr-1968	3	0	$275,000	$0	A blizzard started early evening over the southern half of the state and continued until late afternoon of the 3rd. Three people were killed in blizzard associated incidents. Numerous people were stranded and there were numerous outages of power and communications.
Statewide	13-Mar-1973	14-Mar-1973	0	0	$275,000		Heavy snow and strong winds blanketed the state, with roads, streets, and farms and ranches blocked. There were numerous power and communications outages as well as livestock losses.
Statewide	27-Mar-1975	28-Mar-1975	0	0	$2,750,000		A severe blizzard with winds 40 to 50 mph and gusts to 75 mph, snow and temperatures down to 0 degrees started the morning of the 27th and continued to the evening of the 28th. Highways were blocked and some people stranded for varying times but all rescued. Some damage to signs, windows, trees, etc., but most damage to livestock, especially new born, and to cows (udders frostbitten, etc.). The storm was most severe over the

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							eastern half of the state and most of the damage was there also.
Most of Wyoming	31-Dec-1975	1-Jan-1976	0	0	$275,000	$0	Heavy snow with strong winds began early on the 31st of December 1975 and continued through most of the State through most of the storm. Livestock losses were minimal and most of the damage is attributed to loss of time, cars stuck, rescue missions and snow removal.
All of Wyoming	16-Nov-1977	19-Nov-1977	1	0	$275,000	$0	Snow with large accumulations entered the state the afternoon on the 16th, accompanied by very cold temperatures. Some blowing and drifting caused hazardous driving conditions in many areas. The snow ended by the morning of the 18th but was quickly followed by strong gusty westerly winds which moved the large amounts of loose snow into ground blizzards with severe problems on highways, ranches, etc. One man was killed at Rawlins as he tried to walk into town along the interstate from the west. Numerous people were stranded along the highways and in towns and ranches until the roads were opened.
Statewide	5-Dec-1978	7-Dec-1978	0	0	$275,000	$0	This very heavy snowstorm dumped over a foot of snow across much of the state causing road and airport closures in many areas throughout the state. Winds gusting to 75 mph caused extensive blowing and drifting snow, stopping both local and interstate travel. This storm isolated livestock from ranchers, contributing to subsequent substantial losses of cattle and sheep in Wyoming.
Statewide	1-Jan-1979	31-Jan-1979	0	0	$2,500,000		Numerous heavy snows combined with prolonged extremely cold temperatures have caused widespread damage across much of Wyoming during the month of January. Estimated loss of 2700 sheep and 2000 cattle with projected losses of calves and lambs to 35,000 head are reported. Also, numerous towns and communities across the state have extensive damages to their water systems due to frozen water mains and sewer systems. Emergency Winter Storm Relief Aid of $2.5 million is currently being asked for by the state.
Statewide	10-Jan-1980		0	0	?		Much of the state was paralyzed. Freak thunderstorms occurred in Casper, Riverton, and Lander areas. Roads were closed and some motorists stranded. Interstate 25

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							from Laramie to the Utah state line was closed by winds approaching 80mph in south-central Wyoming. An estimated 60 vehicles were in the ditch along I-80 west of Rawlins. Reported 90 mph winds in Medicine Bow blew out car and truck windows and a large window in a cafe. Many schools were closed.
Statewide	25-Jan-1980	27-Jan-1980	4	?	?		Snow and blowing snow from the morning of the 25th to the evening of the 27th swept across Wyoming dumping a record 11 inches of snow on Cheyenne in a 12-hour period. Heavy snow and slick road surfaces due to bitter cold temperatures closed many highways and interstates, including I-80 from the Nebraska state line to Rock Springs. Near Bitter Creek Hill, 38 miles east of Rock Springs, 21 cars and trucks were involved in a pile-up on the afternoon of the 25th. Two men were killed at 7 p.m. on the 26th, 9 miles east of Powell when the driver lost control, ejecting both men. One fatality occurred on the 27th at 11:30 a.m. on I-80 near Rock Springs when a car slowed down because of poor visibility and slick roads and the truck driver, trailing the vehicle, failed to slow down in time and crushed the back end of the car in which the victim was riding. A man died about 12:45 p.m. on the 27th when the flatbed truck he was driving 95 miles south of Gillette jack-knifed on a left-hand curve and rolled on its top. Schools in Cheyenne were closed at noon on Friday and did not reopen until Wednesday. Most churches in Cheyenne remained closed on Sunday. Casper thermometers dipped to record lows of -27 degrees on Saturday, -28 degrees on Sunday night, and -32 degrees Monday morning. Cheyenne reported temperatures at 0 or below zero for a period of 79 hours. Weather-related problems may have caused the derailment of 12 empty freight cars at Point of Rocks at 6:45 a.m. on the 25th.
Statewide	14-Oct-1980	16-Oct-1980	4	5	?	$0	Snow beginning on the evening of the 14th moved across the state leaving 13 inches in Laramie and 11 inches in Rawlins. Most other areas received from 1-3 inches. Some highways were closed on the 16th, including Interstate 80 between Cheyenne and Walcott Junction (100 miles). One person was killed and three

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							others injured in a storm-related two-vehicle accident southwest of Cody on the 15th. The storm apparently contributed to a light plane crash that killed one man near the airport at Rock Springs at 9:10 p.m. on the 15th. Blizzard-like conditions were contributing factors when a freight train plowed into the caboose of a grain train 13 miles southeast of Laramie about 4 p.m. on October 16, killing two crewmembers and injuring two others. Schools in Laramie, including the University of Wyoming, were closed on the 16th. Many hunters were stranded. Tree limbs snapped causing power outages in Rawlins and Sinclair.
	1-Dec-1982		1	0	?	$0	A major winter storm dumped heavy snow in the state Wednesday and Thursday morning. Casper was hit the hardest with 24 inches of snow, breaking the previous 24-hour total. The Wind River Canyon between Shoshoni and Thermopolis also reported 24 inches. Elsewhere in the basins and plains, amounts varied from 5 to 11 inches. Winds to 40 mph caused blizzard conditions in the central and northeast areas causing drifts of 5 to 8 feet deep. One death was attributed to this storm.
	25-Mar-1983	26-Mar-1983	0	0	$2,750	$0	Several hundred miles of state and federal highways were closed as a strong spring snowstorm moved east. Snow, with accumulations up to 8 inches in the southwest, was blown about by 20 to 30 mph winds causing ground blizzard conditions.
Statewide	20-Dec-1983	25-Dec-1983	0	?	$2,750,000	$0	The worst arctic outbreak ever in December hit WY full force with almost all of the state remaining below zero for five days. Overnight lows in the 20 to 40 below range were common, with quite a few towns setting record Dec lows. Most WY residents fared much better in the cold than mechanical items. A malfunctioning transformer left the town of Lander without power for 12 hrs., and the extreme temperatures damaged numerous vehicles. The greatest damage, however, occurred to homes and businesses as hundreds of water pipes froze and burst. The State Capitol Building in Cheyenne, for example, suffered almost a quarter of a million dollars damage due to burst water pipes.
	26-Nov-1984		1	1	$27,500	$0	Eight inches of snow was reported on Beaver Creek, 10

