Wyoming Region 4

Lincoln County

Sweetwater County

Uinta County

Regional
Hazard Mitigation Plan

PUBLIC REVIEW DRAFT – August 2016

Developed by Lincoln, Sweetwater and Uinta Counties

with professional planning assistance from
Amec Foster Wheeler
Hazard Mitigation and Emergency Management

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EXECUTIVE SUMMARY

This plan is the product of a planning process undertaken by the three counties in Wyoming Region 4 – Lincoln, Sweetwater and Uinta. The purpose is to meet the requirements of the Disaster Mitigation Act of 2000 (PL 106-390), and thereby maintain continued eligibility for certain Hazard Mitigation – or disaster loss reduction – programs from the Federal Emergency Management Agency (FEMA). This plan updates existing hazard mitigation plans for Uinta and Lincoln counties, and serves as a new hazard mitigation plan for Sweetwater County.

The process followed a methodology prescribed by FEMA. It consisted of two levels of planning teams; a coordinating planning team comprised of the three County Emergency Manager Coordinators, and three local government teams – one in each county. Every local government and 'FEMA-Eligible' entity in each county was invited to participate.

The planning process examined the recorded history of losses resulting from natural hazards, and analyzed the future risks posed to each county by these hazards. Hazard profiles were created for Avalanche, Dam Failure, Drought, Earthquake, Expansive Soils, Flood, Hailstorm, Hazardous Materials, High Winds and Downbursts, Landslide, Lightning, Mine Subsidence, Tornadoes, Severe Winter Weather and Wildfire, based on the State of Wyoming Hazard Mitigation Plan. Where applicable, these profiles were built on existing information found in the previous plans for Lincoln and Uinta Counties. The hazards were assessed for geographic extent, potential magnitude and probability, and given a rating for overall significance.

The plan's mitigation strategy is based on five regional goals for the entire planning area. The plan also puts forth county-specific recommendations for mitigation, based on the risk assessment, that are designed to reduce future losses in each county and ultimately, in the Region.

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1 INTRODUCTION

1.1 Purpose

The counties of Wyoming Region 4 including Lincoln, Sweetwater and Uinta prepared this regional hazard mitigation plan to guide hazard mitigation planning and to better protect the people and property of the planning area from the effects of hazard events. This plan demonstrates the region's commitment to reducing risks from hazards, and serves as a tool to help decision makers direct mitigation activities and resources. This plan also maintains the planning area's eligibility for certain federal disaster assistance under the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Assistance (HMA) grant programs.

1.2 Background and Scope

Each year in the United States, disasters take the lives of hundreds of people and injure thousands more. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. These monies only partially reflect the true cost of disasters, because additional expenses to insurance companies and nongovernmental organizations are not reimbursed by tax dollars. Many disasters are predictable, and much of the damage caused by these events can be alleviated or even eliminated.

Hazard mitigation is defined by FEMA as "any sustained action taken to reduce or eliminate long-term risk to human life and property from a hazard event." The results of a three-year, congressionally-mandated independent study to assess future savings from mitigation activities provides evidence that mitigation activities are highly cost-effective. On average, each dollar spent on mitigation saves society an average of $4 in avoided future losses in addition to saving lives and preventing injuries (National Institute of Building Science Multi-Hazard Mitigation Council 2005).

Hazard mitigation planning is the process through which hazards that threaten communities are identified, likely impacts of those hazards are determined, mitigation goals are set, and appropriate strategies to lessen impacts are determined, prioritized, and implemented. This plan documents the planning region's hazard mitigation planning process, identifies relevant hazards and risks, and identifies the strategies that each participating County and jurisdiction will use to decrease vulnerability and increase resiliency and sustainability.

This plan was prepared pursuant to the requirements of the Disaster Mitigation Act of 2000 (Public Law 106-390) and the implementing regulations set forth by the Interim Final Rule published in the *Federal Register* on February 26, 2002 (44 CFR §201.6) and finalized on October 31, 2007 (hereafter, these requirements and regulations will be referred to collectively as the Disaster Mitigation Act (DMA)). While the act emphasized the need for mitigation plans and more

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coordinated mitigation planning and implementation efforts, the regulations established the requirements that local hazard mitigation plans must meet in order for a local jurisdiction to be eligible for certain federal disaster assistance and hazard mitigation funding under the Robert T. Stafford Disaster Relief and Emergency Act (Public Law 93-288). Because the planning area is subject to many kinds of hazards, access to these programs is vital.

Information in this plan will be used to help guide and coordinate mitigation activities and decisions for local land use policy in the future. Proactive mitigation planning will help reduce the cost of disaster response and recovery to the community and its property owners by protecting critical community facilities, reducing liability exposure, and minimizing overall community impacts and disruption. The planning area has been affected by hazards in the past and is thus committed to reducing future disaster impacts and maintaining eligibility for federal funding.

1.3 Plan Organization

Wyoming Region 4 Regional Hazard Mitigation Plan is organized in alignment with the DMA planning requirements and the FEMA plan review crosswalk as follows:

- Chapter 1: Introduction
- Chapter 2: Community Profile
- Chapter 3: Planning Process
- Chapter 4: Risk Assessment
- Chapter 5: Mitigation Strategy
- Chapter 6: Plan Adoption, Implementation, and Maintenance
- County Planning Annexes
- Appendices

County Annexes

Each county participating in this plan developed its own annex, which provides a more detailed assessment of the county and respective jurisdiction's unique risks as well as their mitigation strategy to reduce long-term losses. Each county annex contains the following:

- Community profile summarizing geography and climate, history, economy, and population
- More detailed hazard vulnerability information and unique risks by jurisdiction, where applicable, for geographically specific hazards
- Hazard map(s) at an appropriate scale for the jurisdiction, if available
- Number and value of buildings, critical facilities, and other community assets located in hazard areas, if available
- A capability assessment describing existing regulatory, administrative, and technical resources
- Mitigation actions specific to the county and municipalities

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1.4 Multi-Jurisdictional Planning

This plan was prepared as a regional, multi-jurisdictional plan. The planning region is comprised of three counties in Wyoming Region 4, established by the Wyoming Office of Homeland Security (WOHS); the region includes Lincoln, Sweetwater and Uinta Counties. All local units of government in each county were invited to participate in the planning process. The decision whether or not to participate in this process was a local decision, based on local community needs. Communities have the options to not prepare a plan, to prepare a stand-alone plan for their jurisdiction, or to participate in a multi-jurisdiction or county-wide plan. All of the counties in the Region with the exception of Sweetwater County had county-wide multi-jurisdictional hazard mitigation plans prior to the development of this Regional Plan. These plans were last updated in 2010-2011 with the exception of Uinta which most recently updated its plan in 2005. The following table lists counties and their local governments that have opted to participate in this effort and are seeking FEMA approval of the 2016 version of this plan. Changes in participation since the 2010-2011 planning updates are noted. Additional details about participation can be referenced in Chapter 3 and the county annexes.

Table 1.1. Multi-Jurisdictional Participation 2016

Jurisdiction	Participation Status
Lincoln County	Participated in 2015-16 plan update
City of Kemmerer	Participated in 2015-16 plan update
Town of Afton	Participated in 2015-16 plan update
Town of Alpine	Participated in 2015-16 plan update
Town of Cokeville	Participated in 2015-16 plan update
Town of Diamondville	Participated in 2015-16 plan update
Town of La Barge	Participated in 2015-16 plan update
Town of Opal	Participated in 2015-16 plan update
Star Valley Ranch	Participated in 2015-16 plan update
Town of Thayne	Participated in 2015-16 plan update
Sweetwater County	**New in 2016**
City of Green River	New in 2016
City of Rock Springs	New in 2016
Town of Bairoil	New in 2016
Town of Granger	New in 2016
Town of Superior	New in 2016
Town of Wamsutter	New in 2016
Uinta County	Participated in 2015-16 plan update
City of Evanston	Participated in 2015-16 plan update
Town of Bear River	Participated in 2015-16 plan update
Town of Lyman	Participated in 2015-16 plan update

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Jurisdiction	Participation Status
Town of Mountain View	Participated in 2015-16 plan update

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2 COMMUNITY PROFILE

This section provides a brief overview of the geography of the planning area. Additional geographic profiles of the participating counties are provided in the county annexes.

2.1 Geography and Climate

Wyoming Region 4 is comprised of three counties in southwestern Wyoming, and was established by the Wyoming Office of Homeland Security (WOHS). Member counties include Lincoln, Sweetwater and Uinta. This region of the state is generally characterized by its location in the Rocky Mountains.

The region covers some 16,674 square miles and elevations range between 3,000 and 6,000 feet. The major rivers in the region include the Greys River, the Hams River, the Bear River, the Big Sandy River, the Little Muddy River, the Bitter River and the Green River. Major roadways include Interstate 80, Highway 89, Highway 189, Highway 30 and Highway 191. A base map of the planning region is illustrated in Figure 2.1. A large percentage of the Region's land is public or federally managed as shown in the land stewardship designations on the base map.

The climate of the Region 4 is characterized by dry winters with occasional wind-blown snow and periods of very cold temperatures. Springs are windy and highly variable, including the occasional blizzard, rapid and drastic temperature changes, and high levels of precipitation in the form of both snow and rain. Summers offer low humidity with warm days and cool nights. The fall is cool and dry. Overall, the area is considered semi-arid.

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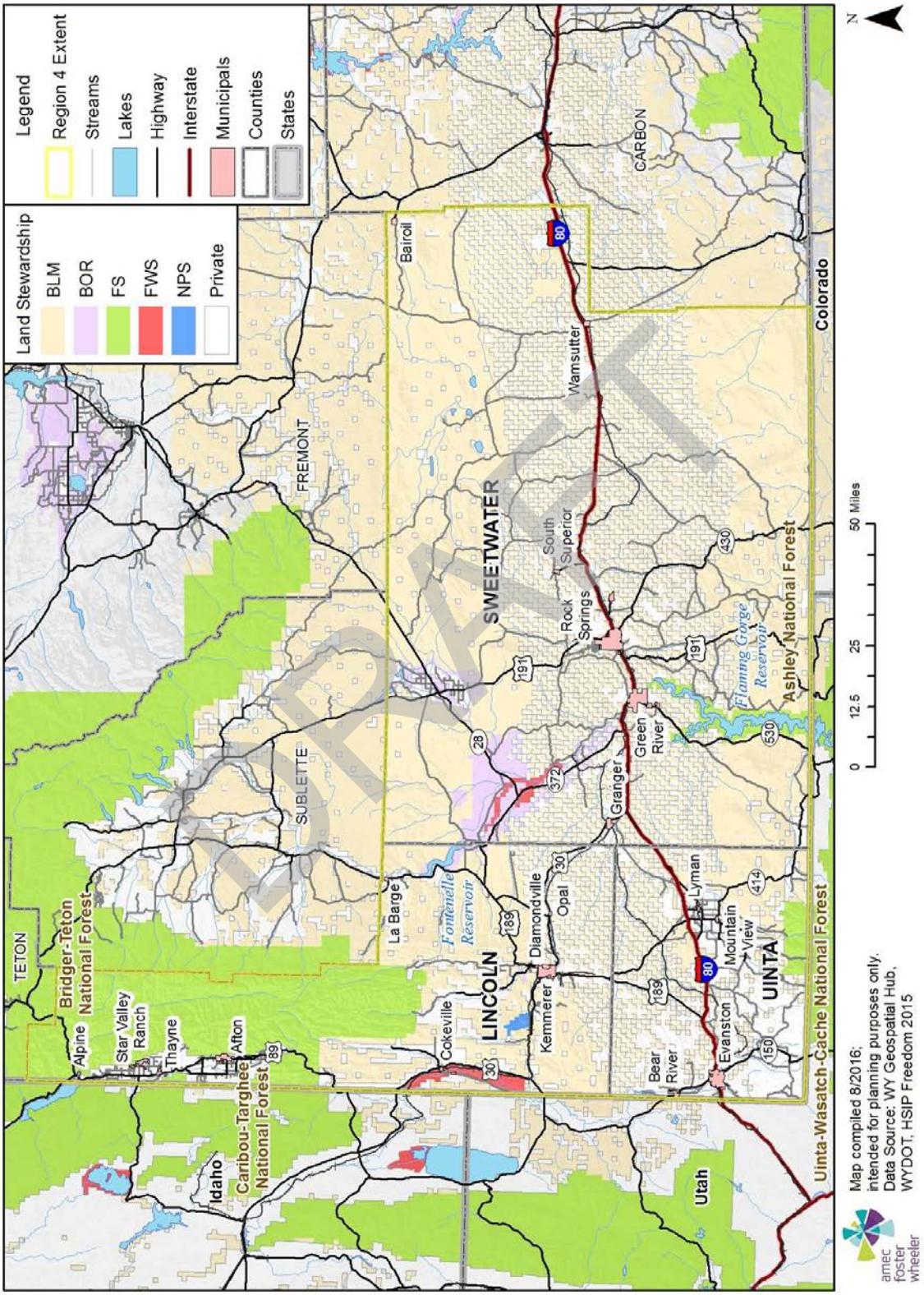
Figure 2.1. Wyoming Region 4



2.2 Population

Table 2.1 describes the population and estimated population change for the planning region as a whole and each individual county. Estimates beyond 2010 are based on the American Community Survey data from the US Census Bureau. As a whole, the Region is increasing slightly in population, but percent increase varies by county within the region.

Table 2.1. Planning Region Projected Population

	2010 Census	2011 Estimate	2012 Estimate	2013 Estimate	2014 Estimate	2015 Estimate	Change 2010 to 2015	% Change 2010 to 2015
Region 4	83,030	82,975	84,036	84,512	84,392	84,170	1,140	1.3
Lincoln	18,106	18,022	17,943	18,328	18,564	18,722	616	3.4
Sweetwater	43,806	44,041	45,104	45,162	44,925	44,626	820	1.9
Uinta	21,118	20,912	20,989	21,022	20,903	20,822	-296	-1.4

Source: US Census Bureau

2.3 Economy

The primary industry in Region 4 is mining. In 2004, mining contributed $5.99 billion to Wyoming Gross State Product, or 25% of all private industry in Wyoming. Wyoming is estimated to contain 1.4 trillion tons of coal, making it the largest coal resource in the US. Sweetwater County is home to the most massive and easily mineable deposits of coal and trona in the world. The mining sector has experienced large profits in recent years in Uinta County. Oil and natural gas production is also a major component in Region 4. Numerous gas plants exists throughout the counties, many can be seen from Interstate 80. Wyoming's second highest earning industry is tourism. Lincoln County is located just south of Grand Teton National Park and Yellowstone National Park, and sees many tourists pass through. In addition to tourism and energy extraction, agriculture is a major industry in the Region including row crops, farming and ranching.

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3 PLANNING PROCESS

Requirements §201.6(b) and §201.6(c)(1): An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include:

1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;
2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia, and other private and nonprofit interests to be involved in the planning process; and
3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

[The plan shall document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.]

3.1 Background on Mitigation Planning in Region 4

While Region 4 has never had a regional hazard mitigation plan prior to 2016, multiple counties in the region have adopted county-specific hazard mitigation plans over the years. Lincoln County and Uinta County each had county-specific plans, and this Regional Plan builds upon and updates those efforts.

Lincoln County. Lincoln County has had a county hazard mitigation plan in place for 10 years, adopted in 2006. The plan included analysis and projects for all hazards profiled in this plan, excluding expansive soils.

Uinta County. Uinta County has had a county hazard mitigation plan in place since 2003, followed by an updated plan in 2011. The plan included analysis and projects for dam failure, drought, earthquake, flood, wildfire, winter storm and hazardous materials. Along with its county plan, Uinta also has a Community Wildfire Protection Plan in place since 2010.

Sweetwater County. Sweetwater County did not have an adopted local hazard mitigation plan prior to the development of this Regional Plan. The county developed a plan in 2005, but it was not formally adopted. The City of Rock Springs included a hazard analysis as part of its Master Plan in 2009.

Regional Planning. In Wyoming, the Wyoming Office of Homeland Security (WOHS) utilizes a regional support structure to assist the counties with all aspects of emergency management, including planning. Each county has an Emergency Management Coordinator. Lincoln County, Sweetwater County, and Uinta County comprise Region 4. In 2016, the WOHS began the process

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of initiating the development of regional hazard mitigation plans statewide. This initiative recognized that actual process of facilitating and developing or updating multi-jurisdictional hazard mitigation plans compliant with the DMA 2000 was often beyond local capabilities and expertise. Instead of each county hiring separate consultants, the WOHS took the lead in procuring and funding a professional hazard mitigation planning consultant through a competitive bid process. Due to the timing of plan updates Regions 4 and 6 were chosen as the first regions in the state to develop regional plans. Amec Foster Wheeler of Boulder, Colorado was selected in March of 2016 to provide assistance to both regions.

Prior to initiating the development of this regional multi-jurisdictional Hazard Mitigation Plan in 2016 a substantial coordination effort took place to ensure the participation of all three counties within Region 4. The WOHS received letters of commitment from each county (copies included in Appendix C) indicating their interest in and willingness to participate in the regional planning process. Each county designated as a primary point of contact their emergency management coordinator. Each coordinator was required to undertake a coordination role within their respective counties to help fulfill DMA planning requirements. The county Emergency Management Coordinators then contacted each of the incorporated communities, offering them the opportunity to participate in the development of the Region 4 Hazard Mitigation Plan. Each incorporated community within the three counties chose to participate in the development of the initial Regional Plan.

Each Emergency Management Coordinator led county-level Hazard Mitigation Planning Committees (HMPCs) working in concert with the hazard mitigation planning consultant. As the planning consultant, Amec Foster Wheeler's role was to:

- Provide guidance on a planning organization for the entire planning area representative of the participants;
- Meet all of the DMA requirements as established by federal regulations, following FEMA's most recent planning guidance;
- Facilitate the entire planning process;
- Identify the data requirements that the participating counties and municipalities could provide, and conduct the research and documentation necessary to augment that data;
- Develop and help facilitate the public input process;
- Produce the draft and final plan documents; and
- Ensure acceptance of the final Plan by WOHS and FEMA Region VIII

3.2 Local Government Participation

The Disaster Mitigation Act (DMA) planning regulations and guidance stress that each local government seeking FEMA approval of their mitigation plan must participate in the planning effort in the following ways:

- Participate in the process as part of the Hazard Mitigation Planning Committee (HMPC),

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- Detail areas within the planning area where the risk differs from that facing the entire area,
- Identify specific projects to be eligible for funding, and
- Have the governing board formally adopt the plan.

For the Region 4 Multi-Hazard Mitigation Plan's HMPC, "participation" meant:

- Attending and participating in HMPC meetings;
- Establishing/reconvening a local steering committee;
- Providing available data requested by the HMPC coordinator/Amec Foster Wheeler;
- Providing/updating the hazard profile and vulnerability details specific to jurisdictions;
- Developing/updating the local mitigation strategy (action items and progress);
- Advertising and assisting with the public input process;
- Reviewing and commenting on plan drafts; and
- Coordinating the formal adoption of the plan by the governing boards.

This Regional Plan includes the participation of all counties and the municipalities in Region 4 as noted in Chapter 1 and detailed further in Section 3.3.1. Documentation of participation is included in Appendix C in the form of meeting sign in sheets, meeting summaries, and more.