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							miles south of Encampment in Carbon County; 5.5 inches snow was logged at nearby Saratoga. One man was killed and one injured when the fatality's car slid broadside into oncoming traffic south of Laramie.
Northern and west-central Wyoming, South-central mountains	6-May-1988	7-May-1988	0	0	$0	$0	The strong low pressure system both at the surface and aloft moved slowly northeastward to extreme southeast Montana by the 7th. This storm unleashed very heavy snow over most areas with elevations above 6000 feet MSL in the north and west sections of Wyoming. Since this storm had begun the morning of the 6th more than 20 inches of new snow had fallen in the Big Horn Mountains of northern Wyoming, while there was 6 to 10 inches of snow at Yellowstone National Park. Additionally, more than 10 inches of new snow was on the ground near Pinedale, located in west-central Wyoming, and the Snowy Range to the west of Laramie. More snow fell at these locations during the 7th. By 1335 MST on the 7th, Arrowhead Lodge in the Big Horn Mountains had a total of 3 feet of new snow on the ground. Bear Lodge, located in the Wyoming Black Hills, had 24 to 30 inches of new snow by the afternoon of the 7th. Numerous trees and power lines were downed by very wet snow, with several communities without electricity through much of the 7th.
Entire State	2-Feb-1989	6-Feb-1989	0	0	$0	$0	Record cold temperatures gripped the cowboy state from the 2nd through the morning of the 6th, the coldest in at least 5 years. Many locations had at least 80 to 100 consecutive hours of subzero readings. Wind chills from 50 to 90 degrees below zero accompanied the cold. Most overnight lows were between minus 20 and minus 40 degrees with maximum temperatures struggling above 15 or 20 degrees below zero. On the morning of the 3rd, Sheridan set a record low of minus 32, eclipsing the old record of 24 degrees below zero, set in 1985. Casper had a record low 27 degrees below zero. The minimum at Cheyenne was minus 24, one degree shy of the record low for the 3rd, dating back to 1883. Additionally, Weston, located over far northern Wyoming, dropped to 47 degrees below zero while locations in Yellowstone Park dipped lower than minus 40 degrees.

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							These low temperatures, including several records, were typical through the 6th. The maximum temperature for Cheyenne on the 3rd was 18 degrees below zero. Not only was that a record low maximum, but the second coldest such reading since weather records have been kept at Cheyenne, back more than 100 years. During the morning of the 6th, the temperature at the capitol city finally rose above zero. The record is 120 hours, set in December 1983. Due to this Arctic episode, February was the coldest February ever for Casper. It was also the worst cold spell for Gillette in a decade.
Statewide	21-Dec-1989	22-Dec-1989	0	0	$0	$0	As a result of the combination of calm winds, a bitterly cold arctic air mass and deep snow cover, extremely low minimum temperatures occurred across the cowboy state during the morning of the 22nd. Many of these temperatures were not only record lows for the date, but also the coldest ever for December. The lowest temperatures were generally over the Eastern two-thirds of Wyoming. Recluse, in the far Northeast corner, had a low of 50 degrees below zero. Other lows included 47 below in Redbird, 40 below at Douglas, 35 degrees below at both Sheridan and Gillette, 34 degrees below zero in Laramie, 28 below at both Casper and Cheyenne, 23 below in Cody, 14 below at Farson and 13 degrees below zero in Lander.
Southern Wyoming	11-Feb-1994		0	?	?	$0	Snow fell heavily at times across southern Wyoming. Eleven inches of new snow fell at Rock Springs closing I-80 for a time. Cheyenne observed near blizzard conditions that evening. Seven inches of snow combined with 35 mph gusts caused 40 automobile accidents in and near Cheyenne.
All except the Southwest Corner	21-Oct-1995	23-Oct-1995	0	0	$1,000,000	$0	Heavy snow and strong winds caused blizzard conditions over much of Wyoming. Snowfall amounts ranged from four inches at Rock Springs and Gillette to seventeen inches at Casper Mountain. Generally, six to ten inches of snowfall was common. Winds gusted to 55 mph and caused blizzard conditions with drifts up to five feet deep. Reported drifts of two to four feet were common. Many roads were closed from the 22nd to the afternoon of the 23rd due to drifting and near zero visibilities. Many

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							travelers were stranded across the state until the 23rd and a number of hunters had to be rescued. Power was out for a time in various places, due to downed power lines from the heavy snow and strong winds.
In and near most mountains	1-Nov-1995		0	0	$0	$0	Snow fell over most of Wyoming, with areas in and near the mountains receiving significant snowfall. Most of these areas had between 6 and 10 inches of snow, with the largest amount being 11 inches at Story (Sheridan County). Due to the snow, Highway 70 between Baggs and Encampment (Carbon County) was closed during the afternoon.
Statewide	18-Dec-1990	22-Dec-1990	0	0	$27,500	$0	A major winter storm followed by a bitterly cold Arctic outbreak, plagued most of Wyoming for about 2 to 4 days. Heavy snows with strong winds occurred on the 18th over the far western part of the state, with up to a foot in the mountains. Light snows of 2 to 6 inches generally occurred over the rest of the state, except in the far southwest where storm totals approached 15 to 20 inches by 1800 MST on the 19th. Bitterly cold Arctic air started spilling into the state after 1200 MST on the 18th on brisk northern winds. On the 19th and 20th, wind chills dropped to -40 to -75 degrees at times in many areas. The coldest temperatures occurred on the 21st and 22nd, with most areas from -25 to -45 degrees. Minus 50 degree readings were reported at Worland and near Jackson. Casper set an all-time record-low of -41 degrees on the 21st. Major roads affected by the snow and winds were confined to the far west and southwest. The worst conditions occurred along Interstate 80 from Rock Springs to Rawlins on the night of the 19th and 20th where snow and strong winds closed the road, stranding many people. The bitter cold caused power outages in some places, most notably in Jackson. Schools and other events were widely canceled due to the cold weather.
Green Mountains, Natrona, Rock Springs/Green River, Red Desert, Flaming Gorge, Southeast	20-Jan-1996	21-Jan-1996	0	0			Winds were sustained between 40 and 50 mph from Jeffrey City and Casper, southeast to just east of the Laramie Mountains. Wind gusts were between 55 and 65 mph, with the strongest gust being 71 mph, 10 miles south of Wheatland between 1753 and 1909 MST.

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
Sweetwater, Southwest Carbon, North Carbon, Snowy Range, North Laramie Mountains, Laramie Valley, Laramie Mountains, Platte							Highway 191, south of Rock Springs was closed due to blowing snow from 2300 to 0600 MST.
Southwest Carbon, North Carbon, Snowy Range, Laramie Valley, Laramie Mountains	23-Jan-1996	24-Jan-1996	0	0			Widespread blowing snow created near zero visibilities over the south central part of the state. Interstate 80 was closed during that time from Walcott Junction to Laramie.
Kemmerer, Uinta, Rock Springs/Green River, Red Desert, Flaming Gorge, Southeast Sweetwater, Southwest Carbon, North Carbon	24-Jan-1996		0	0			Strong winds and heavy snowfall created blizzard conditions in southwest and south central Wyoming. Winds gusted to around 50 mph over the area. Snowfall was from 12 to 18 inches in Evanston, with 3 to 6 inches over the rest of the area. Many roads, including I-80 in the southwest corner, were closed due to the snow and blowing and drifting snow. A number of travelers were stranded in the southwest corner. Some snowplows in the area even became stuck and stranded due to the poor conditions.
Yellowstone National Park MT, and ID; north and south Absarokas, Teton Range, Jackson Valley, Wind River Mountains, Star Valley, Salt River Range, Snowy Range	27-Jan-1996	28-Jan-1996	0	0			Heavy snow and strong winds were over the western mountains and the Snowy Range. Fifteen to 40 inches of snow fell, with the greatest amount being 40 inches in some of the west facing mountains. Jackson saw 24 inches of snow in 24 hours, which was the largest 24-hour snowfall ever recorded for that city. Some roads in the area were closed on the 28th. In addition, winds were from 55 to 70 mph with gusts more than 100 mph over the open, higher areas. The strong winds caused considerable blowing and drifting snow.
Converse, Niobrara, southwest Carbon, north Carbon, Snowy Range, north Laramie Mountains, Laramie Valley, Laramie Mountains, Platte, Cheyenne Foothills	25-Oct-1996	26-Oct-1996	0	0			Heavy snow and strong winds created blizzard conditions in much of south central and eastern Wyoming. The snow and winds closed many roads in that area, especially in and near the southeast mountains. The heaviest snowfall was in the Laramie Mountains and Snowy Range, where 12 to 18 inches of snow was reported. Other snowfall amounts in the area were 7 inches in Laramie, 8 inches in Douglas and 5

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							inches in Lusk. Only 1 to 4 inches fell in parts of the southeast plains. Winds gusted to near 50 mph and produced near zero visibilities. Drifts as high as 5 feet were observed in the Laramie Mountains between Cheyenne and Laramie. The strong winds and snow caused power outages to many rural areas in south central and southeast Wyoming.
Southwest Carbon, north Carbon, Snowy Range, Laramie Valley, Laramie Mountains, Cheyenne Foothills, Pine Bluffs	9-Jan-1997	11-Jan-1997	0	0			Heavy snow that began on the 9th and ended on the 10th combined with strong winds to create whiteout conditions in southeast and south central Wyoming and the Nebraska panhandle. I-80 was closed between Cheyenne and Big Springs, NE due to blowing and drifting snow on the 10th from 0100 to 0645 MST, and Nebraska Highway 71 was closed between Scottsbluff and Kimball from 0100 until 0830 MST. Some snowfall totals include 3 inches in Scottsbluff, NE; 4 inches at Kimball, NE; 7 inches at Sidney, NE; 5 inches at Potter, NE; 6 inches at LaGrange; 4 inches at Cheyenne; and 8 inches at Snowy Range Ski Area. Additionally, I-80 was closed January 11 for a few hours at night between Rawlins and Laramie, and for almost 24 hours between Laramie and Cheyenne.
Southwest Carbon	25-Jan-1997		0	0			Strong winds combined with snow to create whiteout conditions in south central Wyoming. Highway 287 was closed north of Rawlins by 1900 MST due to blowing and drifting snow. Sustained winds were 40 to 45 mph with a gust to 63 mph at Rawlins at 2150 MST.
Converse, Niobrara, southwest Carbon, north Carbon, Snowy Range, north Laramie Mountains, Laramie Valley, Laramie Mountains, Platte, Goshen, Cheyenne Foothills, Pine Bluffs	4-Apr-1997	5-Apr-1997	0	0			Strong winds combined with snow amounts of generally 8 to 12 inches to create widespread blizzard conditions in southeast Wyoming and the Nebraska panhandle. By 2045 MST on the 4th, all roads had been closed in and out of Cheyenne except for I-25. Closed and impassable roads became the norm from the evening of April 4 through April 6 due to blowing and drifting snow. Many automobile accidents occurred as a result of the treacherous conditions, and many power lines were downed due to the weight of snow. Many livestock were killed by the snow and accompanying cold temperatures because the storm occurred in the calving season. The highest snow amount was 12 inches at Albin and Lusk,

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							and sustained winds were generally 40 to 50 mph through the event.
North Carbon, Laramie Valley, Laramie Mountains	12-Oct-1997		1	30	$25,000	$0	A Utah man died of head injuries after his pickup truck slid on black ice on a bridge and rolled. The accident occurred on I-80 at the Arlington interchange. An accident near Laramie involving a bus injured at least 30 people. Icy conditions created a 20-mile long traffic backup on westbound I-80 near the summit rest area between Laramie and Cheyenne.
Converse, Niobrara, southwest Carbon, north Carbon, Snowy Range, north Laramie Mountains, Laramie Valley, Laramie Mountains, Platte, Goshen, Cheyenne Foothills, Pine Bluffs	24-Oct-1997	25-Oct-1997	0	0	$100,000	$10,000	An early season blizzard dumped up to 20 inches of snow in areas of southeastern Wyoming, downing power poles and power lines as well as making many roads impassable. Wet, wind-driven snow damaged trees in addition to unharvested milo, corn, and sunflower fields. Many motorists were stranded on impassable roads or when vehicles slid off roads. High School athletic events were postponed, and high school bands and athletic teams were stranded when their buses could continue no further. The following occurrences were documented as occurring on the 24th. Semi-tractor trucks with trailers tipped over after jackknifing on I-80 near Sinclair and at milepost 340; no damage estimates were available. The Wyoming Highway Patrol received 198 accident reports by 1645 MST, compared to the normal of 30 to 50. I-25 was closed from the Colorado border to Wheatland at approximately 1600 MST. I-80 was closed the entire length of Wyoming, from border to border, by late evening. The following occurrences were documented as occurring on the 25th. I-80 remained closed from the Nebraska border to Rock Springs. A Wyoming Department of Transportation employee received minor injuries when the snow plow he was operating flipped over east of Cheyenne. Postal delivery service from Cheyenne was shut down for the first time in at least 15 years. Two hunters were rescued in the Snowy Range near Arlington after spending the previous night in the Medicine Bow National Forest; they had entered the Snowy Range north of Centennial the morning of the 24th, and became lost after the onset of the blizzard. The Wyoming Highway Patrol received 252 accident reports