3.3 The 10-Step Planning Process

Amec Foster Wheeler established the planning process for the Region 4 plan using the DMA planning requirements and FEMA's associated guidance. This guidance is structured around a four-phase process:

1) Organize Resources
2) Assess Risks
3) Develop the Mitigation Plan
4) Implement the Plan and Monitor Progress

Into this four-phase process, Amec Foster Wheeler integrated a more detailed 10-step planning process used for FEMA's Community Rating System (CRS) and Flood Mitigation Assistance (FMA) programs. Thus, the modified 10-step process used for this plan meets the requirements of six major programs: FEMA's Hazard Mitigation Grant Program, Pre-Disaster Mitigation program, Community Rating System (CRS), Flood Mitigation Assistance Program, Severe Repetitive Loss program, and new flood control projects authorized by the U.S. Army Corps of Engineers. FEMA's March 2013 *Local Mitigation Planning Handbook* recommends a nine step process within the four phase process. Table 3.1 summarizes the four-phase DMA process, the detailed CRS planning steps and work plan used to develop the plan, the nine handbook planning tasks from FEMA's 2013 *Local Mitigation Planning Handbook*, and where the results are captured in the Plan. The sections that follow describe each planning step in more detail.

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Table 3.1. Mitigation Planning Process Used to Develop the Regional Hazard Mitigation Plan

FEMA 4 Phase Guidance	Community Rating System (CRS) Planning Steps (Activity 510) and Amec Foster Wheeler Work Plan Tasks	FEMA Local Mitigation Planning Handbook Tasks (44 CFR Part 201)	Location in Plan
Phase I: Organize Resources	Task 1. Organize Resources	1: Determine the Planning Area and Resources	Chapters 1, 2 and 3
		2: Build the Planning Team 44 CFR 201.6(c)(1)	Chapter 3, Section 3.3.1
	Task 2. Involve the public	3: Create an Outreach Strategy y 44 CFR 201.6(b)(1)	Chapter 3, Section 3.3.1
	Task 3. Coordinate with Other Agencies	4: Review Community Capabilities 44 CFR 201.6(b)(2) & (3)	Chapter 3, Section 3.3.1 and Chapter 4, Section 4.4
Phase II: Assess Risks	Task 4. Assess the hazard	5: Conduct a Risk Assessment 44 CFR 201.6(c)(2)(i) 44 CFR 201.6(c)(2)(ii) & (iii)	Chapter 4, Sections 4.1-4.3
	Task 5. Assess the problem		Chapter 4, Sections 4.1-4.3
Phase III: Develop the Mitigation Strategy	Task 6. Set goals	6: Develop a Mitigation Strategy 44 CFR 201.6(c)(3)(i); 44 CFR 201.6(c)(3)(ii); and 44 CFR 201.6(c)(3)(iii)	Chapter 5, Section 5.2
	Task 7. Review possible activities		Chapter 5, Section 5.3
	Task 8. Draft an action plan		Chapter 5, Section 5.4
Phase IV: Adopt and Implement the Plan	Task 9. Adopt the plan	8: Review and Adopt the Plan	Chapter 6, Appendix C
	Task 10. Implement, evaluate, revise	7: Keep the Plan Current	Chapter 7
		9: Create a Safe and Resilient Community 44 CFR 201.6(c)(4)	Chapter 7

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3.3.1 Phase 1: Organize Resources

Planning Task 1: Organize the Planning Effort

With each county's commitment to develop a Regional Plan, Amec Foster Wheeler worked with WOHS and each county coordinator to establish the framework and organization for the process. Organizational efforts were initiated with each county to inform and educate the plan participants of the purpose and need for the regional hazard mitigation plan. During the development of this

Regional Plan, the planning process was directed through a regional planning committee comprised of Lincoln County Emergency Management, Sweetwater County Emergency Management, Uinta County Emergency Management and participating jurisdictions. The planning consultant held an initial conference call/webex to discuss the organizational aspects of the planning process with the county coordinators. Using FEMA planning guidance representatives for each county's HMPC base membership was established, with additional invitations extended as appropriate to other federal, state, tribal, and local stakeholders and the public throughout the planning process. The list of agencies and individuals invited to participate is included in Appendix A with documentation of participation included in Appendix C.

Amec Foster Wheeler and each county's Emergency Management Coordinator identified key county, municipal, and other local government and initial stakeholder representatives. Letters of invitation were mailed to invite them to participate as members of the HMPC and to attend a series of planning workshops. Representatives from the following county and municipal departments participated on each county HMPC and in the development of the regional plan:

Table 3.2. HMPC Members by County

Lincoln County	
Jurisdictions/ Representatives	
Lincoln County	Lincoln County Emergency Management
	Lincoln County IT/GIS
	Lincoln Conservation District
	Lincoln County Public Health
	Lincoln County Sheriff's Office
City of Kemmerer	
Town of Afton	
Town of Alpine	
Town of Cokeville	
Town of Diamondville	Diamondville Police Department
Town of La Barge	
Town of Opal	
Town of Star Valley Ranch	Star Valley EMS
Town of Thayne	
Stakeholders	Military Families

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Jurisdictions/Representatives	
Sweetwater County	Sweetwater County Emergency Management
	Sweetwater County Public Works
	Sweetwater County Conservation District
	Sweetwater County Fire Department
	Sweetwater County District Board of Health
	Sweetwater County Sheriff's Office
City of Green River	Green River Public Works
	Green River Community Development
	Green River Fire Department
City of Rock Springs	Rock Springs Fire Department
Town of Bairoil	
Town of Granger	Granger Mayor
Town of Superior	
Town of Wamsutter	
Fire District #1	
Stakeholders	Memorial Production Partners
Uinta County	
Jurisdictions/ Representatives	
Uinta County	Uinta County Emergency Management
	Uinta County Sheriff's Office
	Uinta County Fire Department
	Uinta County IT
	Uinta County Public Health
City of Evanston	Evanston Police Department
Town of Bear River	Bear River Public Works
Town of Mountain View	
Town of Lyman	Lyman Police Department
Stakeholders	National Weather Service
Federal Agency Representatives	National Oceanic and Atmospheric Administration
	Bureau of Land Management
	Federal Aviation Administration
	US Forest Service
	Red Cross
State Agency Representatives	Wyoming State Forestry Division
	Wyoming State Geological Survey

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	Wyoming Highway Patrol
	Wyoming Office of Homeland Security

During the plan development process communication amongst the county planning teams occurred through a combination of face-to-face meetings, conference calls, a webex, phone interviews, and mail and email correspondence. Following the initial kickoff webex/conference call on April 12, 2016 two planning workshops with each county's HMPC were held during the plan's development between May 2016 and July 2016. The meeting schedule and topics are listed below. In addition monthly conference calls were held with the county coordinators and Amec Foster Wheeler to discuss the process including upcoming milestones and information needs. The sign-in sheets and agendas for each of the meetings are documented in Appendix B.

The County HMPC meetings were scheduled as follows. Each meeting was 3-4 hours:

Workshop #1: Hazard Identification and Risk Assessment and Goals update

May 24, 2016 – Uinta County
May 25, 2016 – Lincoln County
May 26, 2016 – Sweetwater County

The purpose of this workshop was to review the results of the risk assessment and review and update/develop goals.

Workshop #2: Mitigation Strategy update

July 18, 2016 – Lincoln County, PM; public meeting in late afternoon/eve
July 19, 2016 – Sweetwater County, PM; public meeting in late afternoon/eve
July 20, 2016 – Uinta County, PM; public meeting in late afternoon/eve

This workshop was aimed to update the mitigation strategy and brainstorm new mitigation actions to include in the HMP. These meetings were all followed by a public meeting.

During the kickoff webex/conference call, Amec Foster Wheeler presented information on the scope and purpose of the plan update, participation requirements of HMPC members, and the proposed project work plan and schedule. A plan for public involvement (Step 2) and coordination with other agencies and departments (Step 3) were discussed. The HMPC reviewed the hazard identification information for each county and the Region and refined the list of identified hazards to mirror that of the Wyoming Hazard Mitigation Plan. In follow-up to the meeting participants

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were provided worksheets to facilitate the collection of information needed to support the plan update, such as data on historic hazard events, values at risk, and current capabilities.

Planning Task 2: Involve the Public

The 2016 planning process was an open one, with the public informed and involved early in the process. Mitigation planning was primarily accomplished at HMPC meetings, which in some cases included members of the public and/or local media.

Public meetings were held in each county as part of the 2016 plan process. The Lincoln County HMPC meeting on July 18 was followed by a public meeting at the County EOC. Amec Foster Wheeler Project Manager Kyle Karsjen and Emergency Management Coordinator Jay Hokanson were present to facilitate the meeting, but there were no public attendees by 6 PM, so the meeting adjourned.

After Sweetwater County's HMPC meeting on July 19, seven members of the public arrived for the meeting. Every member of the public was concerned with the same topic. All seven members run businesses that own or lease property in the Elk Street Commercial Subdivision. Shawn Bridges, the real estate consultant for the property owners of 839 Elk Street had been in contact with Judy and Kyle prior to the meeting. Shawn explained that the entire industrial subdivision experienced severe flooding and damage in the July 2015 flood in Rock Springs and again in May 2016. The Killpecker Creek abuts the Elk Street commercial subdivision. Kelly Brown was the first attendee to speak and presented photos exhibiting the damage. Kelly explained that Killpecker Creek was diverted at some point in the past and has filled with sediment over the years, which caused the drainage to fill into small channels and eventually inundate the Elk Street Subdivision. The main questions posed by the attendees involved ownership of water, who to contact to get federal money, and how to get help from the city or county. The attendees agree that the most practical short-term solution will be to clean out the drainage ditches. Judy then announced that she will be in contact with the City of Rock Spring's Emergency Management Coordinator. Kyle also explained that there will be a Hazard Mitigation Project written up about this specific site in the Regional Hazard Mitigation Plan.

After Uinta County's HMPC meeting on July 20, multiple members who work for the county and were in the previous HMPC meetings in May 2016 attended this public meeting. Many of these attendees did not attend the HMPC meeting held beforehand. Kyle initiated the meeting with a discussion of the background of the plan, its intent, and the planning process followed. The remainder of the meeting involved discussing the plan and potential project ideas.

2016 Public Survey

During the regional planning process and drafting stage, a public survey was developed as a tool to gather public input. The survey was for the public to provide feedback to the county planning teams on topics related to hazard concerns and reducing hazard impacts. The survey provided an opportunity for public input during the planning process, prior to finalization of the plan update. The survey gathered public feedback on concerns about wildfires, floods, winter storms and other hazards and solicited input on strategies to reduce their impacts. The highest rated hazards in

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Region 4 were wind and extreme cold. The survey was released as both an online tool and a hardcopy form on or around May 6th in each county and closed on June 30th, 2016. The counties provided links to the public survey by distributing it using social media, email, and posting the link on websites. Forty-five responses were received and shared with the county planning committees to inform the process.

The survey included a question on ranking hazard significance. The results generally track with the significance levels noted in Chapter 4 of this plan, with drought, winter storm, wildfire, and wind as being the most significant. The following graph is a display of the results from Question 4. Question 4 read: *The following types of mitigation actions may be considered in this plan. Please indicate all the types of mitigation actions that you think should have the highest priority in the Regional Multi-Hazard Mitigation Plan. These results will be considered during the planning process.* The results indicate that public education/awareness, indoor/outdoor warning, and flood reduction/drainage improvement were popular with the public. Additional results of the survey are included in Appendix C Planning Process Documentation.

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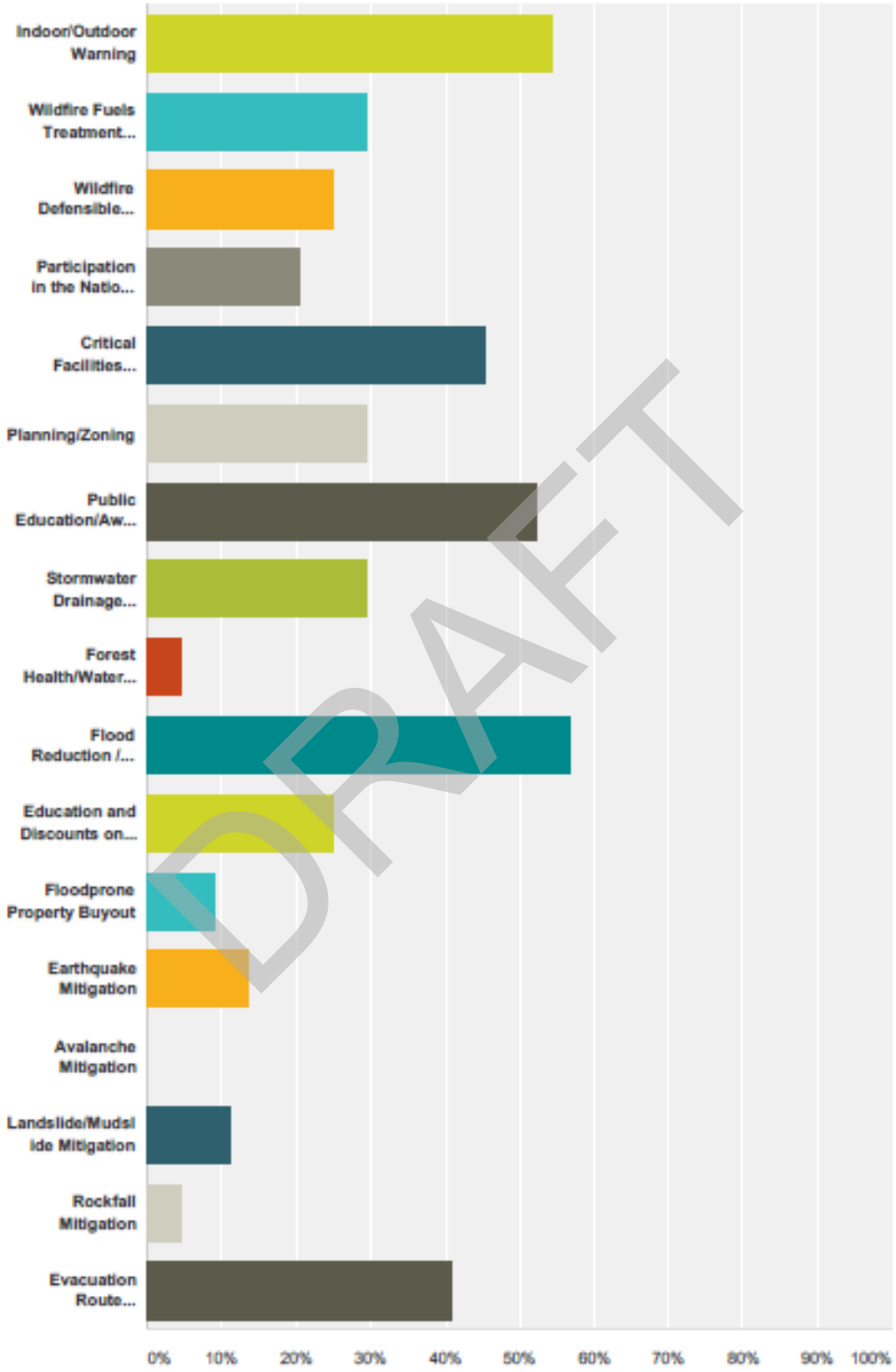
Figure 3.1. Mitigation Action Survey Results Region 4



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Prior to finalizing, a draft of the regional plan was made available to the public for review and comment. The plan was placed on each county's web page and a press release and social media were used to announce the public comment period. A feedback form was provided to collect specific comments.

This accomplished task three (3) in the FEMA Local Mitigation Planning Handbook (Create an outreach strategy).

Planning Task 3: Coordinate with Other Departments and Agencies

Early in the planning process, the HMPC determined that data collection, mitigation strategy development, and plan approval would be greatly enhanced by inviting state and federal agencies and organizations to participate in the process. Based on their involvement in hazard mitigation activities or their role in land stewardship in the Region, representatives from several state and federal agencies, local businesses were invited to participate on the HMPC in 2016 and are noted in Table 3.2.

Many of these stakeholders participated in the process by attending HMPC meetings or providing data and information that was used to update hazard profiles in the plan. Stakeholders were also given an opportunity to review and comment on the draft plan.

Other Community Planning Efforts and Hazard Mitigation Activities

Coordination with other community planning efforts is an important aspect to mitigation planning. Hazard mitigation planning involves identifying existing policies, tools, and actions that will reduce a community's risk and vulnerability from natural hazards. Each county and most municipalities in the Region use a variety of comprehensive planning mechanisms, such as master plans and ordinances, to guide growth and development. Integrating existing planning efforts and mitigation policies and action strategies into this plan establishes a credible and comprehensive plan that ties into and supports other community programs. The development of this plan incorporated information from the following existing plans, studies, reports, and initiatives as well as other relevant data from neighboring communities and other jurisdictions. Examples of this include.

- County comprehensive plans
- Community Wildfire Protection Plans
- Wyoming Hazard Mitigation Plan (2016)

Other documents were reviewed and cited, as appropriate, during the collection of data to support Planning Steps 4 and 5, which include the hazard identification, vulnerability assessment, and capability assessment.

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3.3.2 Phase 2: Assess Risks

Planning Tasks 4 and 5: Identify the Hazards and Assess the Risks

Amec Foster Wheeler led the HMPC in an exhaustive research effort to identify and document all the hazards that have, or could, impact the planning area. Data collection worksheets were used in this effort to aid in determining hazards and vulnerabilities and where risk varies across the planning area. The existing hazard mitigation plans and Wyoming Hazard Mitigation Plan provided a basis for many of the hazard profiles. The HMPC decided to focus on certain hazard chapters most relevant to the County instead of looking at all of the State of Wyoming Hazard Mitigation Plan hazard chapters. Where data permitted, Geographic Information Systems (GIS) were used to display, analyze, and quantify hazards and vulnerabilities. Sophisticated analyses for flood, landslide and wildfire hazards were performed by Amec Foster Wheeler that included an analysis of flood risk based on the recent Digital Flood Insurance Rate Maps (DFIRMs).

Also included in the 2016 plan is a capability assessment to review and document the planning area's current capabilities to mitigate risk and vulnerability from natural hazards. By collecting information about existing government programs, policies, regulations, ordinances, and emergency plans, the HMPC can assess those activities and measures already in place that contribute to mitigating some of the risks and vulnerabilities identified. The results of this assessment are captured in each county annex. A more detailed description of the risk assessment process and the results are included in **Chapter 4 Risk Assessment**.

3.3.3 Phase 3: Develop the Mitigation Plan

Planning Tasks 6 and 7: Set Goals and Review Possible Activities

Amec Foster Wheeler facilitated discussion sessions with the HMPC's that described the purpose and the process of developing planning goals, a comprehensive range of mitigation alternatives, and a method of selecting and defending recommended mitigation actions using a series of selection criteria. This process was used to update and enhance the mitigation action plan, which is the essence of the planning process and one of the most important outcomes of this effort. The action plans are detailed in each county annex; the process used to identify and prioritize mitigation actions are described in greater detail in **Chapter 5 Mitigation Strategy**.

Planning Task 8: Draft an Action Plan

Based on input from the HMPC's regarding the draft risk assessment and the goals and activities identified in Planning Steps 6 and 7, Amec Foster Wheeler produced a complete first draft of the Regional Plan. This complete draft was shared for HMPC review and comment. Other agencies were invited to comment on this draft as well. HMPC and agency comments were integrated into the second draft, which was advertised and distributed to collect public input and comments. Amec Foster Wheeler integrated comments and issues from the public, as appropriate, along with additional internal review comments and produced a final draft for the Wyoming Office of

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Homeland Security and FEMA Region VIII to review and approve, contingent upon final re-adoption by the governing boards of each participating jurisdiction.

3.3.4 Phase 4: Implement the Plan and Monitor Progress

Planning Task 9: Adopt the Plan

In order to secure buy-in and officially implement the plan, the plan was adopted by the governing boards of each participating jurisdiction. As the adoption process follows the FEMA plan review and approval copies of the adoption resolution will be included electronically in **Appendix E Records of Adoption**.

Planning Task 10: Implement, Evaluate, and Revise the Plan

The true worth of any mitigation plan is in the effectiveness of its implementation. Up to this point in the planning process, all of the HMPC's efforts have been directed at researching data, coordinating input from participating entities, and developing/updating appropriate mitigation actions. Each recommended action includes key descriptors, such as a lead manager and possible funding sources, to help initiate implementation. Progress on the implementation of specific actions identified in the plan is captured in a discussion and the mitigation action plan summary table in **Chapter 5 Mitigation Strategy.** An overall implementation strategy is described in **Chapter 6 Plan Adoption, Implementation and Maintenance**.

Finally, there are numerous organizations within the Region 4 planning area whose goals and interests interface with hazard mitigation. Coordination with these other planning efforts, as addressed in Planning Step 3, is paramount to the ongoing success of this plan and mitigation in Region 6 and is addressed further in Chapter 6. A plan update and maintenance schedule and a strategy for continued public involvement are also included in Chapter 6.

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4 HAZARD ANALYSIS AND RISK ASSESSMENT

44 CFR Requirement 201.6(c)(2): [The plan shall include] a risk assessment that provides the factual basis for activities proposed in the strategy to reduce the losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

As defined by the Federal Emergency Management Agency (FEMA), risk is a combination of hazard, vulnerability, and exposure. It is the impact that a hazard would have on people, services, facilities, and structures in a community and refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage.

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. The process allows for a better understanding of a jurisdiction's potential risk to hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

This risk assessment builds upon the methodology described in the 2013 FEMA Local Mitigation Planning Handbook, which recommends a four-step process for conducting a risk assessment:

1) Describe Hazards
2) Identify Community Assets
3) Analyze Risks
4) Summarize Vulnerability

Data collected through this process has been incorporated into the following sections of this chapter:

Section 4.1 Hazard Identification identifies the hazards that threaten the planning area and describes why some hazards have been omitted from further consideration.

Section 4.2 Hazard Profiles discusses the threat to the planning area and describes previous occurrences of hazard events, the likelihood of future occurrences, and the County's vulnerability to particular hazard events. Further county-specific hazard data can be found in the county annexes, where applicable.

A **Capabilities Assessment**, though not required by FEMA, inventories existing county and community mitigation activities, policies, regulations, and plans that pertain to mitigation and can affect net vulnerability. An assessment was conducted as part of the Region 4 planning process; capability information for each county and its communities can be found in the county-specific annexes.

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4.1 Hazard Identification

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

The Hazard Mitigation Planning Committee (HMPC) conducted a hazard identification study to determine the hazards that threaten the planning area.

4.1.1 Results and Methodology

Using existing hazards data, plans from participating jurisdictions, and input gained through planning and public meetings, the HMPCs of each county agreed upon a list of hazards that could affect the Region. Hazards data from FEMA, the Wyoming Office of Homeland Security (including the 2016 State of Wyoming Multi-Hazard Mitigation Plan), the National Oceanic and Atmospheric Administration, the Spatial Hazard Events and Losses Database for the United States (SHELDUS), and many other sources were examined to assess the significance of these hazards to the planning area. The hazards evaluated in this plan include those that have occurred historically or have the potential to cause significant human and/or monetary losses in the future.

The final list of natural hazards identified and investigated for the 2016 Region 4 Multi-Hazard Mitigation Plan includes:

- Avalanche
- Dam Failure
- Drought
- Earthquake
- Expansive Soils
- Flood
- Hailstorm
- Hazardous Materials
- High Winds and Downbursts
- Landslide/Rockfall/Debris Flow
- Lightning
- Mine Subsidence
- Severe Winter Weather
- Tornado
- Wildfire

Members of the HMPC used a hazard worksheet to rate the significance of hazards that could potentially affect the region. Significance was measured in general terms, focusing on key criteria such as the likelihood of the event, past occurrences, spatial extent, and damage and casualty potential. Table 4.1 represents the worksheet used to identify and rate the hazards, and is a

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composite that includes input from all the participating jurisdictions. Note that the significance of the hazard may vary from jurisdiction to jurisdiction. The most significant hazards, based on the subjective input from the team, are listed alphabetically as drought, flooding, and wildfire. Some modifications were made to the original HMPC input based on the results of this risk assessment. Table 4.1 illustrates the location of occurrence of several hazards throughout the Region.

Table 4.1 Table 4.1. Region 4 County Hazards Identification Worksheet

Hazard	Lincoln County	Sweetwater County	Uinta County
Avalanche	Medium	Low	Low
Dam Failure	Low	Low	High
Drought	High	High	High
Earthquake	High	Medium	Medium
Expansive Soils	Low	Low	Low
Flood	Medium	Medium	Medium
Hailstorm	Low	Low	Low
Hazardous Materials	Medium	Medium	Medium
High Winds and Downbursts	Low	Medium	Low
Landslide/Rockfall/Debris Flow	High	Medium	Low
Lightning	Low	Low	Low
Mine Subsidence	Medium	High	Low
Tornadoes	Low	Low	Low
Severe Winter Weather	Medium	Medium	Medium
Wildfire	High	Medium	High

*Significance based on a combination of Geographic Extent, Potential Magnitude/Severity and Probability as defined below.

Geographic Extent
Negligible: Less than 10 percent of planning area or isolated single-point occurrences
Limited: 10 to 25 percent of the planning area or limited single-point occurrences
Significant: 25 to 75 percent of planning area or frequent single-point occurrences
Extensive: 75 to 100 percent of planning area or consistent single-point occurrences

Probability of Future Occurrences
Unlikely: Less than 1 percent probability of occurrence in the next year, or has a recurrence interval of greater than every 100 years.
Occasional: Between a 1 and 10 percent probability of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
Likely: Between 10 and 90 percent probability of occurrence in the next year, or has a recurrence interval of 1 to 10 years
Highly Likely: Between 90 and 100 percent probability of occurrence in the next year, or has a recurrence interval of less than 1 year.

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Potential Magnitude/Severity
Negligible: Less than 10 percent of property is severely damaged, facilities and services are unavailable for less than 24 hours, injuries and illnesses are treatable with first aid or within the response capability of the jurisdiction.
Limited: 10 to 25 percent of property is severely damaged, facilities and services are unavailable between 1 and 7 days, injuries and illnesses require sophisticated medical support that does not strain the response capability of the jurisdiction, or results in very few permanent disabilities.
Critical: 25 to 50 percent of property is severely damaged, facilities and services are unavailable or severely hindered for 1 to 2 weeks, injuries and illnesses overwhelm medical support for a brief period of time, or result in many permanent disabilities and a few deaths.
Catastrophic: More than 50 percent of property is severely damaged, facilities and services are unavailable or hindered for more than 2 weeks, the medical response system is overwhelmed for an extended period of time or many deaths occur.

Overall Significance
Low: Two or more of the criteria fall in the lower classifications or the event has a minimal impact on the planning area. This rating is also sometimes used for hazards with a minimal or unknown record of occurrences/impacts or for hazards with minimal mitigation potential.
Medium: The criteria fall mostly in the middle ranges of classifications and the event's impacts on the planning area are noticeable but not devastating. This rating is also sometimes utilized for hazards with a high impact rating but an extremely low occurrence rating.
High: The criteria consistently fall along the high ranges of the classification and the event exerts significant and frequent impacts on the planning area. This rating is also sometimes utilized for hazards with a high psychological impact or for hazards that the jurisdiction identifies as particularly relevant.

4.1.2 Disaster Declaration History

As part of the hazard identification process, the HMPC researched past events that triggered federal and/or state emergency or disaster declarations in the planning area. 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 government's 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 the provision of 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.

0 provides information on federal emergencies and disasters declared in Wyoming between 1963 and 2016. While some of these declarations were statewide or occurred outside of the Region they are indicative of the types of incidents that could cause declarations.

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Table 4.2 Major Disaster Declarations in Wyoming: 1963 - 2016

Event/ Hazard	Year	Declaration Type	Remarks/Description
Heavy rains, flooding	1963	Presidential – Major Disaster Declaration	
Drought	1977	Presidential - Emergency Declaration	
Severe storms, flooding, mudslides	1978	Presidential – Major Disaster Declaration	
Severe storms, tornadoes	1979	Presidential – Major Disaster Declaration	
Severe storms, hail, flooding	1985	Presidential – Major Disaster Declaration	
Methane gas seepage	1987	Presidential - Emergency Declaration	
Severe winter storm	1999	Presidential – Major Disaster Declaration	
Winter storm	2000	Presidential – Major Disaster Declaration	
Hensel Fire	2002	Fire Mgmt Assistance Declaration	
Reese Mountain Fire	2002	Fire Mgmt Assistance Declaration	
Commissary Ridge Fire	2002	Fire Mgmt Assistance Declaration	
Tongue River Fire	2003	Fire Mgmt Assistance Declaration	
Tornado	2005	Presidential – Major Disaster Declaration	
Drought	2006	USDA Declaration	Statewide drought affecting
Thorn Divide Fire Complex	2006	Fire Mgmt Assistance Declaration	
Jackson Canyon Fire	2006	Fire Mgmt Assistance Declaration	
Drought	2007	USDA Declaration	Statewide drought affecting
Little Goose Fire	2007	Fire Mgmt Assistance Declaration	
Flooding	2010	Presidential – Major Disaster Declaration	Rain and snowmelt flooding in Fremont County
Severe Storms, Flooding, and Landslides	2011	Presidential-Major Disaster Declaration	
Arapahoe Fire	2012	Fire Mgmt Assistance Declaration	
Squirrel Creek Fire	2012	Fire Mgmt Assistance Declaration	
Oil Creek Fire	2012	Fire Mgmt Assistance Declaration	
Sheep Herder Hill Fire	2012	Fire Mgmt Assistance Declaration	
Severe Storms and Flooding	2015	Presidential-Major Disaster Declaration	
Station Fire	2015	Fire Mgmt Assistance Declaration	
Lava Mountain Fire	2016	Fire Mgmt Assistance Declaration	
Tokawana Fire	2016	Fire Mgmt Assistance Declaration	

Source: Public Entity Risk Institute Presidential Disaster Declaration Site, www.peripresdecusa.org/

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4.2 Hazard Profiles

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the…location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

The hazards identified in Section 4.1 Identifying Hazards are profiled individually in this section. Much of the profile information came from the same sources used to initially identify the hazards.

4.2.1 Profile Methodology

Each hazard is profiled in a similar format that is described below.

Hazard/Problem Description

This subsection gives a description of the hazard and associated problems, followed by details on the hazard specific to the Region.

Geographical Area Affected

This subsection discusses which areas of the Region are most likely to be affected by a hazard event.

Limited: Less than 10 percent of the planning area
Significant: 10 to 50 percent of the planning area
Extensive: 50 to 100 percent of the planning area

Past Occurrences

This subsection contains information on historic incidents, including impacts where known. Information provided by the HMPC is included here along with information from other data sources, including the National Climatic Data Center (NCDC) and SHELDUS where available.

SHELDUS is a county-level data set for the United States that tracks 18 types of natural hazard events along with associated property and crop losses, injuries, and fatalities. In 2014, this formerly free service transitioned into a fee-based service. Due to this and the availability of similar data in NCDC databases, it was not used as a resource during the 2016 regional plan development except for when the data was already available.

When available, tables showing county-specific data from the NCDC and SHELDUS databases may be found in each hazard profile.

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Likelihood of Occurrence

The frequency of past events is used in this section to gauge the likelihood of future occurrences. Based on historical data, the likelihood of future occurrences is categorized into one of the following classifications:

Highly Likely—Near 100 percent chance of occurrence in next year, or happens every year.
Likely—Between 10 and 100 percent chance of occurrence in next year, or has a recurrence interval of 10 years or less.
Occasional—Between 1 and 10 percent chance of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
Unlikely—Less than 1 percent chance of occurrence in next 100 years, or has a recurrence interval of greater than every 100 years.

The frequency, or chance of occurrence, was calculated where possible based on existing data. Frequency was determined by dividing the number of events observed by the number of years and multiplying by 100. Stated mathematically, the methodology for calculating the probability of future occurrences is:

$$\frac{\textbf{\# of known events}}{\text{years of historic record}} \times \mathbf{100}$$

This gives the percent chance of the event happening in any given year. An example would be three droughts occurring over a 30-year period which equates to 10 percent chance of that hazard occurring any given year.

Potential Magnitude

This subsection discusses the potential magnitude of impacts, or extent, from a hazard event. Magnitude classifications are as follows:

Catastrophic—More than 50 percent of property severely damaged, and/or facilities are inoperable or closed for more than 30 days. More than 50 percent agricultural losses. Multiple fatalities and injuries. Critical indirect impacts.

Critical—25 to 50 percent of property severely damaged, and/or facilities are inoperable or closed for at least 2 weeks. 10-50 percent agricultural losses. Injuries and/or illnesses result in permanent disability and some fatalities. Moderate indirect impacts.

Limited—10 to 25 percent of area affected. Some injuries, complete shutdown of critical facilities for more than one week, more than 10 percent of property is severely damaged.

Negligible—Less than 10 percent of area affected. Minor injuries, minimal quality-of-life impact, shutdown of critical facilities and services for 24 hours or less, less than 10 percent of property is severely damaged.

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Vulnerability Assessment

Vulnerability is the measurement of exposed structures or populations relative to the risk of the hazard. For most hazards, vulnerability is a best-estimate. Some hazards, such as flood, affect specific areas so that exposure can be quantified, and vulnerability assessments result in a more specific approximation. Other hazards, such as tornados, are so random and unpredictable in location and duration that only approximate methods can be applied.

Future Development

This section describes how the hazard could impact future development.

Summary

This section summarizes risk by county according to the area affected, likelihood, and magnitude of impacts. If the hazard has impacts on specific towns or cities in the region they are noted here, where applicable.

4.2.2 Avalanche

Hazard Description

An avalanche is a mass of snow sliding down a mountainside. The vast majority of avalanches occur during and shortly after storms. Avalanches occur when loading of new snow on a slope increases stress at a rate faster than strength develops, and the slope fails. There are four factors that contribute to an avalanche: a steep slope, a snow cover, a weak layer in the snow cover, and a trigger. About 90 percent of all avalanches start on slopes of 30-45 degrees; about 98 percent 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). Nevertheless, avalanches can run 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.

Wyoming is one of the top-ranking states for avalanche hazard because of its rural character and mountain recreation. 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 62 years (1950-2012), Wyoming ranks sixth among the eight states with the most avalanche fatalities.

Avalanche generally affects a small number of people, such as snowboarders, skiers, and hikers, who venture into backcountry areas during or after winter storms. Roads and highway closures, damaged structures, and destruction of forests are also a direct result of avalanches. Areas prone to avalanche hazards include hard to access areas deep in the backcountry.

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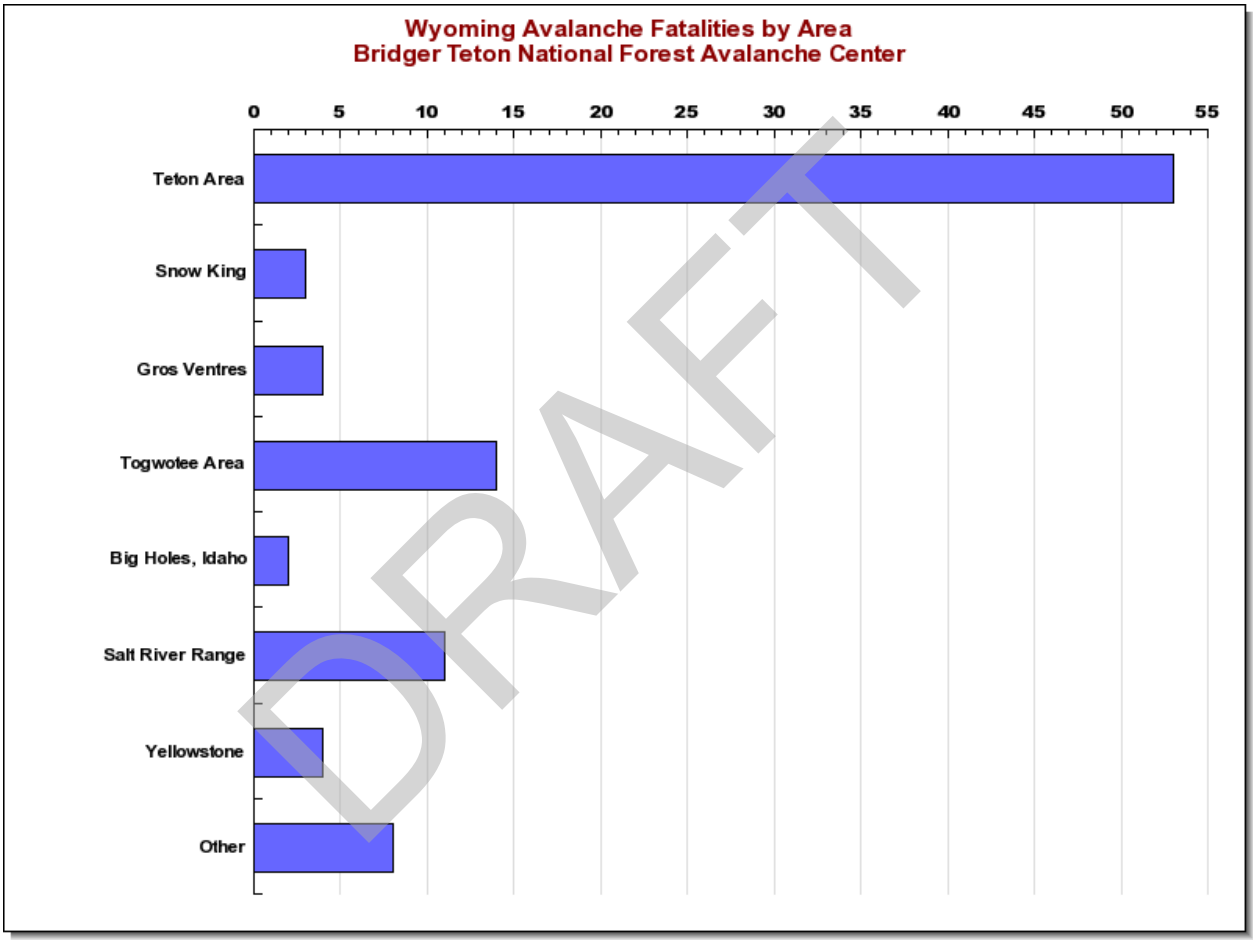
Geographical Area Affected

Avalanches affect a limited spatial area in this region. The Salt River Range Mountains in Lincoln 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. Figure 4.1 illustrates the geographic distribution of avalanche fatalities around Wyoming.

Figure 4.1. Wyoming Avalanche Fatalities by Area: 1913 - 2016



Source: www.jhavalanche.org

Past Occurrences

Historically, avalanches occur within the Region between the months of December and April, following snowstorms.