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							since 0800 MST on the 24th, several times the normal figure.
Southwest Carbon	9-Nov-1997	10-Nov-1997	1	0	$8,000	$0	An 81-year-old Rawlins man died when his car slid off an icy Rawlins street, crashing through a small fence and tumbled over a 17-foot retaining wall, landing on its roof. Several inches of snow fell on November 9, making roads slick. M81VE
Converse, Niobrara, southwest Carbon, north Carbon, Snowy Range, Platte	6-Mar-1998	7-Mar-1998	0	19	$65,000	$0	A winter storm affected parts of southeast Wyoming, with a total of 11 inches of snowfall reported in Rawlins, 10 inches at Lusk and Hanna, and 8 inches of snowfall was reported across Platte County. The Wyoming Highway Patrol received 19 reports of automobile accidents involving injuries due to snow packed roads, and another 90 accidents without injuries between midnight and 1917 MST.
Snowy Range	17-Jun-1998		0	0	$0	$0	Heavy snow up to 8 inches fell over the higher elevations of the Snowy Range. The snow stranded travelers on the Snowy Range Pass. Two snowplows slid off of curves and into ditches as they tried to plow the Pass.
North Carbon, Laramie Mountains	5-Oct-1998		0	0	$0	$0	Law enforcement officials reported that the summit of I-80 and Highway 210 were closed due to whiteout conditions at the higher elevations of these roads. The Town of Buford also had whiteout conditions.
Southwest Carbon, north Carbon, Snowy Range, Laramie Mountains, Cheyenne Foothills, Pine Bluffs	18-Dec-1998	19-Dec-1998	0	0	$0	$0	A winter storm dumped 12 to 18 inches of snow on the southwest mountains, and 8 to 10 inches of snow on parts of the adjacent plains. Interstates 80 and 25 in southeast Wyoming were closed due to icy conditions and poor visibilities.
Southwest Carbon	11-Feb-1999		0	0	$30,000	$0	A winter storm dumped 8 to 12 inches of snow across southwest Carbon County. In addition, strong winds overturned 10 semi-trailers along I-80 in Carbon County.
Southwest Carbon	27-Mar-1999		0	2	$37,000	$0	Ice on U.S. Highway 287 caused a collision between two pickup trucks. The driver of one of the pickup trucks was seriously injured and was extricated from the vehicle. The accident occurred 6 miles south of Muddy Gap at 0730 MST. Another accident occurred 30 miles north of Rawlins, in which a person lost control of their vehicles on the ice. The vehicle slid into the ditch and rolled 3 times. The driver sustained a broken arm. The accident occurred at 0715 MST.

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
Southwest Carbon, Snowy Range, Laramie Mountains	28-Sep-1999		1	1			Snow fell over parts of south central and southeast Wyoming, with snowfall of 8 inches reported at Elk Mountain, and 6 inches at Buford. Icy bridges resulted in an accident on I-80, 15 miles east of Rawlins, which killed one person and injured another. F68VE
Converse, Niobrara, southwest Carbon, Snowy Range, Platte	16-Feb-2000	17-Feb-2000	0	12	$100,000		Heavy snow fell over parts of south-central and eastern Wyoming, resulting in icy roads and numerous accidents. I-80 was closed for a while between Laramie and Rawlins. Around 8 inches of snow accumulated in Rawlins, with 6 inches reported in Douglas, Wheatland, and Lusk.
Southwest Carbon, north Carbon, Snowy Range, north Laramie Mountains, Laramie Valley, Laramie Mountains, Platte, Cheyenne Foothills	22-Sep-2000	24-Sep-2000	0	0	$100,000		Heavy snow fell over south central and southeast Wyoming over a two-day period, with 5 to 9 inches common. Elk Mountain, reported 12 to 14 inches of snow while Cheyenne, recorded a record 10.5 inches. I-80 between Laramie and Rock Springs, as closed during much of the storm, stranding up to 1200 travelers, mostly in Rawlins.
North Carbon, Laramie Mountains, Platte, Cheyenne Foothills	16-Dec-2000	17-Dec-2000	0	0			Strong winds were reported over the mountains and foothill areas of southeast Wyoming, with gusts as high as 83 mph recorded near Chugwater, and gusts up to 73 mph at Arlington. I-80 was closed for a few hours for localized conditions due to blowing snow.
Converse, southwest Carbon, north Carbon	7-Feb-2001		0	0			Heavy snow fell in a swath from south central into east central Wyoming, with as much as 11 to 13 inches of snow reported in Rawlins and 6 to 7 inches in Douglas. A 250-mile stretch of I-80 was closed for much of the day between Laramie and Rock Springs, with many secondary roads also closed.
Converse, Niobrara, north Carbon, Laramie Valley, Laramie Mountains, Platte, Goshen, Cheyenne Foothills, Pine Bluffs	21-Apr-2001	22-Apr-2001	0	0	$100,000		The second major winter storm in 10 days produced heavy snow over much of southeast Wyoming, with blizzard conditions in some spots. Twelve to 16 inches recorded in Wheatland and Cheyenne. All roads out of Cheyenne, were closed again, as was much of I-80. Power outages were also reported in parts of Laramie County as winds gusted to around 40 mph.
Converse, Niobrara, southwest Carbon, north Carbon	13-Mar-2002	14-Mar-2002	0	0	$10,000		Heavy snow fell across a swath of southeast Wyoming from near Rawlins to Lusk. Lusk was buried under 24 to 26 inches of snow, which caused a drive-in canopy to collapse. Douglas reported around 18 inches of snowfall

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
							while Rawlins and Shirley Basin recorded 12 to 15 inches. Many roads in the area were closed for more than 24 hours.
Converse, north Carbon, north Laramie Mountains, Laramie Valley, Laramie Mountains, Platte, Goshen, Cheyenne Foothills	17-Mar-2003	19-Mar-2003	0	0	$100,000		A powerful winter storm produced heavy snow and blizzard conditions over much of southeastern Wyoming over a 2.5-day period, closing most roads and isolating many areas. Snowfall amounts of 2 to 3 feet were reported over the Laramie Mountains west of Cheyenne. Snowfall amounts from 12 to 20 inches were common over the adjacent plains from Douglas to Cheyenne, with Cheyenne recording just over 18 inches. In addition, gusty winds from 30 to 45 mph combined with the snow to produce drifts from 6 to 10 feet in some areas.
North Carbon – Snowy Range	27-Apr-2005		0	0	$0	$0	
North Carbon, Snowy Range, Southwest Carbon	28-Mar-2007		0	0	$0	$0	
Snowy Range	5-Dec-2008		0	0	$0	$0	
Snowy Range	13-Dec-2008		0	0	$0	$0	
Snowy Range	6-Jan-2009		0	0	$0	$0	
North Carbon	24-Jan-2009		0	0	$0	$0	
North Carbon	27-Jan-2009		0	0	$0	$0	
Snowy Range, North Carbon	23-Mar-2009		0	0	$0	$0	
Snowy Range	26-Mar-2009		0	0	$0	$0	
Snowy Range	3-Apr-2009		0	0	$0	$0	
Southwest Carbon, North Carbon	4-Apr-2009		0	0	$0	$0	
Snowy Range	25-Oct-2010		0	0	$0	$0	
Snowy Range, Central Carbon	18-Dec-2010		0	0	$0	$0	
Snowy Range, Central Carbon, Southwest Carbon	20-Dec-2010		0	0	$0	$0	
Central Carbon	29-Dec-2010		0	0	$0	$0	
Snowy Range, Sierra Madre Range	15-Jan-2011		0	0	$0	$0	
Snowy Range	18-Jan-2011		0	0	$0	$0	
Central Carbon	4-Feb-2011		0	0	$0	$0	

Table 17.1 Winter Storm History in Carbon County

Location	Start Date	End Date	Deaths	Injured	Estimated Damage - Property	Estimated Damage - Crops	Information
Snowy Range	3-Apr-2011		0	0	$0	$0	
Snowy Range	17-Apr-2011		0	0	$0	$0	
Southwest Carbon County, Sierra Madre Range, Snowy Range	30-Nov-2011		0	0	$0	$0	
Southwest Carbon County, Sierra Madre Range, Snowy Range	1-Dec-2011		0	0	$0	$0	
Sierra Madre Range, Snowy Range	13-Oct-2012		0	0	$0	$0	
Southwest Carbon County, Snowy Range	17-Dec-2012		0	0	$0	$0	
Snowy Range, Sierra Madre Range	28-Jan-2013		0	0	$0	$0	
Central Carbon County, Snowy Range	9-Feb-2013		0	0	$0	$0	
Snowy Range, Sierra Madre Range	23-Feb-2013		0	0	$0	$0	
Snowy Range	11-Mar-2013		0	0	$0	$0	
Southwest Carbon County, Central Carbon County, Sierra Madre Range, Snowy Range	8-Apr-2013		0	0	$0	$0	
Snowy Range, Sierra Madre Range	15-Apr-2013		0	0	$0	$0	
Central Carbon County	16-Apr-2013		0	0	$0	$0	
Snowy Range	22-Apr-2013		0	0	$0	$0	
Encampment	11-May-2014		0	0	$0	$0	This event did not result in any monetary damages, but many area trees were damaged causing power outages and private property damages. The event impeded travel and stranded vulnerable populations such as seniors.

Table 17.2 NCDC Winter Storm Events by Year*	
Year	Total Number of Events
2009	4
2010	17
2011	13
2012	18
2013	26
2014	19

Source: NCDC Storm Events Database
*NCDC records winter storm events between 1950 and 2014. However, a search for winter storm events in Carbon County did not return any results prior to 2009. This could be a reporting error rather than an indication that winter storm events are rare in Carbon County.

Impacts

Because winter storms are so prevalent in Wyoming, vulnerable populations can be significantly impacted. Impacts include inability to get from one location to another because of closed roads, making pharmacies and grocery stores inaccessible. Electrical outages are also prevalent during winter snow storms and blizzards, limiting or eliminating household heating and cooking capability. Preparation for winter storms is needed to ensure successful weathering of the situation. Some winter storm preparations to be considered by residents include the creation and maintenance of adequate water and food within a 72-hour kit both in vehicles and at home, backup power generation capabilities, and backup household heating options. Winter storms are best weathered by sheltering in place during the storm, and attempting to go out only after the storm has ended.

Rural areas tend to be more susceptible to power outages in winter storms, and power outages in rural areas tend to be of greater duration than those in more populated areas. Rural locations are more likely to have livestock and farming economic factors, which can be significantly impacted by winter weather. Blizzards and winter storms have resulted in livestock deaths and livestock rescue efforts including hay drops by helicopter and snow removal efforts to give ranchers access to their livestock to minimize losses.

Winter storms and blizzards are particularly impactful on people unfamiliar with the hazard. This makes those areas of increased development more vulnerable and subject to risk from the hazard, assuming a percentage of those moving to developing areas are unfamiliar with winter storms, specifically the need to make preparations ahead of the storm and the need to shelter-in-place through a blizzard or winter storm. The 2010 census documents those counties with the greatest increase in population. In areas of high development with an influx of families, education is critical to help prepare the community for the hazard. Carbon County's population growth was only 1.5% between the 2000 and 2010 U.S. Census, but residents should still be educated about the impacts of severe winter storms. Other important mitigation efforts include advance warning through the media and all-hazard radios.

The 2014 Wyoming Multi-Hazard Mitigation Plan used data from SHELDUS to estimate winter storm losses by county. Between 1960 and 2012, SHELDUS recorded 42 damaging winter storm events in Carbon County, with a damage estimate of $1,077,694. The actual impacts are much greater because of the effects on transportation and because of loss of life and injuries. The impacts from loss of livestock can carry over for many years.

Future Impacts

Based on the history of winter storms in SHELDUS, Carbon County will continue to experience damaging winter storms nearly every year. Based on the worst case regional event that involved Carbon County (1949) the dollar impacts could be in excess of $8 million (assuming an equal distribution of the total losses of $88.7 million, in 2014 dollars, across the 10 counties involved), enough power lines could be toppled that emergency intervention could be required, significant property damage could occur, and the livestock industry could lose 15%-20% of its inventory.

Life safety will continue to be a concern on the I-80 corridor, where winter storms strand travelers and contribute to multiple vehicle pileups. Isolation of towns will also be a concern as I-80 and other roads are closed or become impassable.

Future Development

Future residential or commercial buildings built to code should be able to withstand snow loads from severe winter storms. Population growth in the county and growth in visitors will increase problems with road, business, and school closures and increase the need for snow removal and emergency services related to severe winter weather events.

Summary

PROPERTY AFFECTED: Medium
POPULATION AFFECTED: High
PROBABILITY: High
JURISDICTION AFFECTED: All jurisdictions in the county

Chapter XVIII. Hazard Mitigation Goals and Projects

How the Goals and Projects Were Developed

This plan contains eleven goals. Each of the ten incorporated communities and the county have their own individual goal. Projects to address a range of hazards are listed under each of the goal statements. The LEPC agreed with the contractor's recommendation to organize the goals by jurisdiction rather than by hazard. This allows each jurisdiction and the public to easily see and track the projects that will protect their citizens and property, and for which the jurisdiction will take the lead.

A total of 63 mitigation projects were identified as follows;

- Projects from the 2009 plan were reviewed for status and carried forward as appropriate,
- The LEPC identified hazards to which each jurisdiction was vulnerable and then identified projects for those jurisdictions to address the specific hazard vulnerabilities,
- The contractor reviewed other local plans and brought forward needs and projects in those plans that related to hazard mitigation, and
- The public and elected officials were queried for project ideas.

Once a draft list of projects was compiled, the contractor and the LEPC prioritized those projects. The projects were then presented to the Carbon County Council of Governments comprised of representatives from each of the incorporated jurisdictions in the county. The project list was finalized and incorporated into the draft plan, made available for public comment.

Project Costs

Costs for mitigation actions will to fall within three ranges low, medium, or high.

- Low Cost Projects: from $0 to $5,000
- Medium Cost Projects: from $5,001 to $50,000
- High Cost Projects: Over $50,000

Project Priorities

Priority rankings of High, Medium, or Low were also assigned. Generally, the jurisdictions will initiate and depending on the complexity, try to accomplish the High priority projects within two years, the time frame for Medium priority projects will be three to four years, and Low priority projects will be accomplished by the five-year anniversary of this plan if feasible. All projects were initially ranked by the coordinator and contractor based on the following criteria. The LEPC then validated the rankings.

- Perceived cost effectiveness and feasibility of obtaining funding,
- Level of risk to life and property posed by hazard which project addresses,
- Reasonableness of project and extent to which it provides a long-term solution,

- Potential consequences of not implementing,
- Support from the public and elected officials, and
- Compatibility with other plans and policies.

The county commissioners and the mayors and elected bodies have the ability to adopt additional plans, policies, ordinances and regulations as needed.