The Wyoming State Mitigation Plan compiled a table from SHELDUS and NCDC databases that lists loss-causing avalanche events and associated damage by county. Lincoln County recorded 35 of the 143 events from 1960-2015 in the state of Wyoming. The table also shows that Lincoln County experienced $5,000 in total property damage. This accounts for one-third of the total

property damage in the state ($15,000). Although few records exist of avalanches in Sweetwater County or Uinta County, it is important to remember that many avalanches go unreported or undocumented when no fatalities or injuries are involved.

According to the Bridger-Teton Avalanche Center, fatalities in the region include 12 in the Salt River Range in Lincoln County. There were no reported fatalities in the other two counties. Table 4.3 lists Avalanche Fatalities in Region 4, all of which were recorded in Lincoln County.

Table 4.3. Avalanche Fatalities in Region 4: 1962 - 2016

Date	Location	Description
02/10/1962	Swift Creek, Salt River Range	Snowshoer
02/25/1994	Greys River Road, Salt River Range	Snowmobiler
01/14/1996	Bradley Mountain, Near Alpine	Helicopter Skiing
02/10/1996	Strawberry Creek, Salt River Range	Snowmobiler
03/03/2001	Lee Bowl, Salt River Range	Snowmobiler
01/05/2003	Balls Mountain, Salt River Range	Snowmobiler
02/24/2003	Smiths Fork, Salt River Range	Snowmobiler
12/16/2006	Stewart Peak, Salt River Range	Snowmobiler
01/12/2008	Cottonwood Creek, Salt River Range	Snowmobiler
01/12/2008	Cottonwood Creek, Salt River Range	Snowmobiler
01/12/2008	Cottonwood Creek, Salt River Range	Snowmobiler
02/06/2010	North Murphy Creek, Salt River Range	Snowmobiler

Source: http://www.jhavalanche.org/areaFatalities

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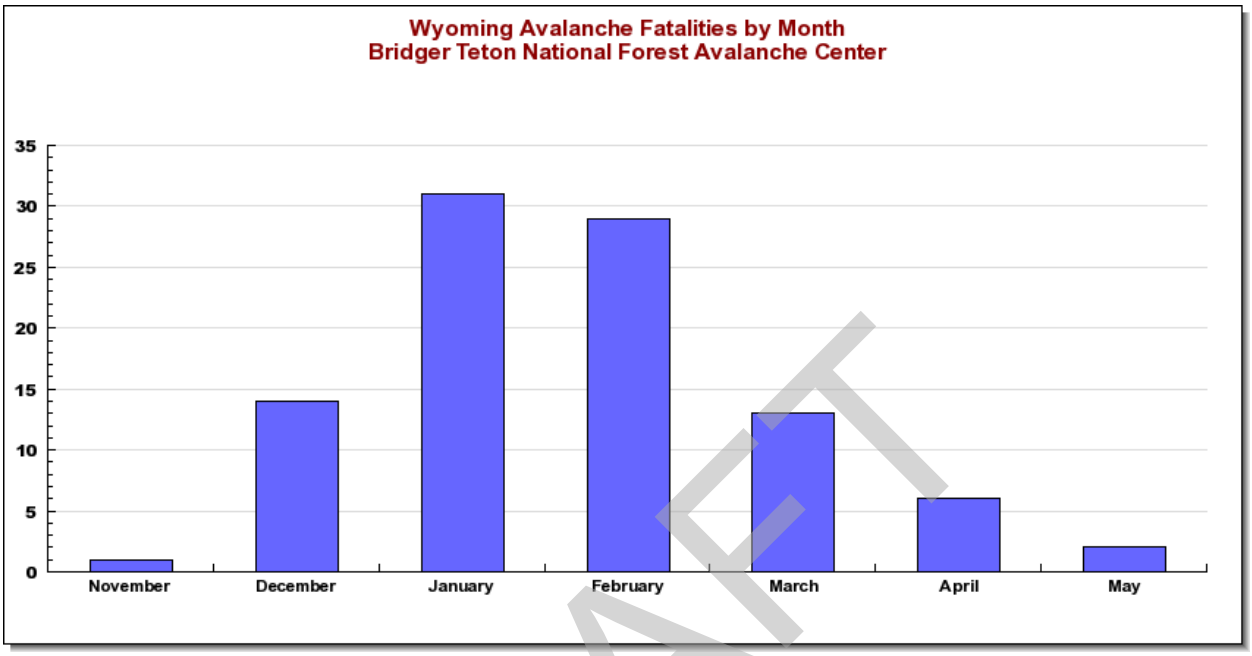
Likelihood of Future Occurrence

The probability that an avalanche will occur in the region in any given year can be determined by using the formula described in Section 4.2. According to the Wyoming State Mitigation Plan, 32 events occurred between 1960 and 2015 in Lincoln County. This yields a 42.6% occurrence probability. Therefore, the likelihood rating for avalanches in Lincoln is likely**.** Given the terrain and weather conditions in the western part of the state, avalanches are likely to occur, but the damages should continue to be limited. Injuries and loss of life from an avalanche are usually due to people recreating in remote areas at the wrong time. Many residents and visitors to Lincoln County avidly enjoy outdoor recreation, so it is highly likely that people will continue to be exposed to avalanche hazards in the Salt River Range. There have been no reported fatalities in Sweetwater County or Uinta County between 1960 and 2015, so the likelihood rating for avalanches is unlikely. The figure below lists the distribution of avalanche fatalities by month

based on statewide statistics, with January and February being the most likely time of year for avalanche accidents.

Figure 4.2. Wyoming Avalanche Fatalities by Month: 1913 - 2016



Source: www.jhavalanche.org

Potential Magnitude

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of a common occurrence. Only one recorded event, a fatality in 2001, exists in national storm and disaster databases such as SHELDUS and NCDC.

Overall, avalanche impacts would likely be negligible in the Region. However, a road closure due to avalanche activity could result in transportation disruptions due to the limited number of roads region wide. Apart from backcountry skiers, snowshoers, snowmobilers and snowboarders, the threat to life and safety is minimal.

Vulnerability Assessment

Although future avalanches are likely to occur, the spatial extent is limited and the magnitude is low. Therefore, avalanches are a low significance hazard in Sweetwater and Uinta Counties. However, avalanches are a high significance hazard in Lincoln County. No known critical facilities or cultural resources were located in avalanche paths at the time this plan was written. It is public safety that is most threatened by this hazard. Outdoor recreationalists who travel into backcountry

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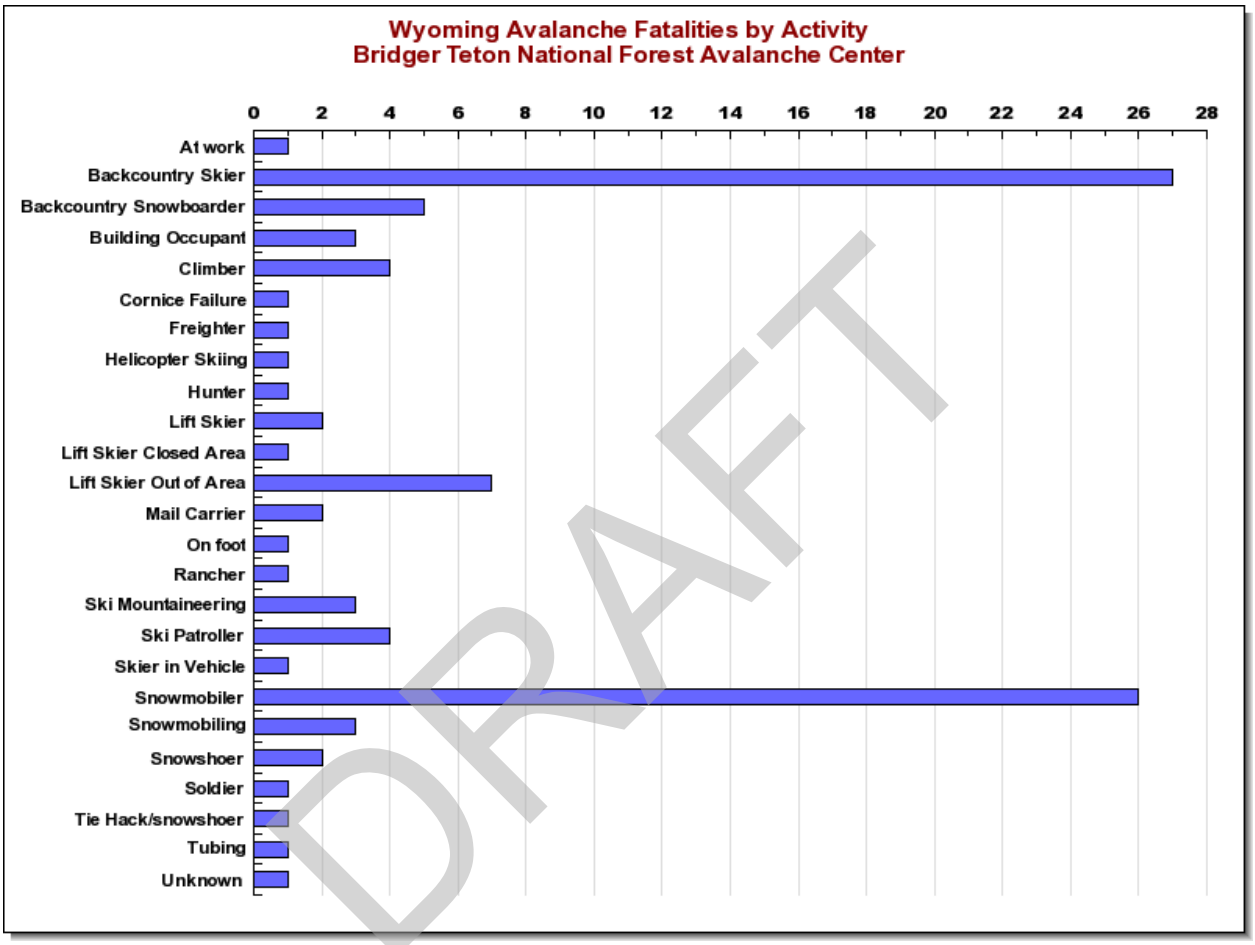
areas are most at risk. Additionally, while road closures help to mitigate impacts to travelers in avalanche-prone areas, snowplow drivers can still be exposed while clearing roads of snow or avalanche debris. The following is an analysis of fatalities by activity, based on statewide statistics through 2016.

Figure 4.3. Wyoming Avalanche Fatalities by Activity: 1913 - 2016



Source: www.jhavalanche.org

The keys to limiting impacts to individuals recreating in the area are knowledge an awareness of the hazard and being properly equipped for self-rescue, if necessary, with tools such as locator beacons, shovels, and probes.

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 mapped or suspected avalanche hazard zones.

Summary

Overall, avalanches are a low significance hazard to counties in the Region, though Lincoln County has more risk than Sweetwater or Uinta Counties. Generally, impacts are isolated to backcountry users and possibly first responders.

Table 4.4. Avalanche Hazard Risk Summary

County	Geographic Extent	Probability of Future Occurrence	Potential Magnitude	Overall Significance
Lincoln	Limited	Likely	Negligible	Medium
Sweetwater	Negligible	Unlikely	Negligible	Low
Uinta	Negligible	Unlikely	Negligible	Low

4.2.3 Dam Failure

Hazard Description

Dams are man-made structures built for a variety of uses, including flood protection, power, agriculture, water supply, and recreation. Dams typically are constructed of earth, rock, concrete, or mine tailings. Dams and reservoirs serve a very important role for Wyoming residents and industry. Rarely, however, the dams fail, either completely or partially, and become a significant hazard for those downstream.

Dam failure is the uncontrolled release of impounded water resulting in downstream flooding, which can affect life and property. Two factors that influence the potential severity of a full or partial dam failure are the amount of water impounded and the density, type, and value of development and infrastructure located downstream.

Dam failure occurs when the retention function of the dam is compromised, in part or in its entirety. Damage to a dam structure that may result in a failure may be caused by many sources:

- 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
- Improper design
- Age
- Improper maintenance
- Negligent operation
- Failure of upstream dams on the same waterway
- Vandalism or terrorism

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A dam failure is not the only type of emergency associated with dams. Spillway discharges that are large enough to cause flooding in downstream areas or flooding upstream of dams due to backwater effects or high pool levels are both considered dam emergencies and may cause significant property damage and loss of life.[1]

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

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. Dams are classified into three classes. The State of Wyoming has adopted FEMA's risk classifications as set forth in FEMA's *Federal Guidelines for Dam Safety:* Hazard *Potential Classification System for Dams*. These guidelines define High Hazard (Class I) dams as those rated based on an expected loss of human life, should the dam fail, and Significant Hazard (Class II) dams as those rated based on expected significant damage, but not loss of human life. Significant damage refers to structural damage where humans live, work, or recreate; or public or private facilities exclusive of unpaved roads and picnic areas. Damage refers to making the structures inhabitable or inoperable. Low hazard dams would have minimal downstream impacts in the event of a failure.

Geographical Area Affected

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**.**

[1] US Army Corps of Engineers *Flood Emergency Plans: Guidelines for Corps Dams*. Hydrologic Engineering Center, (June 1980) p 4.

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There were 1,458 dams in Wyoming that were reviewed by the Corps of Engineers. Of that number 38 were rated high hazard, 56 were rated significant hazard, and the remaining 1,364 were rated low hazard. The Wyoming State Engineers Office (WSEO) inspects 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. According to the WSEO web site[2], as of 2012 there are 1,515 dams that are inspected by the State Engineer once every five years. Of those dams, 84 are rated high hazard, 106 were rated significant hazard, and 1,325 were rated low-hazard by the Wyoming State Engineer's Office.

Figure 4.4 shows the dams affecting Region 4. Of these, 24 are classified as High Hazard (Class I) and 28 are classified as Significant Hazard (Class II). Table 4.5 below provides details of the High and Significant Hazard Dams. It also notes dams upstream of Region 4 counties that can impact the Region; some of these are located in adjacent counties in both Utah and Idaho.

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[2] http://www.damsafety.org/map/state.aspx?s=51 (Accessed 7/12/2016)

Figure 4.4. Locations of High and Significant Dams Affecting Region 4

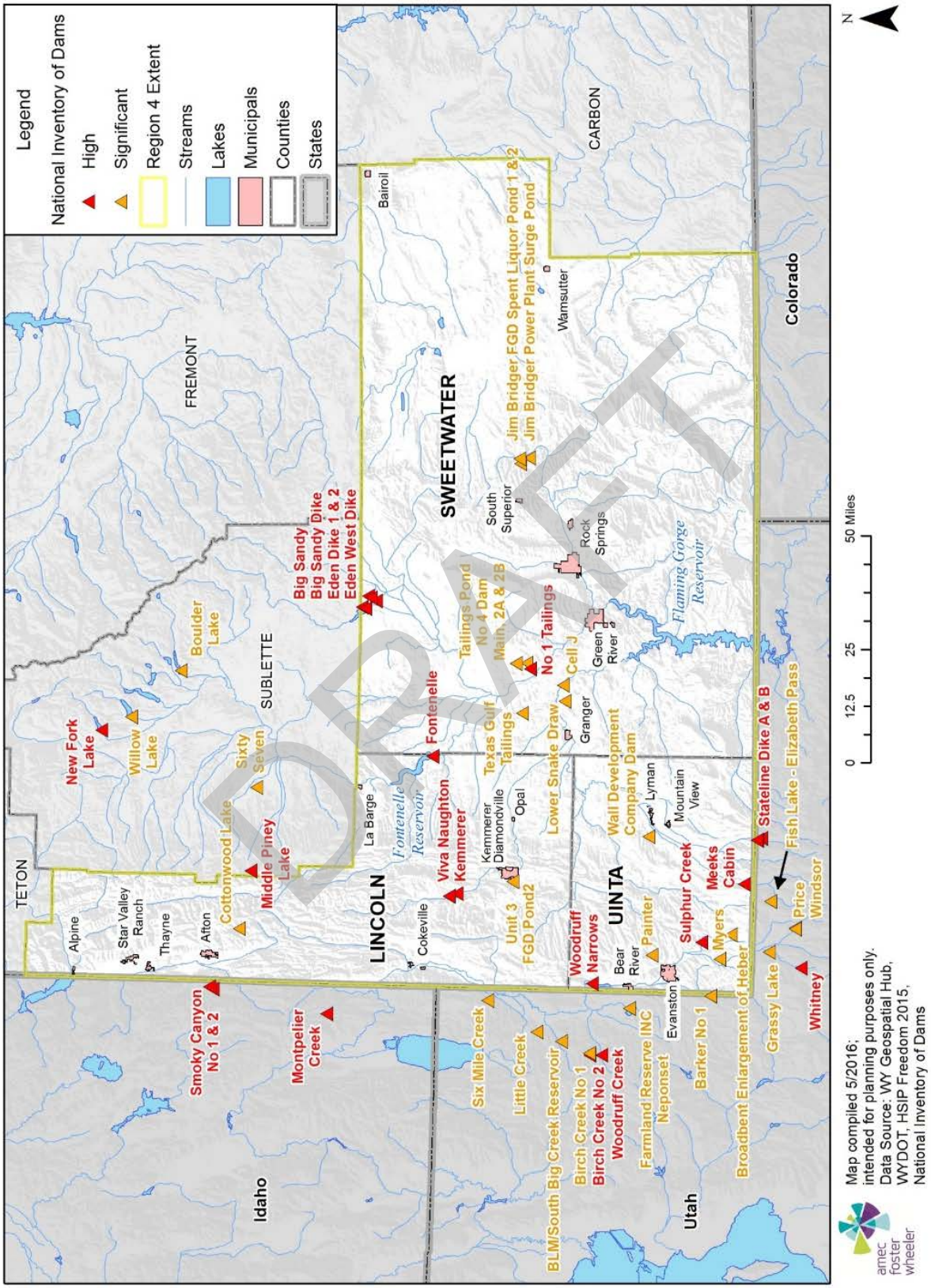

Table 4.5. High and Significant Dams Affecting Region 4

Dam Name	Owner	River	Hazard Class	Nearest Downstream City	Distance To Nearest Downstream City (Miles)	EAP
Summit County, Utah (Upstream Of Uinta County)						
Stateline Dike A	Doi Br	East Fork Smith Creek	H	None	0	Y
Stateline Dike B	Doi Br	East Fork Smith Creek	H	None	0	Y
Bor Stateline Summit Co.	Doi Br	E. Fork Smiths Fork	H	Robertson	16	N
Whitney	Upper Bear River & Mill Creek Water	West Fork Of Bear River	H	Evanston	38	Y
Fish Lake – Elizabeth Pass	Anadarko Petroleum/ Land Corp	Fish Lake Creek	S	None	0	N
Price			S		0	Y
Grassy Lake (Hatch)	Two Bear Land And Grazing Corporation	Trib To West Fk Bear River	S	Evanston	27	N
Windsor		East Fork Bear River	S		0	Y
Barker No. 1	A.J. Barker	Yellow Creek	S	Evanston	14	N
Caribou County, Idaho (Upstream of Lincoln County)						
Smoky Canyon No 1	Jr Simplot Co.		H	Auburn	15	Y
Smoky Canyon No 2	Jr Simplot Co.		H	Afton	1	Y
Rich County, Utah (Upstream of Uinta And Lincoln Counties)						
Woodruff Creek	Woodruff Reservoir & Irrigation Company	Woodruff Creek	H	Woodruff	9	Y
Birch Creek No. 2	Woodruff Reservoir & Irrigation Company	Birch Creek	H	Woodruff	8	Y
B.L.M./South Big Creek Reservoir	Woodruff Reservoir & Irrigation Company	Birch Creek	H	Woodruff	8	Y
Farmland Reserve, Inc.- Neponset	Bureau Of Land Mgmt		S		0	N
Little Creek	Farmland Reserve, Inc. LDS Church	Bear River – Offstream	S	Woodruff	18	Y

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Birch Creek No. 1 (Lower)	Little Creek Irrigation & Reservoir Co.	Little Creek	S	Randolph	2	N
Six Mile Creek	Larry Johnson	Six Mile Creek	S	Beckwith	7	N
Sublette County (Upstream Of Lincoln And Sweetwater Counties)						
New Fork Lake	New Fork Lake Irrigation District	West Fork Of New Fork River	H	Boulder	30	Y
Middle Piney Lake Dam	USDA FS	Middle Piney Creek	H	Big Piney	25	Y
Willow Lake	Wilson, Binning, Bayer, Jorgensen, Et al	Lake Creek	S	Boulder	22	Y
Boulder Lake	Boulder Lake Irrigation District	Boulder Creek	S	Boulder	6	N
Sixty Seven	67 Reservoir Corp., C/O Jay Downes	Spring Creek Offstream	S	Big Piney	6	N
Lincoln County						
Fontenelle	DOI BR	Green River	H	Jamestown	59	Y
Kemmerer	Joint Powers Board C/O Dale Crank	Hams Fork River	H	Kemmerer	12	N
Viva Naughton	Pacificorp	Hams Fork	H	Frontier	13	Y
Unit 3 Fgd Pond 2	Pacificorp, Naughton Power Plant	Culvert Draw	S	Hwy 189	1	N
Cottonwood Lake	Usda Forest Service (Mesia Nyman)	Cottonwood Creek	S	Smoot	14	N
Sweetwater County						
Eden West Dike	DOI BR	Little Sandy Creek	H	Farson	7	Y
Eden Dike 2	DOI BR	Little Sandy Creek Os	H	Farson	7	Y
Big Sandy Dike	DOI BR	Big Sandy Creek	H	Farson	11	Y
Eden Dike 1	DOI BR	Little Sandy Creek Os	H	Farson	7	Y
Fontenelle	DOI BR	Green River	H	Jamestown	59	Y

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Big Sandy	DOI BR	Big Sandy Creek	H	Farson	11	Y
No. 1 Tailings	Ciner Wyoming, L.P.	Stevens Draw	H	Green River	19	N
Jim Bridger Power Plant Surge Pond	Pp&L – Jbpp (Robert Arambel)	Humphrey Draw	S	Point Of Rocks	7	N
Jim Bridger Fgd Spent Liquor Pond No. 1	Pp & L – Jbpp (Robert Arambel)	Fontenelle Res, Supp Frm Green	S	Point Of Rocks	7	N
Jim Bridger Fgd Spent Liquor Pond No. 2	Pp & L – Jbpp (Robert Arabel)	Fontenelle Res, Supp Frm Green	S	Point Of Rocks	7	N
Tailings Pond No. 4 Dam 2b	Oci Wyoming, L.P.	Stevens Draw	S	Green River	19	N
TRONOX	Ciner	Drainage Of Bluebell Draw	S	Alchem	12	N
Tailings Pond No. 4 Main Dam	Ciner Wyoming, L.P.	Stevens Draw	S	Green River	19	N
Tailings Pond No. 4 Dam 2a	Oci Wyoming, L.P.	Stevens Draw	S	Green River	19	N
Lower Snake Draw (4th Enl.)	TRONOX	Snake Draw	S	Green River	0	N
Cell J	TATA		S	Manila	60	N
Uinta County						
Meeks Cabin	DOI BR	Blacks Fork River	H	Millburne	18	Y
Woodruff Narrows	Woodruff Narrows Reservoir Association	Bear River	H	Woodruff, Utah	9	Y
Sulphur Creek	City Of Evanston & Sulphur Creek Res. Co	Sulphur Creek	H	Evanston	12	Y
Broadbent Enlargement Of Heber	J. R. Broadbent Company	Broadbent Ditch, La Chapelle Creek	S		0	N
Wall Development Company Dam	John Eyre	Quarry Creek, Tr Blacks Fork Creek	S	Fort Bridger Military Reservation	0	N
Myers	Dan Cowan	Mill Creek Offstream	S	Woodruff, Utah	16	N
Painter	Brad Fearne	Pleasant Valley Creek	S	Woodruff, Utah	28	N

Source: National Inventory of Dams

There are two high hazard dams in Uinta County and two high hazard dams that are upstream from populated communities in Uinta County. Sulfur Creek Dam is above Evanston and the town of

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Bear River. Meeks Cabin Dam and State Line Dikes 1 & 2 are above Mountain View and Fort Bridger. Sulphur Creek Dam is an earthen dam built primarily for water storage.

Meeks Cabin is owned and operated by the U.S. Federal Bureau of Reclamation (USBR). It is an earthen dam used primarily for irrigation water storage. It was last inspected on September 1, 2009. State Line Dikes 1 & 2 are located in Summit County, Utah, just south of Uinta County. They are earthen dams owned by the USBR as fish and wildlife ponds. They were last inspected on September 19, 2011. All high hazard dams affecting Uinta County have emergency action plans.

Fontenelle Dam is a high hazard dam above Green River in Sweetwater/Lincoln County. It was built between 1961 and 1964 on the Green River by the U.S. Federal Bureau of Reclamation. Failure of the Fontenelle Dam would directly impact Jamestown and Green River. The earthfill dam primarily impounds water for storage. It is owned and operated by the USBR and is not subject to State regulation. It has an emergency plan and its last inspection was July 24, 2008.

Viva Naughton is a high hazard dam upstream of Kemmerer on the Hams Fork River in Lincoln County. It is a privately owned dam used for water supply, irrigation and flood control. There is an emergency action plan. Its last inspection by the State was June 6, 2012.

Given the geographical extent and number of High and Significant dams in the Region the rating ranges from low to significant depending on the location in the Region.

Past Occurrences

There has been one documented dam failure in Region 4. Fontenelle Dam suffered a significant breach in 1965, when the dam's right abutment developed a leak. Emergency releases from the dam flooded downstream properties, but repairs to the dam were successful.

In June 8, 2010, rapidly melting snow and downpours flowed into an already full Meeks Cabin Reservoir above Fort Bridger in Uinta County. Over 1,500 cfs had to be released over the spill way of the dam. Total release was 2,500 cfs, causing flooding downstream.

There have been a number of dam failures elsewhere in Wyoming, some of which resulted in loss of life and damage to property. In 1906, snow melt flooding along the North Platte caused the failure of a diversion dam. The flooding destroyed a railroad embankment and resulted in a train wreck that claimed 12 lives. Snow melt flooding caused another dam to fail in 1984. Dozens of residences, businesses, and farms were impacted for a total of $5 million in damages to the area.

Likelihood of Future Occurrence

Based on past history, Region 4 could be affected occasionally by dam failures in the future. The structural integrity of dams depends on regular inspections and maintenance, which do not always happen. Additionally, a number of the dam failures in Wyoming and other Rocky Mountain states

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occurred because of snow melt flooding that exceeded the capacity and strength of dams. Wyoming's dams will continue to be tested by snow melt, heavy rains, and other types of floods every year. Thus, dam failures could possibly threaten Wyoming and Region 4 counties.

Potential Magnitude

Potential impacts could include injury and loss of life, property damage, damage to infrastructure, drinking water contamination, loss of crops and livestock, evacuations and sheltering and associated costs, interruption of commerce and transportation, search and rescue, and clean-up costs.

The severity and magnitude of a given dam or levee failure is best assessed on a county basis and case-by-case basis. This information is contained in the emergency action plans for the high hazard dams in the State. More information on the High Hazard and Significant Hazard dams, and an estimate of relative impacts from a failure of them, can be referenced in the County Annexes.

High Hazard (Class I) dams, by definition, would merit a magnitude/severity rating of catastrophic, whereas Significant Hazard (Class II) dams rate as critical and Low Hazard dams fall into the limited rating. The magnitude/severity rating for the hazard is ranges from limited to critical, based on the location in the Region and the number of Class I dams that could impact communities in the Region.

Vulnerability Assessment

The seriousness of flooding hazards in Uinta County comes from the risks posed by dams. Sulfur Creek Dam is above Evanston and the town of Bear River. Meeks Cabin Dam and State Line Dikes 1 & 2 are above Mountain View and Fort Bridger. In the event of a dam break or breach, much of the developed county would be flooded in a short period of time. The communities below would be devastated and there would most likely be loss of life and a loss of water supply for almost all the communities in Uinta County.

Fontenelle Dam is above Green River and Jamestown and Viva Naughton Dam is above Kemmerer. A previous failure of Fontenelle Dam caused flooding to downstream properties.

Another problem area is the aging of the dams. Of the 1,548 dams in the State inventory in 2015, 860 or 56% were constructed before 1965 and are over fifty years old. The SOD staff responds to reports of dam failures or near failures. All of the incidents in the past five years are attributable to the age of the dam and the appurtenant structures. (Source: 2015 WY SOD report.)

Future Development

As communities or unincorporated areas grow, previously lower-classified dams may pose greater risks, which could elevate their hazard classification. Inundation maps and emergency action plans should be consulted in the planning of new development, where applicable. Future development

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along portions of the Hams Fork River, Cottonwood Creek, the Green River, or Culvert Draw could be at risk.

Growth rates in the region do not indicate that risk is increasing substantially.

Summary

Overall, dam failure significance ranges from low to high dependent upon location in the Region. The probability of such an event is low, but impacts could be significant depending upon the dam involved.

Table 4.6. Dam Failure Hazard Risk Summary

County	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/ Severity	Overall Significance
Lincoln	Limited	Occasional	Limited	Low
Sweetwater	Limited	Occasional	Limited	Low
Uinta	Significant	Occasional	Critical	High

<u>Municipalities Impacted:</u>
Lincoln County: Kemmerer
Sweetwater County: Green River
Uinta County: Evanston, Bear River, Mountain View, Fort Bridger

4.2.4 Drought

Hazard Description

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

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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).

Geographical Area Affected

According to estimates by the Region 4 Hazard Mitigation Plan Committee, the Region is at high risk to drought events over an extensive spatial area. Droughts are often regional events, impacting multiple counties and states simultaneously. Therefore, as the climate of the planning area is fairly contiguous, it is reasonable to assume that a drought will impact the entire planning region. According to the Wyoming State Climate Office, Wyoming is the 5th driest state in the U.S. Drought can be a normal occurrence in Wyoming due to the State's natural climate, and each county's HMPC noted that the entire area generally doesn't see much moisture; communities and residents have adapted to life in the drier ecosystem of the region.

Past Occurrences

The planning area has experienced several multi-year droughts over the past several decades. The most recent statewide drought started in 1999, but began in earnest in the spring of 2000 and endured through 2004. 2005 was a wetter year, technically signifying the end of the drought period. Dry conditions returned in the following years and became especially severe between 2006 and 2007. According to the Wyoming State Climate Office, "conditions have eased somewhat in mid-2008, but a near decade with warm temperatures and relatively little precipitation has left [Wyoming] very vulnerable" (http://www.wrds.uwyo.edu/sco/drought/drought.html). Another particularly dry year occurred in 2012.

The 1999-2004 drought is considered by many to be the most severe in collective memory. However, some long-time residents have indicated that they remember streams drying up in the 1930s and 1950s. According to instrument records, since 1895 there have been only seven multi-year (three years or longer) statewide droughts. Based on deficit precipitation totals (negative departures from the long term average), they are ranked on a statewide basis in the table below.

Table 4.7. Signficant Multi-Year Wyoming Droughts of the Modern Instrumented Era

Years	Average Annual Precipitation (inches)	Percent of 1985-2006 Average Annual Precipitation (13.04")
1952-1956	10.65	81.69%
1900-1903	10.76	82.52%
1999-2004	11.07	84.89%
1987-1990	11.12	85.28%

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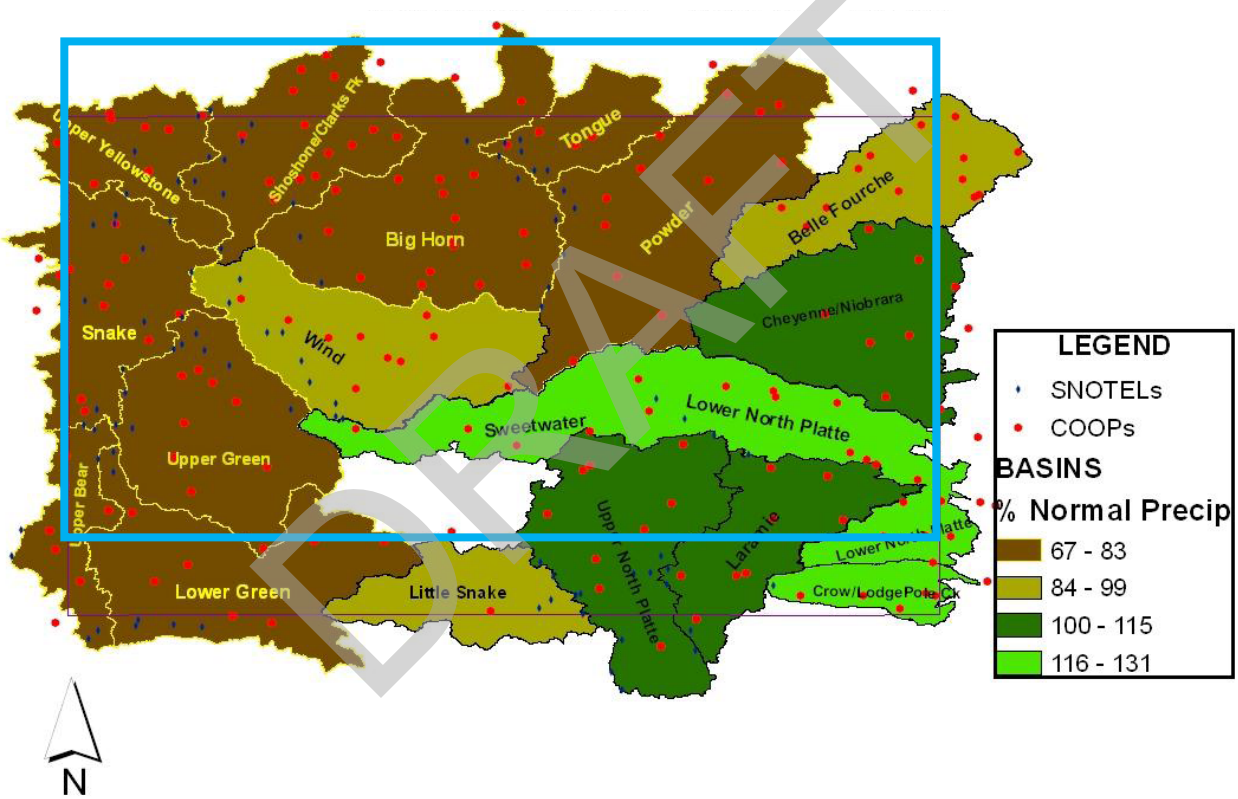
Years	Average Annual Precipitation (inches)	Percent of 1985-2006 Average Annual Precipitation (13.04”)
1958-1964	11.67	89.49%
1974-1977	11.77	90.26%
1931-1936	11.79	90.41%

Widespread droughts in Wyoming, as determined from stream flow records, were most notable during three periods: 1929-1942, 1948-1962, and 1976-1982.

Figure 4.5 illustrates the departure from normal precipitation levels in the state during the winter of 2009-2010.

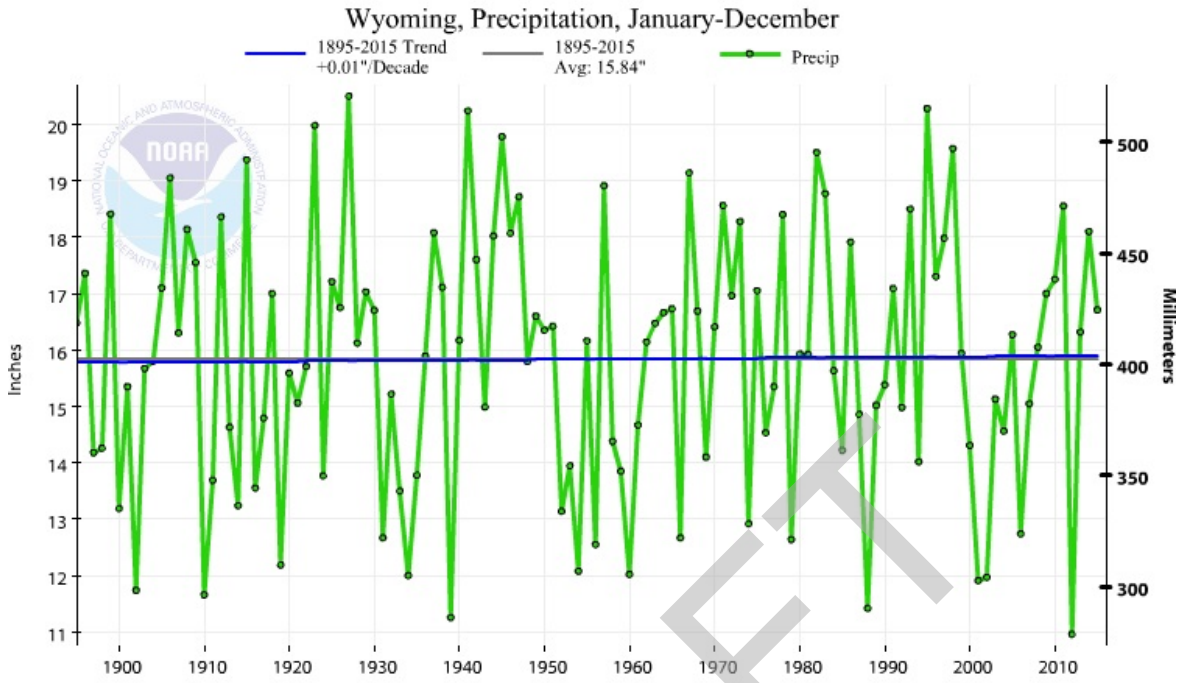
Figure 4.5. Percent of Normal Precipitation by Basin: October 2009 – March 2010



Wyoming state boundary in blue
Source: NOAA, *Wyoming Drought Information*, updated April 30, 2010, http://www.crh.noaa.gov/images/riw/hydro/drought_info.pdf

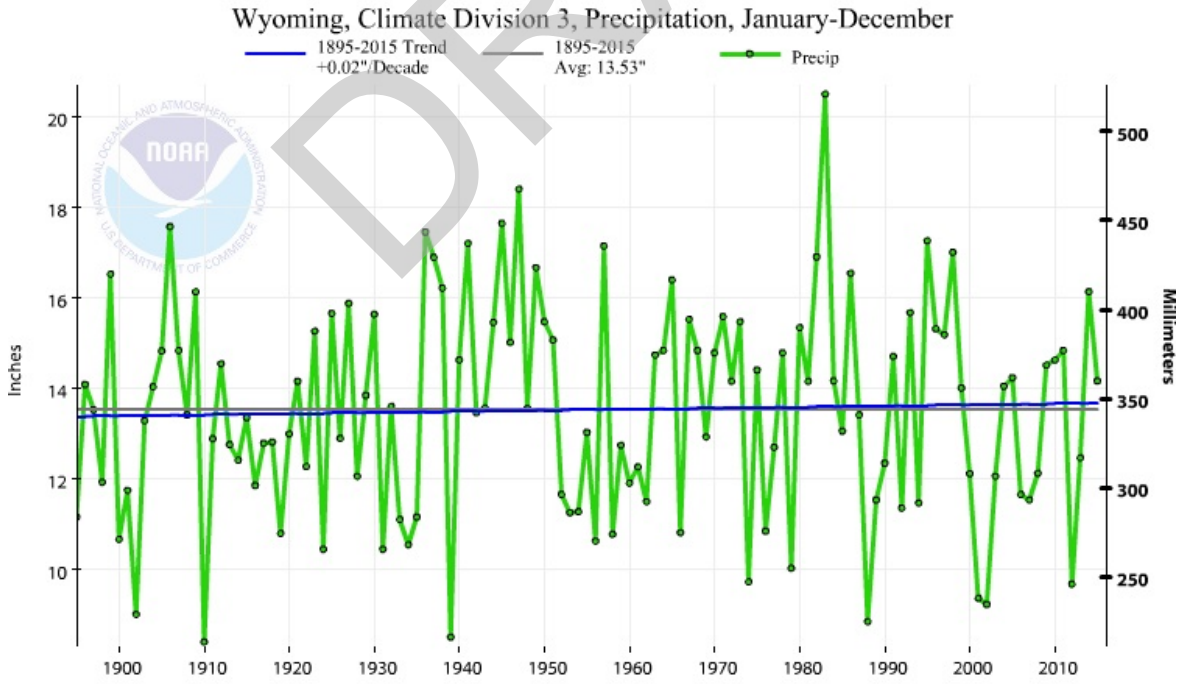
As a whole, Wyoming's precipitation record from 1895-2015 reveals that except for the Dust Bowl years of the 1930s, there was generally a surplus of moisture for the first half of the 20th century. During the second half of the 20th century and into the 21st century, there was an increasing trend of increased periods of drought. The following table illustrates annual precipitation in Wyoming from 1895 through 2015.