There are few planning staff in the county. Carbon County has a planner and planning department. The county planning department is active and has a current land use plan in place. The department works to keep regulations up to date with planning documents. The County Fire Warden has initiated the development of a Community Wildfire Protection Plan (CWPP.) The information in this MHMP can provide a foundation for the CWPP.

The City of Rawlins has a planner and a city administrator. The city has a recently completed land use plan. The Town of Saratoga has a city engineer, but no current land use plan. The town is working on floodplain projects which are consistent with and discussed in this plan.

The Town of Baggs has identified a need to update their Storm Water Management Plan as a project in this MHMP. The update will be consistent with their NFIP status and this plan.

No other planning activities are known to be underway or contemplated in the county during the 5-year horizon of this MHMP.

Project Types

A range of types of mitigation actions or projects were identified by the participants in the planning process. Examples of a range of types of projects from other counties was provided and discussed. This was done to assist the LEPC and other participants in understanding the types of projects that could logically fall under a hazard mitigation plan.

Table 18.1 Project Types by Jurisdiction

Goal	Project Types
Goal One—Baggs	Emergency Services, Prevention, Property Protection
Goal Two—Dixon	Emergency Services, Prevention, Property Protection
Goal Three—Elk Mountain	Emergency Services, Prevention, Property Protection
Goal Four—Encampment	Emergency Services, Property Protection, Natural Resource Protection
Goal Five—Hanna	Emergency Services, Property Protection
Goal Six—Medicine Bow	Emergency Services, Natural Resource Protection, Property Protection
Goal Seven—Rawlins	Emergency Services, Prevention, Property Protection, Structural
Goal Eight—Riverside	Emergency Services, Property Protection, Natural Resource Protection, Property Protection
Goal Nine—Saratoga	Emergency Services, Natural Resource Protection, Prevention, Structural
Goal Ten—Sinclair	Education and Awareness, Natural Resource Protection
Goal Eleven—Carbon County	Education and Awareness, Emergency Services, Natural Resource Protection, Prevention, Property Protection

Goal One: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Baggs.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
Flood	*Participate in county-NF coordination project.	M	Town	L	Town	Prevention/mitigation of conditions causing floods. Save lives and property.
Flood	Continue participation in NFIP. Coordinate with FEMA RiskMAP project.	H	Town	M	Town, FEMA	More accurate information. Protect lives and property.
Flood	Update 1990s Storm Water Management Plan	M	Town	M	Town, State, FEMA	Prevent flooding in town, reduce potential property damage
HazMat	Conduct a tabletop exercise for Baggs first responders on their responsibility during pipeline rupture or leak, how to coordinate with pipeline company.	M	Town, County EM	L	Town, Industry	Protect public, responders, and natural resources.
All	Obtain a permanent 3-phase stand-by generator for the water plant	M	Town	H	Town, FEMA	Be able to continue to produce potable water during emergencies
All	Obtain cots, blankets, and MREs to set up a shelter	M	Town, County EM	L	Town, County	Be prepared to assist (primarily stranded travelers) during disaster
All	Have Red Cross pre-certify 1-2 shelter locations	M	Town, County EM, Red Cross	L	N/A	Be prepared to assist (primarily stranded travelers) during disaster

* The county-NF coordination project is to **"**Coordinate with National Forest managers to understand potential hazards from natural or human-caused actions on the National Forest, and to reduce and mitigate those hazards. " (This relates to potential for flooding and wildland fire.)

Goal Two: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Dixon.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
Flood	Continue participation in NFIP. *Participate in county-NF coordination project.	M	Town	L	Town	Prevention/mitigation of conditions causing floods. Save lives and property.
Flood	Coordinate with FEMA RiskMAP project.	H	Town	M	Town, FEMA	More accurate information. Protect lives and property.
HazMat/ Mass Casualty	Plan for a mass casualty incident at the airport. Coordinate with Baggs and Craig, CO.	L	Town, County EM	L	Town, County	Save lives.

* The county-NF coordination project is to **"**Coordinate with National Forest managers to understand potential hazards from natural or human-caused actions on the National Forest, and to reduce and mitigate those hazards. " (This relates to potential for flooding and wildland fire.)

Goal Three: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Elk Mountain.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
Flood	Continue participation in NFIP. *Participate in county-NF coordination project.	M	Town	L	Town	Prevention/mitigation of conditions causing floods. Save lives and property.
Flood	Coordinate with FEMA RiskMAP project and establish new base flood elevations.	H	Town	M	Town, FEMA	More accurate information. Protect lives and property.
HazMat/ Winter Storm	Develop plan for holding traffic during of I-80 closure.	M	Town, County EM, WYDOT	L	Town, WYDOT	Protect lives, human health.

* The county-NF coordination project is to **"**Coordinate with National Forest managers to understand potential hazards from natural or human-caused actions on the National Forest, and to reduce and mitigate those hazards. " (This relates to potential for flooding and wildland fire.)

Goal Four: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Encampment.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
Flood	Continue participation in NFIP. * Participate in county-NF coordination project.	H	Town	L	Town	Prevention/mitigation of conditions causing floods. Save lives and property.
Flood	Coordinate with FEMA RiskMAP project.	H	Town	M	Town, FEMA	More accurate information. Protect lives and property.
Flood	Implement drainage study to properly route surface water.	H	Town	H	Town, FEMA	Protect infrastructure and property.
Flood	Maintain eligibility of residents to purchase flood insurance.	H	Town	L	Town, FEMA	Protect property.
Flood	Continue to monitor potential damage from high ground water. Identify projects to address situations.	M	Town	L	Town	Protect property.
Dam Failure	Become familiar with Hog Park Dam Emergency Action Plan, role of town during dam breach. Work with City of Cheyenne to ensure plan is current.	M	Town, County EM	L	Town	Provide for quick response to dam failure. Save lives.
Wildland Fire	Continue Fire Wise program, hazard fuel reduction projects. Prepare to host a large fire organization.	H	Town, WY Division of Forestry	M	Town, WY Division of Forestry	Protect property and lives. Be prepared for large fire.
Wildland Fire	Increase capacity of settling pond to handle larger sediment load.	M	Town	H	Town, FEMA	Infrastructure, natural resource protection.
Wildland Fire	Clean up and mitigation of overgrown vegetation areas to prevent spread of fire to populated areas.	M	Town, Property owners	M	Town, WY Division of Forestry	Protect property and lives. Be prepared for large fire.

* The county-NF coordination project is to **"**Coordinate with National Forest managers to understand potential hazards from natural or human-caused actions on the National Forest, and to reduce and mitigate those hazards. " (This relates to potential for flooding and wildland fire.)