Figure 4.6. Wyoming Annual Precipitation: 1895 - 2015



Source: http://www.ncdc.noaa.gov/cag/time-series/

Figure 4.7. Green and Bear Rivers Basin: Annual Precipitation 1895 - 2015

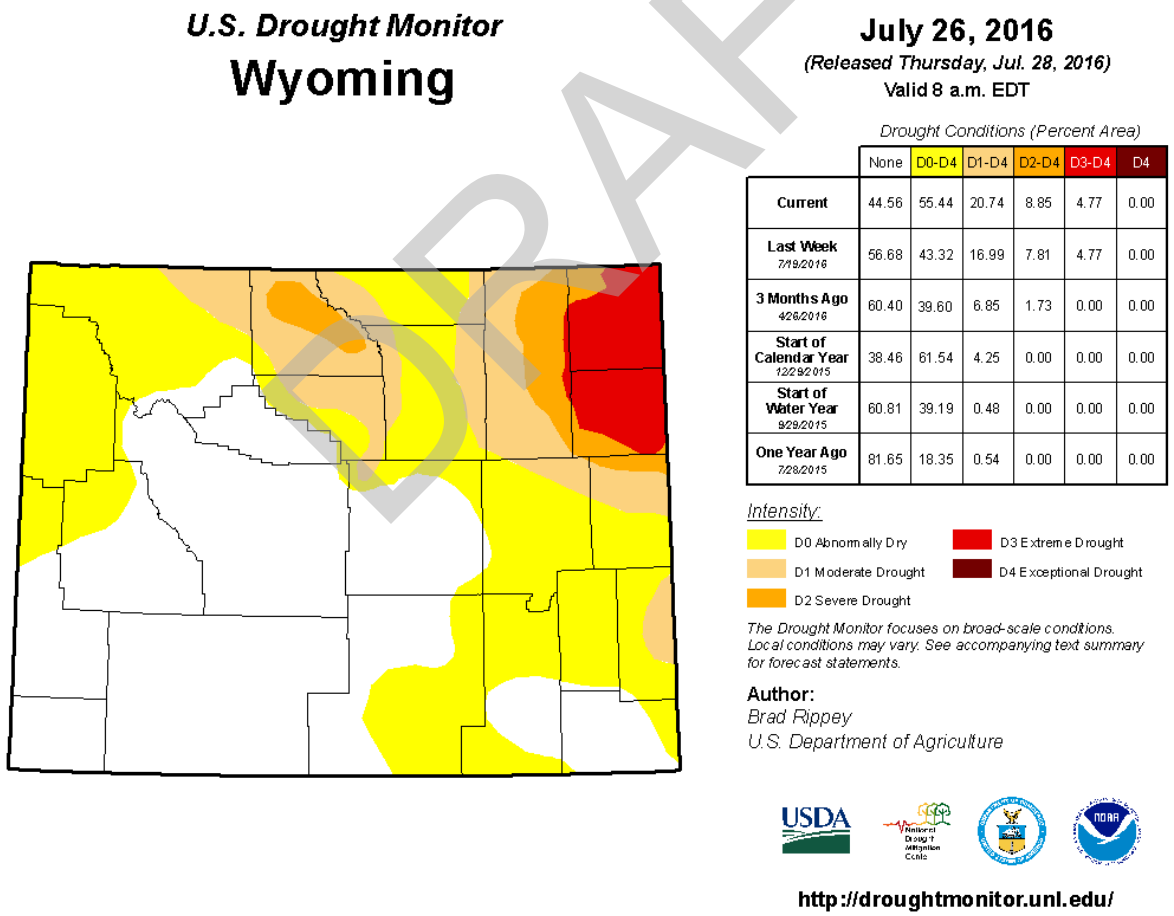


Source: http://www.ncdc.noaa.gov/cag/time-series/

The U.S. Drought Monitor provides a general summary of current drought conditions. The U.S. Department of Agriculture (USDA), the National Oceanic and Atmospheric Administration (NOAA), and the National Drought Mitigation Center (University of Nebraska-Lincoln) collaborate on this weekly product. Multiple drought indicators, including various indices, outlooks, field reports, and news accounts are reviewed and synthesized. In addition, numerous experts from other agencies and offices across the country are consulted. The result is the consensus assessment presented on the USDM map. The image is color-coded for four levels of drought intensity. An additional category, "Abnormally Dry," is used to show areas that might be moving into a drought, as well as those that have recently come out of one. The dominant type of drought is also indicated (i.e. agricultural and/or hydrological). Source: **http://www.drought.unl.edu/dm/index.html**

Figure 4.7 shows that as of July 26, 2016, the northern portions of Lincoln County are considered abnormally dry; no drought conditions are identified in the other areas of Region 4.

Figure 4.8. U.S. Drought Monitor



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	44.56	55.44	20.74	8.85	4.77	0.00
Last Week 7/19/2016	56.68	43.32	16.99	7.81	4.77	0.00
3 Months Ago 4/26/2016	60.40	39.60	6.85	1.73	0.00	0.00
Start of Calendar Year 12/29/2015	38.46	61.54	4.25	0.00	0.00	0.00
Start of Water Year 9/29/2015	60.81	39.19	0.48	0.00	0.00	0.00
One Year Ago 7/28/2015	81.65	18.35	0.54	0.00	0.00	0.00

(Source: http://drought.unl.edu/monitoringtools/droughtimpactreporter.aspx)

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Another useful resource to determine the impacts of drought is the Drought Impact Reporter (DIR), launched by the National Drought Mitigation Center in July 2005 as the nation's first comprehensive database of drought impacts. The Drought Impact Reporter is an interactive web-based mapping tool designed to compile and display impact information across the United States in near real-time from a variety of sources such as media, government agencies, and the public. Information within the Drought Impact Reporter is collected from a variety of sources including the media, government agencies and reports, and citizen observers. Each of these sources provides different types of information at different spatial and temporal scales.

A search of the database for Region 4 from 1999 to 2016 (which includes the most recent severe droughts) shows a total of 12 reported impacts. Figures 4.8 through 4.10 show the breakdown of reported impacts by county. The most reported impacts are in the Agricultural and Relief, Response & Restriction categories. Drought effects associated with agriculture include damage to crop quality; income loss for farmers due to reduced crop yields; reduced productivity of cropland; reduced productivity of rangeland; forced reduction of foundation stock; and closure/limitation of public lands to grazing, among others. The Relief, Response & Recovery category refers to drought effects associated with disaster declarations, aid programs, requests for disaster declaration or aid, water restrictions, or fire restrictions.

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Figure 4.9. Number of Reported Drought Impacts 1999 – 2016 Lincoln County

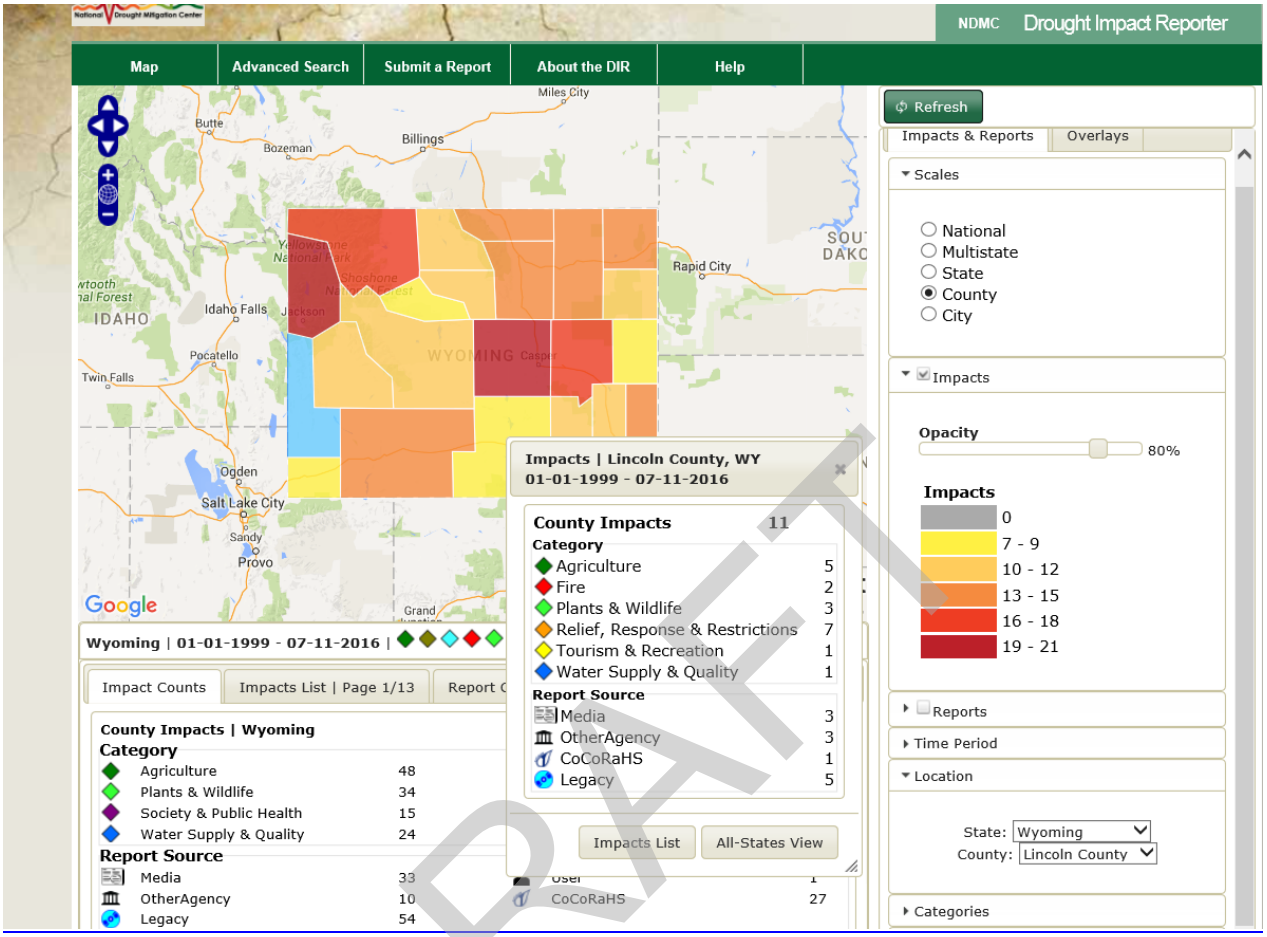

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Figure 4.10. Number of Reported Drought Impacts 1999 – 2016 Sweetwater County

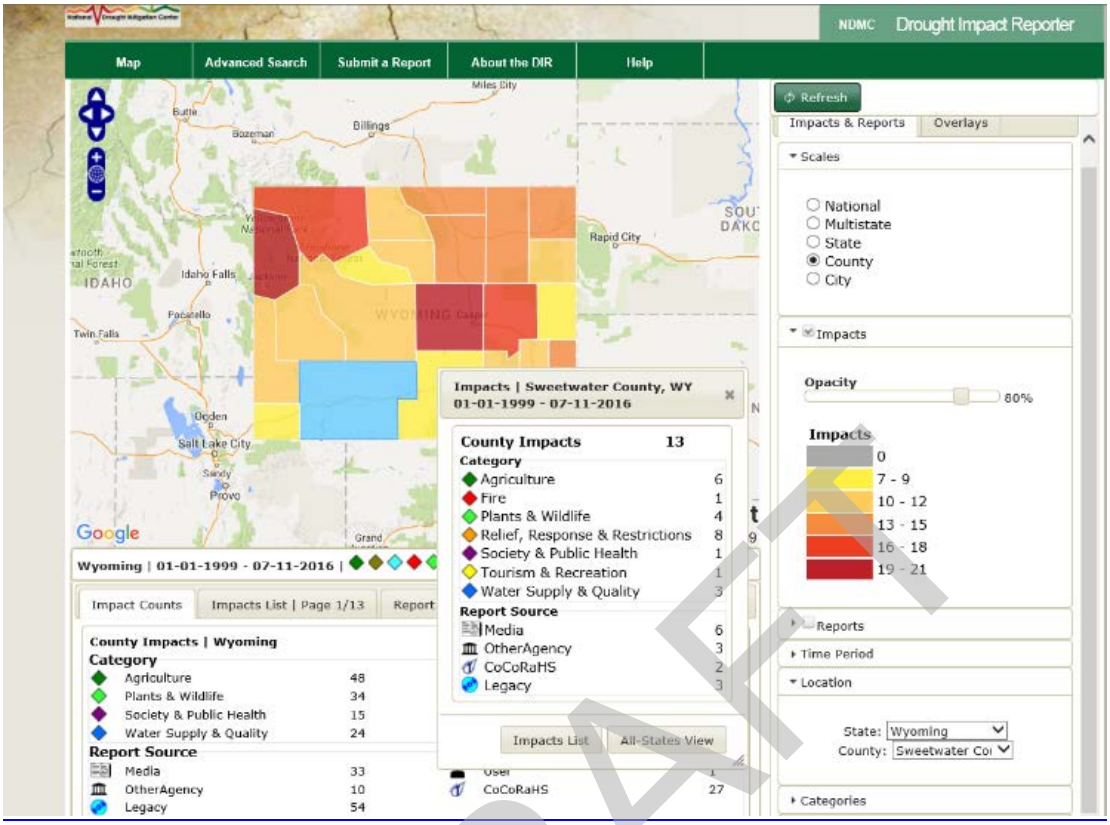

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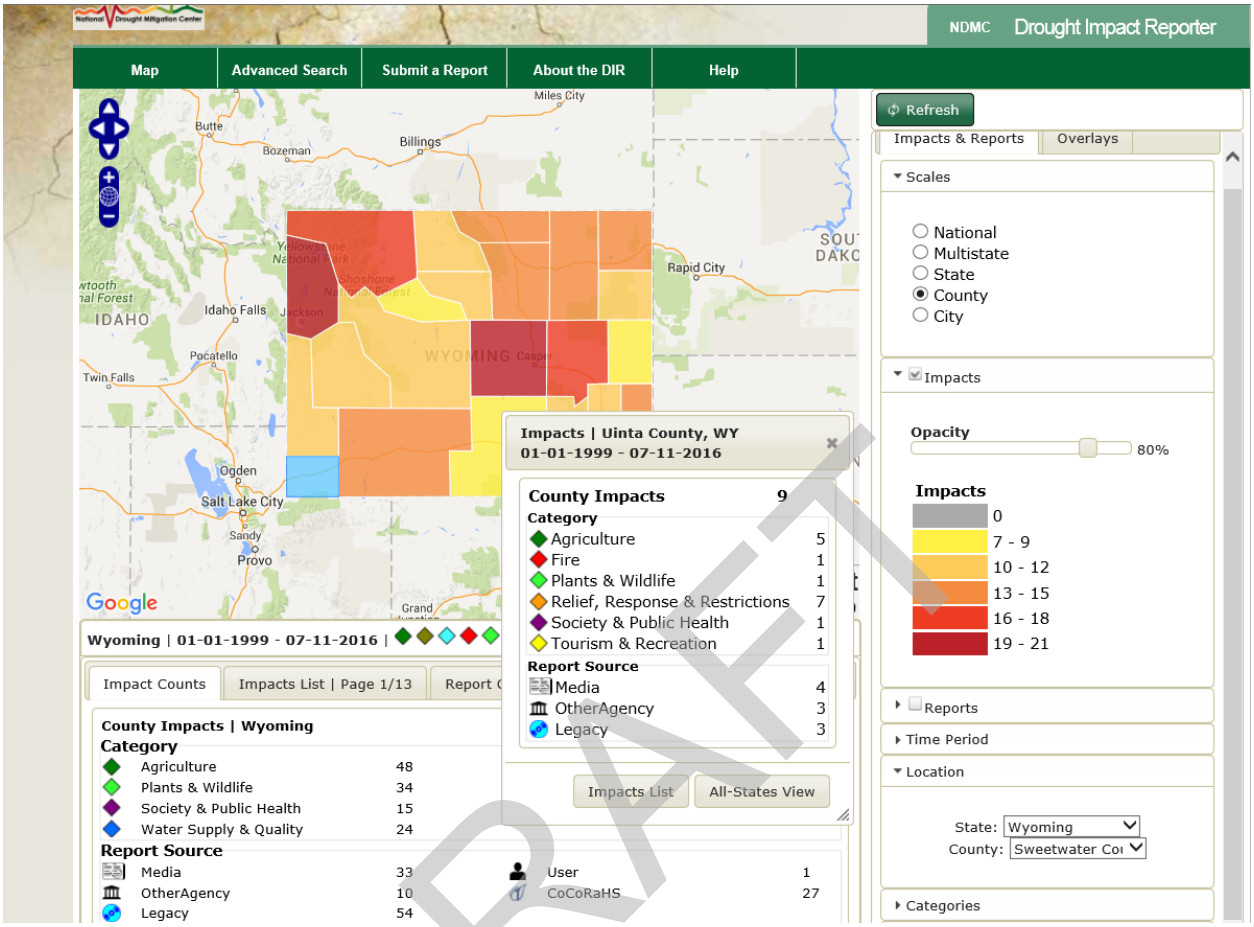
Figure 4.11. Number of Reported Drought Impacts 1999 – 2016 Uinta County



Some examples of losses during a drought include a July 2012 report where ranchers grazing their cattle on Bureau of Land Management property in western Wyoming were anxious about losing their permission to have their cattle on BLM land because riparian lands were deteriorating from drought. (http://trib.com/news/local/state-and-regional/wyoming-ranchers-sell-off-cattle-in-record-amounts-to-cope/article_14a4c30a-a0a1-575c-b1f4-74816a3a5d54.html)