Goal Five: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Hanna.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
HazMat	Plan, train for first 72 hour hazmat response. Understand response role.	M	Town, County EM	L	Town, Industry	Protect public, responders, and natural resources.
Flood	Abate flooding from big ditch and Stink Creek	H	Town, County EM	M	Town, FEMA	Protect property
Mine Sub-sidence	Provide map of subsidence areas in town, prioritize sites for remediation	H	Town, County EM, State	H	Town, State	Protect property, human health and lives
Winter Storms	Certify and supply at least two shelters (back-up power)	M	Town, County EM, Red Cross	L	Red Cross	Be prepared to house displaced individuals

Goal Six: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Medicine Bow.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
Flood	Mitigate danger to wastewater treatment plant.	M	Town, County EM, FEMA	M	Town, State, FEMA	Protect infrastructure, human health, and natural resources.
Flood	Continue participation in NFIP. *Participate in county-NF coordination project.	H	Town	L	Town	Prevention/mitigation of conditions causing floods. Save lives and property.
Flood	Coordinate with FEMA RiskMAP project.	H	Town	M	Town, FEMA	More accurate information. Protect lives and property.
HazMat	Plan, train for railroad incident.	M	Town, County EM	L	Town, UPRR	Protect human health and natural resources.
Sumtorms, Wind, Wild Fire,Winter Storms	Work with county to train and develop a high angle rescue team to respond to wind farm incidents.	M	Town, County EM, County Fire	M	Town, County, Industry	Save lives.

* The county-NF coordination project is to **"**Coordinate with National Forest managers to understand potential hazards from natural or human-caused actions on the National Forest, and to reduce and mitigate those hazards. " (This relates to potential for flooding and wildland fire.)

Goal Seven: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the City of Rawlins.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
Flood	Design, engineer, and construct storm water mitigation project.	H	City, State, FEMA	H	City, FEMA	Protect property and infrastructure.
Flood	Continue participation in NFIP. Coordinate with FEMA RIskMAP project.	H	City	M	Town, FEMA	More accurate information. Protect lives and property.
Winter Storm, HazMat	Continue work with WYDOT to secure truck parking area for Interstate closures.	M	City, WYDOT	M	City, WYDOT	Protect lives, human health.
HazMat	Continue coordination with railroad to establish a mobile or stationary foam cache.	M	City, County EM, County Fire, Sinclair, UPRR	M	City, UPRR	Protect lives, property, and natural resources.
All	Establish an Enhanced Threat Risk Assessment Team. Use team to assess critical infrastructure and buildings.	M	City, County EM	L	City, WYOS	Prevent/mitigate attacks and/or natural resource hazards.

Goal Eight: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Riverside.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
Wildland Fire	Purchase, install air quality monitoring equipment.	L	Town, DEQ	M	Town, DEQ	Protect human health.
Flood	Continue participation in NFIP. *Participate in county-NF coordination project.	H	Town	L	Town	Prevention/mitigation of conditions causing floods. Save lives and property.
Flood	Coordinate with FEMA RiskMAP project.	H	Town	M	Town, FEMA	More accurate information. Protect lives and property.
All	Inventory sensitive lands to determine areas to protect and areas best suited for	M	Town	M	Town	Prevent damage/loss to future buildings. Natural resource protection.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
	development (from Town Master Plan Action D 5.4)					
All	Conduct feasibility study of sewer lift back-up generator to provide power to town during outage	H	Town	L	Town, WYOS	Protect human health.

* The county-NF coordination project is to **"**Coordinate with National Forest managers to understand potential hazards from natural or human-caused actions on the National Forest, and to reduce and mitigate those hazards. " (This relates to potential for flooding and wildland fire.)

Goal Nine: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Saratoga.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
Flood	Continue participation in NFIP. *Participate in county-NF coordination project.	H	Town	L	Town	Prevention/mitigation of conditions causing floods. Save lives and property.
Flood	Coordinate with FEMA RiskMAP project.	H	Town	M	Town, FEMA	More accurate information. Protect lives and property.
Flood	Implement river stabilization project through town.	H	Town	H	Town, WYOS, FEMA	Protect lives and property.
HazMat/ Mass Casualty	Plan and train for aircraft incident at airport.	M	Town, County EM	L	Town	Save lives.
HazMat	Plan, train and equip for hazmat incident in Saratoga.	M	Town, County EM	M	Town, WYOS	Protect public, responders, and natural resources.
Wildland Fire	Work with DEQ to obtain air quality monitors.	L	Town, DEQ	M	Town, DEQ	Protect human health.

* The county-NF coordination project is to **"**Coordinate with National Forest managers to understand potential hazards from natural or human-caused actions on the National Forest, and to reduce and mitigate those hazards. " (This relates to potential for flooding and wildland fire.)

Goal Ten: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in the Town Sinclair.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
HazMat	Develop a welcome packet and an education program for town residents regarding refinery emergencies.	H	Town	L	Town, Sinclair Oil	Reduce fear. Protect lives by people knowing how to respond.
HazMat	Work with DEQ and county to establish real-time permanent monitoring sites with information available on line.	M	Town, DEQ	M	Town, DEQ	Reduce fear. Protect human health.

Goal Eleven: Mitigate natural hazards to reduce the potential for property loss or damage, injury and loss of life in Carbon County.

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
HazMat	Educate, train and equip fire fighters to respond safely to incidents involving production water.	H	County EM, County Fire	M	County, WYOS, Industry	Protect public, responders, and natural resources.
Winter Storm	Understand procedures and be prepared to call in air and other resources as needed.	M	County EM	L	County	Coordinate more effectively during disaster.
Dam Failure	Ensure dam Emergency Action Plans are kept current by responsible entity and available to emergency management.	M	County EM	L	County, State Engineer	Provide for quick response to dam failure. Save lives.
Flood	Continue participation in NFIP. Coordinate with FEMA RiskMAP project.	H	County	M	County, FEMA	More accurate information. Protect lives and property.
Flood	Update County floodplain regulations	M	County Planning	L	County	Protect lives, future buildings and infrastructure.
Flood, Wildland	Coordinate with National Forest managers to	M	County EM County Fire	L	County, WY Division of	Prevention/mitigation of conditions causing floods. Save

Hazards	Mitigation Project	Project Rank	Responsible Agency	Estimated Project Cost	Sources of Funding	Benefit/Comments
Fire	understand potential hazards from natural or human-caused actions on the NF, and to reduce and mitigate those hazards.				Forestry	lives and property.
Wildland Fire	Develop detailed wildland fire hazard maps	M	County Planning	M	County, WY Division of Forestry, Forest Serv.	Protect property and lives, future buildings.
Wildland Fire	Formalize the review process for fire protection in proposed interface development	M	County Planning	L	County	Protect property and lives, future buildings.
Wildland Fire	Construct structure to house Savery fire apparatus	M	County EM	M	County, State	Maintain readiness, protect fire response assets
Weather Hazards	Continue to offer periodic weather spotter training	M	County EM	L	County EM	Raise awareness. Early warning, save lives.
All	Update county subdivision regulations to consider natural hazards in subdivision review process	M	County Planning	M	County	Protect property and lives, future buildings.
All	Continue development of a County Type 3 All-Hazard Response Team.	M	County Fire, County EM	M	County EM and Fire	Enhance disaster responses.
All	Complement Code Red with IPAWS county-wide and complete implementation. Public awareness effort to get everyone signed up for Code Red.	H	County EM, County Sheriff	M	County	Provide early warning to save lives and property.