Another report in June 2010 stated the Killdeer Wetlands Rehabilitation project, located west of Green River in Sweetwater County, was never fully realized as drought prevented the wetlands from filling with water between 1999 and 2008. (Casper Star-Tribune 2010-06-13)

A weather spotter in Lincoln County reported, "Grass in the hills for grazing and even the hay fields had a hard time growing because of the lack of rain and the heat and occasional very cold nights. Dirt became inches of dust, irrigation water evaporated before it could reach the furthest parts of the hay fields (evidenced by the tall grass in places and short burned up grass in others), our little river was about dry. The cloud burst yesterday of .48 inches of water will help greatly. I see the river has a pretty good flow and the entire country is freshened up by this rain." (CoCoRaHS Report from Station #Kemmerer 20.5 NNW on 8/24/2013)

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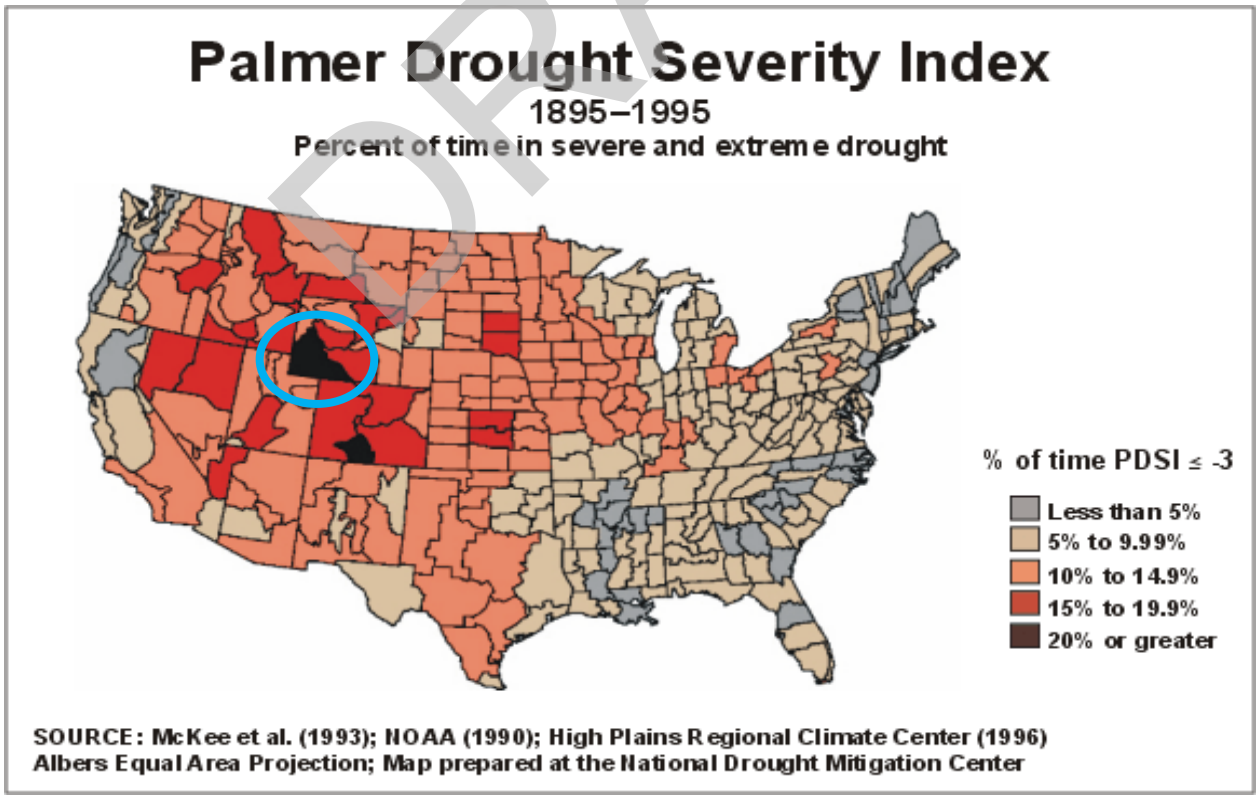
Drought Disaster Declarations

All counties in Region 4 have, at various times, been included in regional USDA disaster declarations for droughts. In November 2007, the USDA designated 11 counties as natural disaster areas for drought including Big Horn, Converse, Fremont, Hot Springs, Lincoln, Niobrara, Platte, Sublette, Sweetwater, Washakie and Weston. An ongoing drought declaration was made in December 2007 for Wyoming. In July 2012, the USDA designated five counties in Wyoming as primary natural disaster areas due to damage and losses caused by drought that began June 5, 2012. Designated counties were Carbon, Laramie, Lincoln, Sweetwater, and Uinta. In July 2015, the USDA designated Summit County in Utah as a primary natural disaster area due to damages and losses caused by a recent drought. Farmers and ranchers in Sweetwater and Uinta counties in Wyoming also qualified for natural disaster assistance because their counties are contiguous.

Likelihood of Future Occurrence

Figure 4.11 indicates that drought occurs approximately every five to 10 years in Region 4. Figure 4.4 indicates the Region has spent anywhere from 15-20% of the 100 year span from 1895 to 1995 in severe or extreme drought. This is more often than shown in Table 4.1 which suggests that severe multi-year droughts have occurred roughly every ten years since the mid-20th century. An occurrence interval of roughly once every ten years corresponds to a likely frequency of occurrence. This is consistent with HMPC estimates.

Figure 4.12. Palmer Drought Severity Index for the Continental U.S.: 1895 - 1995



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Potential Magnitude

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of a common occurrence. Based upon Figure 4.8 and Table 4.9, the drought of 1999-2004 is as significant, if not more significant than any other droughts in the last 100 years for the entire state. The most significant droughts in the last century, in terms of precipitation deficit, were in 1952-1956 and 1999-2004. In order to determine which drought period had the most significant impact on Wyoming, crop production and livestock inventory data for the two periods were compared. 1957 and 2005 were wetter years, with annual statewide precipitation totals above the 1895-2015 average. Those two years were used as endpoints for the droughts that started in 1952 and 1999 respectively. In both cases, the years following saw a return to drier conditions. Because of this, the most recent drought impacts were also calculated for 2005 and 2006, and are included in summary tables. Table 4.8 and Table 4.9 show peak decline (%) in production during drought compared to the 5-year pre-drought production average for various commodities. It should be noted that both tables are based on statewide data; county-specific data was not available for all of the years.

A comparison of the following tables indicate that drought impacts to the Wyoming agricultural community were greater in the 1999-2004 drought than in the 1952-1956 drought. With the exception of dry beans, all commodities in the worst years of the 1999-2004 drought showed a greater percentage decline in production than in the 1952-1956 drought. As a result, the 1999-2004 drought will be used as the drought of historic record to calculate dollar impacts.

Table 4.8. Peak Commodity Production Changes from Pre-Drought (1947 – 1951) to Drought (1952 – 1956)

Commodity	5-Year Pre-Drought Production Average (1947-1951)	Units	Lowest Production During Drought (1952-1956)	Year of Lowest Production (1952-1956)	Percent Change
Alfalfa Hay	490	1,000 tons	675	1954	+38%
Other Hay	674	1,000 tons	442	1954	-34%
Cattle/ Calves Inventory	1,050	1,000 head	1,096	1954	+4%

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Table 4.9. Peak Commodity Production Changes from Pre-Drought (1994 – 1998) to Drought (1999 – 2004)

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	Lowest Production During Drought (1999-2006)	Year of Lowest Production (1999-2006)	Percent Change
Alfalfa Hay	1581	1,000 tons	1150	2002	-27%
Other Hay	817	1,000 tons	450	2002	-45%
Cattle/ Calves Inventory	1536	1,000 head	1300	2004	-16%

Economic Impacts

Agricultural dollar impacts can also be used to show the effects of drought. For the Regional Plan data was obtained from the U.S. Department of Agriculture (USDA) Quick Stats database (https://quickstats.nass.usda.gov).

Drought impacts to agriculture in Region 4 would be found primarily in hay and livestock production. 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 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 4.10. 1999 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	1999 Production	Value (USD)	Production and Inventory Value Impact (USD)
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					**+$58,783,000**

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Table 4.11. 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)
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					**-$35,532,000**

Table 4.12. 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)
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					**-$107,332,000**

Table 4.13. 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)
Alfalfa Hay	1581	1,000 tons	1150	$111.00/ton	- $ 47,841,000
Other Hay	817	1,000 tons	450	$106.00/ton	- $ 38,902,000
Cattle/Calves Inventory	1536	1,000 head	1320	$760.00/head	- $164,160,000
TOTAL					**-$250,903,000**

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Table 4.14. 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)
Alfalfa Hay	1581	1,000 tons	1625	$80.00/ton	$3,520,000
Other Hay	817	1,000 tons	770	$73.00/ton	-$3,431,000
Cattle/Calves Inventory	1536	1,000 head	1350	$890.00/head	-$165,540,000
TOTAL					**-$172,491,000**

Table 4.15. 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 (USD)
Alfalfa Hay	1581	1,000 tons	1305	$74.50/ton	-$20,562,000
Other Hay	817	1,000 tons	756	$69.50/ton	-$4,239,500
Cattle/Calves Inventory	1536	1,000 head	1300	$1020.00/head	-$240,720,000
TOTAL					**-$265,521,500**

Table 4.16. 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 (USD)
Alfalfa Hay	1581	1,000 tons	1560	$75.00/ton	-$1,575,000
Other Hay	817	1,000 tons	756	$72.00/ton	-$4,392,000
Cattle/Calves Inventory	1536	1,000 head	1400	$1140.00/head	-$155,040,000
TOTAL					**-$161,007,000**

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Table 4.17. 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 (USD)
Alfalfa Hay	1581	1,000 tons	1400	$101.00/ton	-$18,281,000
Other Hay	817	1,000 tons	715	$103.00/ton	-$10,506,000
Cattle/Calves Inventory	1536	1,000 head	1400	$1010.00/head	-$137,360,000
TOTAL					**-$166,147,000**

Table 4.18. Production and Inventory Value for Worst Year of Drought

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	Worst Yearly Production of Drought	Year	Value (USD)	Production and Inventory Value Impact (USD)
Alfalfa Hay	1581	1,000 tons	1150	2002	$111.00/ton	-$47,841,000
Other Hay	817	1,000 tons	450	2002	$106.00/ton	-$38,902,000
Cattle/Calves Inventory	1536	1,000 head	1300	2004	$1,020/head	-$240,720,000
TOTAL						**-$327,463,000**

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The 1999-2004 drought can be shown to be the drought of historic record. There have been significant impacts on the agricultural industry from the 1999-2004 drought. The worst-case year was 2004, with a negative dollar impact of $265,521,500 statewide in these three categories. Region 4 is 17% of the State of Wyoming in land area. For the sake of establishing a baseline, if it is assumed that the drought impact is equally distributed across the state, the potential drought impact in Region 4 for 2004 was approximately $45,138,655. The total impact statewide for the 1999-2004 drought is $772,996,500. For the sake of establishing a baseline, if it is assumed that the drought impact is equally distributed across the state, then the potential drought impact in Region 4 was approximately $131,409,405.

Additionally, drought can exacerbate the risk of wildfires; increase the cost of municipal water usage; and deplete water resources used for recreation, affecting the economy.

Vulnerability Assessment

The vulnerability of the people, buildings, and economy of Region 4 to drought is very difficult to quantify. Typically, people and structures are not directly vulnerable to drought, though secondary or indirect impacts may eventually increase vulnerability ratings. However, some areas are more vulnerable overall than others and, therefore, benefit from adequate mitigation planning and

implementation. For Region 4, the agricultural sector is the most vulnerable to drought and will benefit the most from mitigation efforts. Economic resources tied to agricultural production are extremely vulnerable to drought. Outdoor recreation, which is important to the Region 4 economy, is also vulnerable to drought. The geographic extent of the hazard is considered extensive. The probability of future occurrences is considered likely, and the potential magnitude/severity is limited. In addition, the HMPC considers the hazard to have an overall impact rating of high for the Region.

Future Development

Future development in the Region is not anticipated to change vulnerability to drought significantly.

Summary

Drought is considered a high significance hazard for most of the Region due to the extensive economic and environmental impacts. Drought can be widespread and pervasive for several years.

Table 4.19. Drought Hazard Risk Summary

County	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/ Severity	Overall Significance
Lincoln	Extensive	Likely	Limited	High
Sweetwater	Extensive	Likely	Limited	High
Uinta	Extensive	Likely	Limited	High

4.2.5 Earthquake

Hazard Description

An earthquake is generally defined as a sudden motion or trembling in the Earth caused by the abrupt release of strain accumulated within or along the edge of the earth's tectonic plates. 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.

The amount of energy released during an earthquake is usually expressed as a Richter magnitude and is measured directly from the earthquake as recorded on seismographs. Another measure of earthquake severity is intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface as felt by humans or resulting damage to structures and defined in the Modified Mercalli scale (see Table 4.20). Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

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Table 4.20. Modified Mercalli Intensity (MMI) Scale

MMI	Felt Intensity
I	Not felt except by a very few people under special conditions. Detected mostly by instruments.
II	Felt by a few people, especially those on upper floors of buildings. Suspended objects may swing.
III	Felt noticeably indoors. Standing automobiles may rock slightly.
IV	Felt by many people indoors, by a few outdoors. At night, some people are awakened. Dishes, windows, and doors rattle.
V	Felt by nearly everyone. Many people are awakened. Some dishes and windows are broken. Unstable objects are overturned.
VI	Felt by everyone. Many people become frightened and run outdoors. Some heavy furniture is moved. Some plaster falls.
VII	Most people are alarmed and run outside. Damage is negligible in buildings of good construction, considerable in buildings of poor construction.
VIII	Damage is slight in specially designed structures, considerable in ordinary buildings, great in poorly built structures. Heavy furniture is overturned.
IX	Damage is considerable in specially designed buildings. Buildings shift from their foundations and partly collapse. Underground pipes are broken.
X	Some well-built wooden structures are destroyed. Most masonry structures are destroyed. The ground is badly cracked. Considerable landslides occur on steep slopes.
XI	Few, if any, masonry structures remain standing. Rails are bent. Broad fissures appear in the ground.
XII	Virtually total destruction. Waves are seen on the ground surface. Objects are thrown in the air.

Source: USGS. http://earthquake.usgs.gov/learn/topics/mercalli.php

Table 4.21. Magnitude and Modified Mercalli Intensity Comparison

Magnitude	Typical Maximum Modified Mercalli Intensity
1.0-3.0	I
3.0-3.9	II-III
4.0-4.9	IV-V
5.0-5.9	VI-VII
6.0-6.9	VII-IX
7.0 and higher	VIII or higher

Source: USGS. http://earthquake.usgs.gov/learn/topics/mercalli.php

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Table 4.22. Modified Mercalli Intensity (MMI) Scale and Peak Ground Acceleration

MMI	Acceleration (%g) (PGA)
I	<0.17
II	0.17 – 1.4
III	0.17 – 1.4
IV	1.4 – 3.9
V	3.9 – 9.2
VI	9.2 – 18
VII	18 – 34
VIII	34 – 65
IX	65 – 124
X	>124
XI	>124
XII	>124

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

Earthquakes can cause structural damage, injury, and loss of life, as well as damage to infrastructure networks, such as water, power, communication, and transportation lines. Other damaging effects of earthquakes include surface rupture, fissuring, ground settlement, and permanent horizontal and vertical shifting of the ground. Secondary impacts can include landslides, seiches, liquefaction, fires, and dam failure. The combination of widespread primary and secondary effects from large earthquakes make this hazard potentially devastating.

Part of what makes earthquakes so destructive is that they generally occur without warning. The main shock of an earthquake can usually be measured in seconds, and rarely lasts for more than a minute. Aftershocks can occur within the days, weeks, and even months following a major earthquake.

By studying the geologic characteristics of faults, geoscientists can often determine when the fault last moved and estimate the magnitude of the earthquake that produced the last movement. Because the occurrence of earthquakes is relatively infrequent in this region and the historical earthquake record is short, accurate estimations of magnitude, timing, or location of future dangerous earthquakes in the region are difficult to estimate.

Liquefaction

During an earthquake, near surface (within 30 feet), relatively young (less than 10,000 years old), water-saturated sands and silts may act as a viscous fluid. This event is known as liquefaction (quicksand is a result of liquefaction). Liquefaction occurs when water-saturated materials are exposed to seismic waves. These seismic waves may compact the material (i.e. silts and sands), increasing the interior pore water pressure within the material mass.

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When the pore pressure rises to about the pressure of the weight of the overlying materials, liquefaction occurs. If the liquefaction occurs near the surface, the soil bearing strength for buildings, roads, and other structures may be lost. Buildings can tip on their side, or in some cases sink. Roads can shift and become unstable to drive on. If the liquefied zone is buried beneath more competent material, cracks may form in the overlying material, and the water and sand from the liquefied zone can eject through the cracks as slurry.

Geographical Area Affected

Yellowstone National Park is north of the Region and one of the more seismically active areas in the United States. Most Wyoming earthquakes outside of Yellowstone National Park occur as a result of movement on faults. If the fault has moved within the Quaternary geological period, or last 1.6 million years, the fault is considered to be active. Active faults can be exposed at the surface or deeply buried with no significant surface expression. Historically, no earthquakes in Wyoming have been associated with exposed active faults. The exposed active faults, however, have the potential to generate the largest earthquakes. As a result it is necessary to understand both exposed and buried active faults in order to generate a realistic seismological characterization of the state.

There are approximately 80 Quaternary faults mapped in Wyoming, with 26 considered active (*Source: www.wsgs.wyo.gov).* There are several of these faults in the Region including the Teton fault, Star Valley fault, Greys River fault, Rock Creek fault, and the Bear River fault system that are considered to be capable of generating magnitude 7.0 to 7.5 earthquakes. The Chicken Springs fault system near Baroil is capable of generating magnitude 6.5 to 6.7 earthquakes. (Source: Wyoming Multi-Hazard Mitigation Plan, 2016).

A dynamic magma chamber beneath Yellowstone National Park, combined with regional tectonic forces, results in significant seismic activity. Many of the earthquakes are associated with movement of hydrothermal fluids in the subsurface. Some deeper earthquakes may be related to fluids within or around the magma chamber. Earthquakes which may be related to active faults also occur in the park. Yellowstone is a super-volcano, and it has explosively erupted 0.64 million, 1.3 million, and 2.1 million years ago. The explosive eruptions led to the formation of three giant calderas, the collapse of which led to the formation of faults. In addition, after major eruptions, resurgent domes formed within the calderas. The doming process led to the formation of other faults. As a result, many of the faults in Yellowstone are not considered major threats. There are other faults, however, that are easily capable of generating magnitude 6.5+ earthquakes (State Hazard Mitigation Plan 2016).