Action Plan

The above projects will be worked on pending adequate resources (personnel and funding.) Some of the projects are already underway. Other projects will be selected based on priority, timeliness, and the opportunity to complete. The initial priorities assigned with this update are expected to shift somewhat over the course of the five-year planning period based on the needs of the individual jurisdictions and resources available to them.

For projects not requiring outside expertise or funding and located exclusively within one local jurisdiction, the Town of Baggs, for example, the Town may select and proceed with projects they wish to complete. During the previous 5-year planning cycle, Baggs did just this by adding water storage capacity for wildland fire protection and municipal use.

As described in Chapter 19, the County Emergency Management Director will place the MHMP on the LEPC agenda once annually during the summer. Each incorporated community has the opportunity to have representatives on the LEPC. The Director and LEPC will discuss the list of projects in the plan to see if any changes in overall priorities are desired. The discussion will include any direction or emphases from the local governing bodies, WYOS, or FEMA; incidents which have occurred during the previous year that could affect mitigation project priorities; and local resources and funding available to accomplish projects. The LEPC will hold a vote when they wish to pursue grant funds for work on mitigation projects.

Use of Cost-Benefit Analysis

In cases where grants are being sought, the Director will complete a cost/benefit analysis before submitted any funding requests.

The county can also make available information regarding the STAPLEE method for evaluating and prioritizing mitigation actions. The method looks at social, technical, administrative, political, legal, economic, and environmental aspects of projects to weigh pros and cons of implementing specific projects. Information on this analysis method can be found in FEMA's *Developing the Mitigation Plan* (FEMA 386-3). The jurisdictions will need to consider compatibility with goals and objectives in the state's plan, compatibility with goals in this plan, impacts of the project on other jurisdictions, costs and benefits, funding priorities, and compatibility with other plans and programs when selecting projects to implement.

Existing Authorities, Policies, Programs and Resources for Implementation

Existing plans and regulatory mechanisms are listed in Chapter 1. Fire resources are listed in Chapter 14. With the exception of the City of Rawlins and the Town of Saratoga, the remaining communities are small, have no land use or other plans, no planning staff, and no dedicated resources available to implement projects. Generally projects will be accomplished under county leadership either by volunteers (firefighters, emergency medical personnel, and elected officials) or through contractors funded by grants. Communities in Wyoming do have statutory authority to engage in planning and the two larger communities do so. While the authority exists, local governments in Wyoming have consistently shown a preference towards minimizing government regulations especially related to the use and development of private property.

Chapter XIX. Plan Monitoring, Maintenance, Revision, and Coordination

Responsible Parties

The Carbon County Commissioners in cooperation with the mayors of the ten participating incorporated towns and city are responsible for ensuring that the MHMP is kept current. With adoption of the plan, the Commissioners designate the Director, Carbon County Emergency Management—with the assistance of the Local Emergency Planning Committee—as the lead in accomplishing the on-going responsibilities.

Plan Monitoring and Evaluation

There are two types of plan monitoring and evaluation; effectiveness and implementation. Effectiveness monitoring looks at whether the plan has addressed needed items. Implementation monitoring looks at whether projects in the plan are being undertaken and completed. The county's Emergency Management Director with the help of the LEPC will ask the following questions to evaluate the effectiveness and implementation of the plan.

- Have any potential hazards developed that were not addressed in the plan?
- Have any natural disasters occurred that were not addressed in the plan?
- Has any unanticipated development occurred that is vulnerable to hazards?
- Are there any additional mitigation ideas that need to be incorporated?
- Have projects been initiated and/or completed?
- What are the barriers to completing projects identified in the plan?

Each January the LEPC will meet to ask and answer the questions listed above. The discussion will be documented so that when the plan is revised, the findings of the monitoring can be incorporated into the revision. The Carbon County Emergency Management Director will convene the LEPC for this purpose.

Plan Update Review Triggers

Any of the following three situations could trigger a review and update of the plan.

- Occurrence of a major natural disaster in or near Carbon County,
- Passage of five years, or
- Change in state or federal regulations which must be complied with.

Revision Procedures

Should a major natural disaster occur in Carbon County, the LEPC shall meet following the disaster to determine whether a review of the MHMP is warranted. In the absence of a major natural disaster, the five-year review will take place during the six-month period preceding the FEMA approval anniversary date.

Following proper notice in the paper(s) of record, the Carbon County Emergency Management Director will convene the LEPC and with their assistance and/or the assistance of the WOHS or a contractor as determined necessary, carry out the following tasks;

1. Review the Hazard Mitigation Plan Review Tool comments from WOHS and FEMA during their most recent review of the plan (2015.)

2. Examine and revise the risk assessment data as needed to ensure it is current.

3. Update the mitigation strategies to incorporate completion of actions and add any needed strategies or projects.

4. Identify problems that may be hindering or affecting implementation of the plan, and recommend actions for resolving those problems.

5. Recommend any necessary revisions to the MHMP.

6. Comply with all applicable regulations and statutes.

So that the public will have an opportunity to become involved in and comment on the revision, three public meetings will be scheduled around the county. Suggested locations for these meetings would be Rawlins, Saratoga, and Baggs. Meetings will be publicized in the Rawlins Daily Times and the Saratoga Sun.

Forty-five days prior to the five-year anniversary date, a final draft of the revised plan will be submitted to the WYOS.

An annual review will be conducted by the Carbon County Emergency Management Director for the purpose of summarizing the status and effectiveness of the plan mitigation goals or strategies.

Incorporation into Other Plans

The City of Rawlins and Carbon County have both updated their comprehensive land use plans recently. The Carbon County planner is charged with keeping subdivision regulations up to date with the land use plan. He has participated in this process and identified potential projects. As county regulations are updated, he will consider and incorporate elements of this MHMP as appropriate.

The Town of Saratoga is initiating a land use planning effort. The town has been directly impacted by flooding disasters, is pursuing mitigation projects independent of this plan, and has included projects in this plan. Town staff (specifically the Town Engineer who is also the Floodplain Coordinator) has been involved in the preparation of this MHMP and will ensure consistency with the land use plan as it is developed.

The Emergency Management Director is currently updating the Carbon County Emergency Operations Plan and will be adding a debris management annex. He has been intimately involved in the preparation of this update so can assure consistency between the EOP and the MHMP. He will also provide timely comments to town, city, and county planning efforts to incorporate the appropriate elements of this plan in other plans as they are developed or updated.

The smaller towns in the county have no planners on staff and no intent to prepare any land use plans. These communities would likely contract planning assistance if/when a major development is proposed. The county planner and Emergency Management Director could work with any contracted planners to make them aware of natural hazards in the county, and the MHMP.

Opportunity for Continued Public Involvement

In addition to the procedures for including the public in the five-year updates described above, to ensure the public will have the opportunity to remain involved in the implementation and annual updates of the plan, the following will take place.

1) The Carbon County Emergency Management Director will provide a brief annual summary report to the eleven governing bodies on what has been accomplished during the previous year and to receive guidance from the elected officials on their priorities for the coming year.

2) Each year following the summer LEPC meeting called for the purpose of reviewing the status of the plan, the county will provide information to the newspapers to notify the public of the accomplishments of the previous year and allow comment for any revisions.