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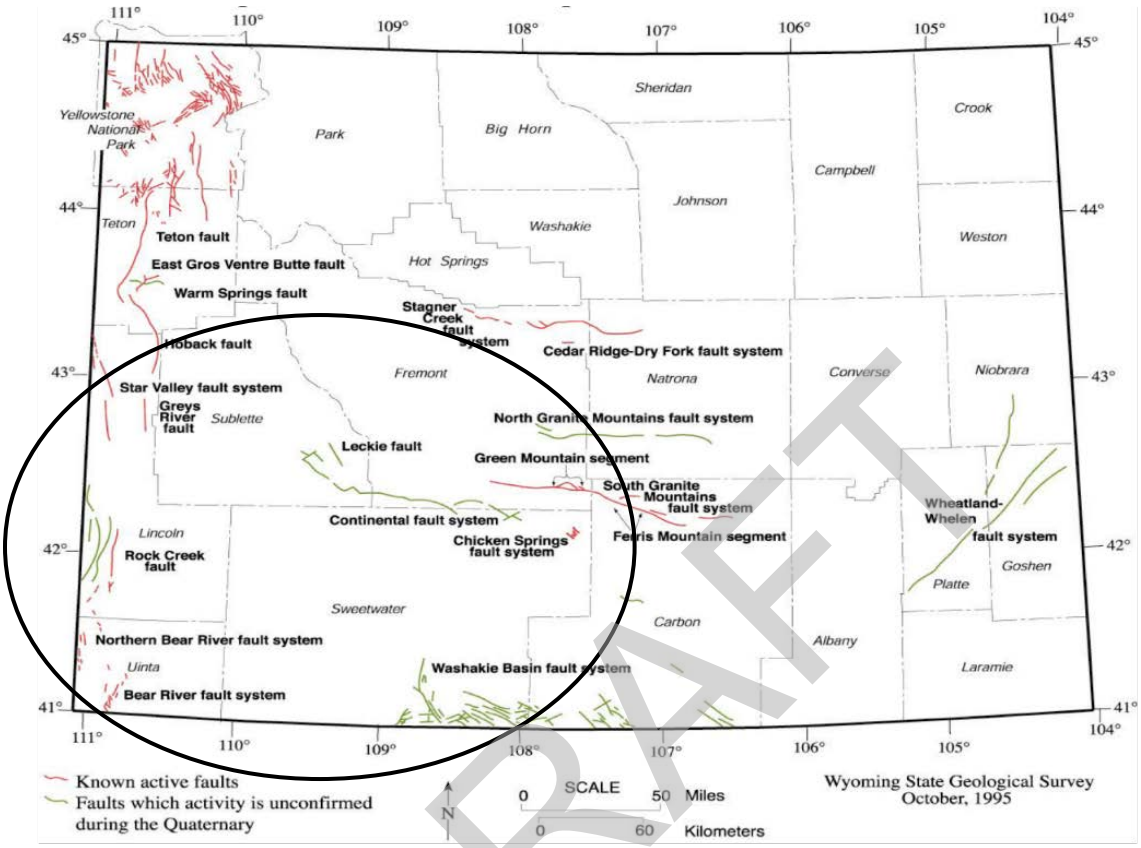
Figure 4.13. Exposed Known or Expected Active Faults in Wyoming



Source: Wyoming Geological Survey

Figure 4.13 shows areas in Wyoming that could experience liquefaction during an intense earthquake. Areas shown have sands and coarse silts that are less than 10,000 years in age and are within 30 feet of the surface. Portions of the Bear River Valley, Star Valley, Snake River Valley, Yellowstone National Park, Yellowstone River Valley, and the New Fork River Valley, as well as portions along the Wind and Bighorn rivers, have the necessary components to experience liquefaction.

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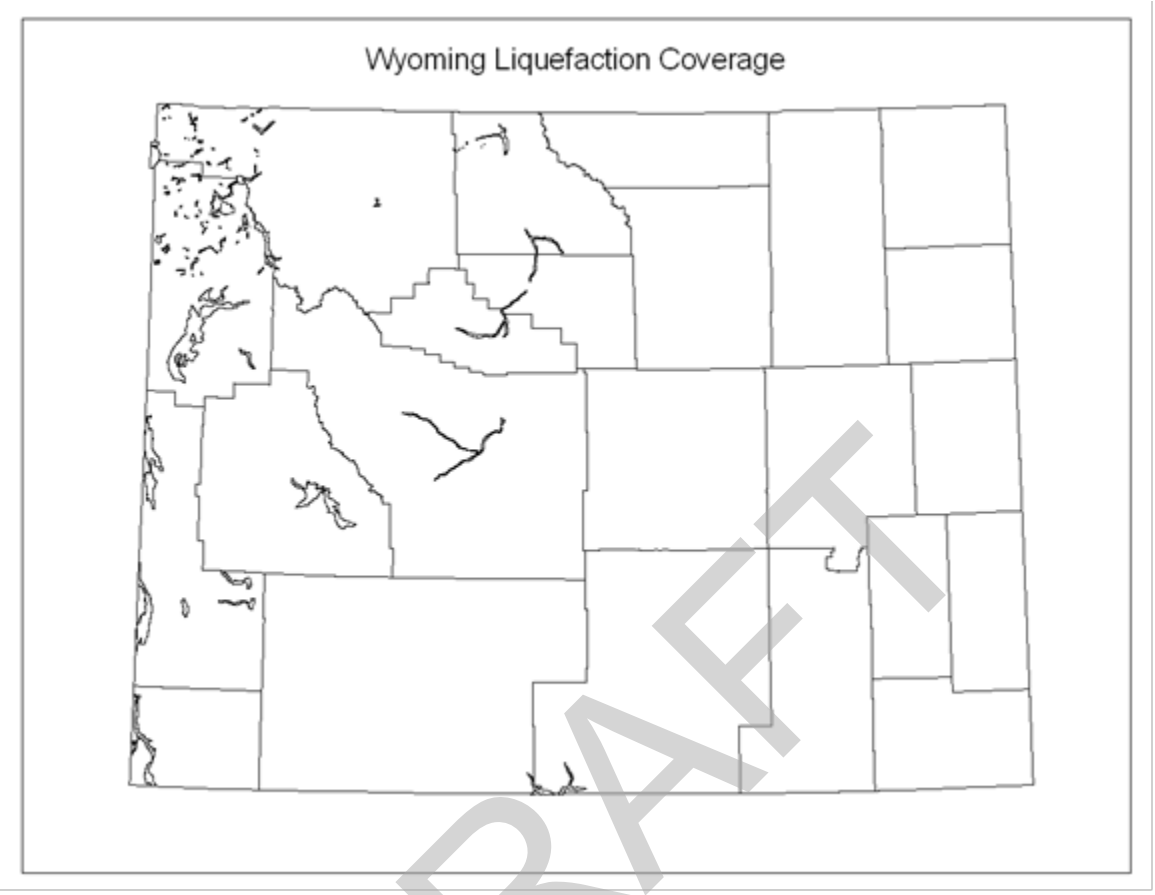
Figure 4.14. Wyoming Liquefaction Coverage



Source: Wyoming Geological Survey

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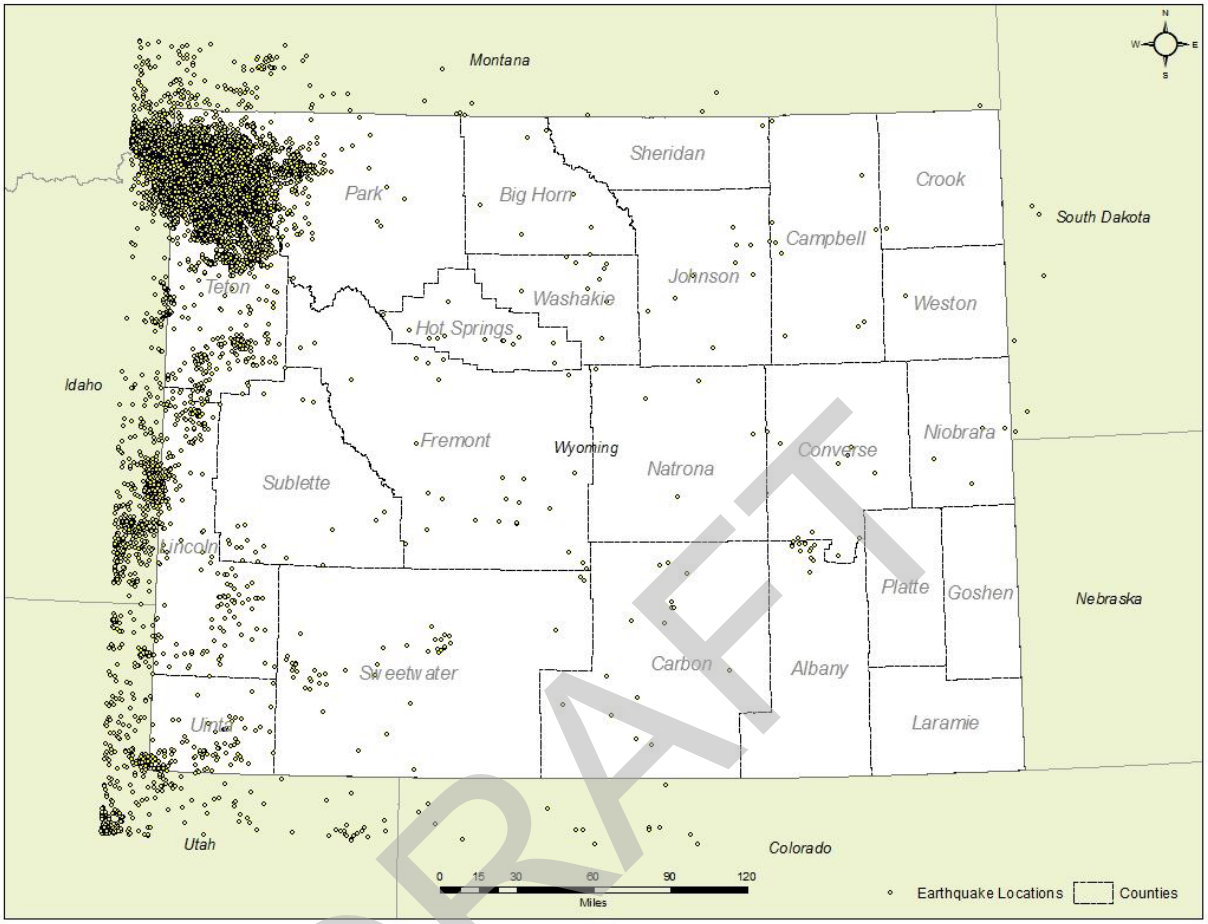
Past Occurrences

Prior to the 1950s, most earthquakes were detected and located by personal reports. After the Hebgen Lake earthquake in 1959 near Yellowstone Park, monitoring in Wyoming started to improve and earthquakes were more commonly located by seismometers.

Since 1871, the state has logged some 47,000 earthquakes, with the majority of the events taking place in the western third of the state where the majority of the active, or Quaternary Period, faults are identified. The figure below illustrates earthquake history between 1963 and 2010.

Figure 4.15. Wyoming Historic Earthquake Occurrences Statewide, 1963 - 2010



Source: Wyoming Geological Survey - Wyoming Earthquake Hazard and Risk Analysis: HAZUS-MH Loss Estimations for 16 Earthquake Scenarios Report

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Historically, earthquakes have occurred in every county in Wyoming. The first was reported in Yellowstone National Park in 1871 and the most recent likely occurred in the Park.

The tables below exhibit each county's history of earthquakes with a magnitude greater than 2.5. Historically, Lincoln County proves to be one of the most seismically active counties in the region.

Table 4.2 Table 4.23. Earthquakes Greater than 2.5 in Region 4: 1975 – June 2016

County	Magnitude 2.5-2.9	3-3.9	4.0-5.8
Lincoln	46	85	18
Sweetwater	5	11	1
Uinta	3	1	0

Table 4.24. Highest Magnitude Earthquakes in Region 4: 1915 – June 2016

County	Magnitude	Date
Lincoln	5.8	1930-06-12
Lincoln	5.8	1994-02-03
Lincoln	4.8	1994-02-11
Lincoln	4.8	1985-08-21
Lincoln	4.7	1994-02-04
Lincoln	4.6	1985-09-07
Sweetwater	4.5	1963-10-14
Lincoln	4.5	1994-02-07
Lincoln	4.4	1994-02-03
Lincoln	4.4	1994-02-03

Source: USGS Earthquake Hazards Program

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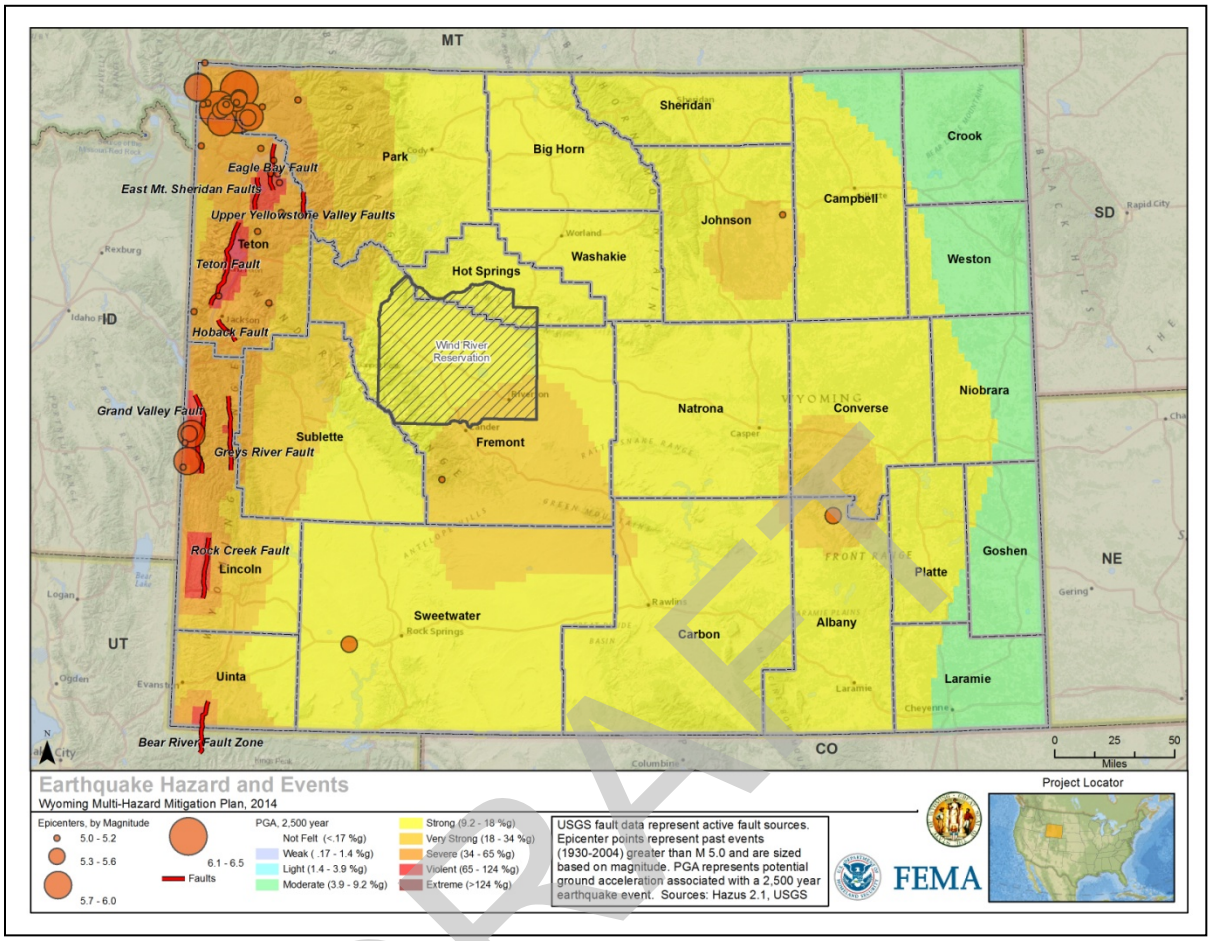
Figure 4.16. Earthquake Hazards in Wyoming



Source: Wyoming Multi-Hazard Mitigation Plan, 2014

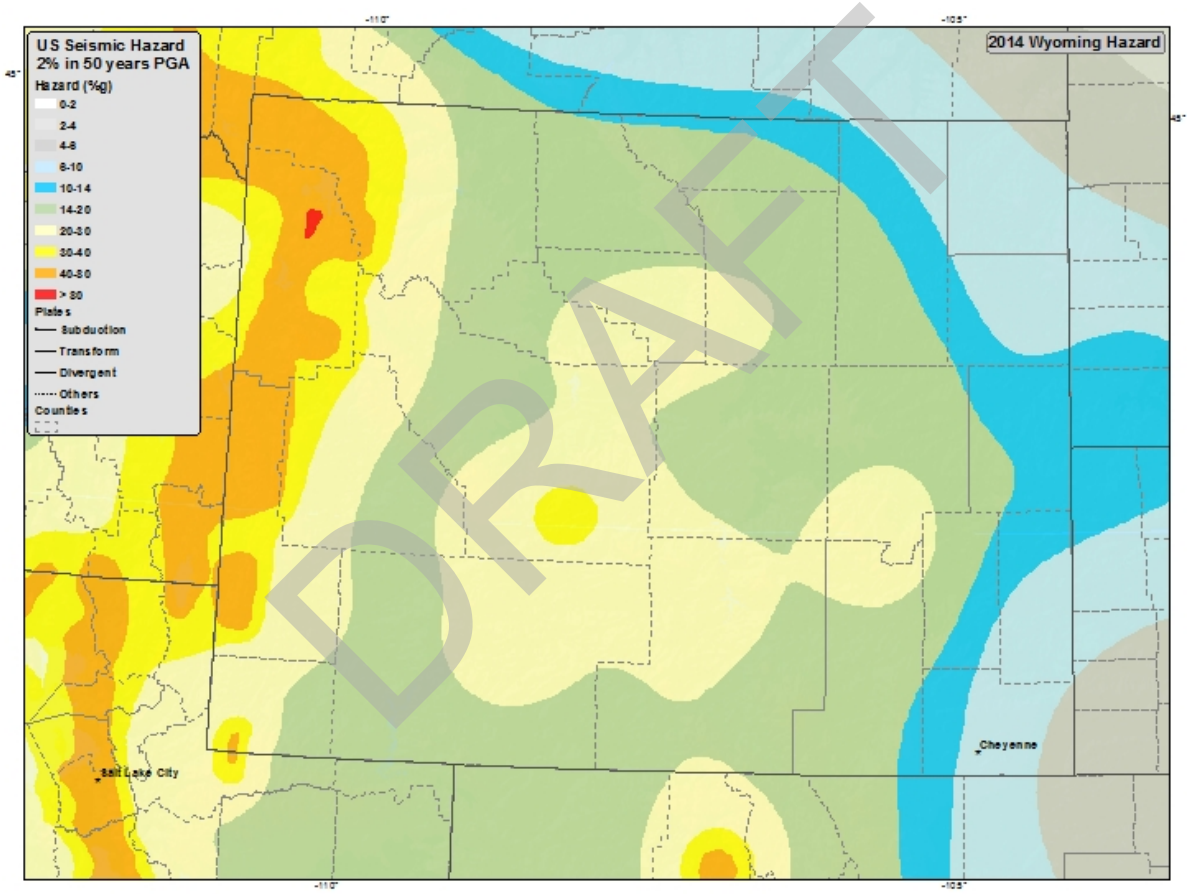
Likelihood of Future Occurrence

Based on past occurrences the Region has a 42% chance of experiencing an earthquake with a magnitude of 2.5 or greater in the next year; however also based on past occurrences, the earthquakes are likely to cause little to no damage. To determine the likelihood of damaging earthquakes the U.S. Geological Survey (USGS) publishes probabilistic acceleration maps for 500-, 1000-, and 2,500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a 10% probability that acceleration may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years. The 2,500-year (2% probability of exceedance in 50 years) map is shown in the figure below. The International Building Code uses a 2,500-year map as the basis for building design. The maps reflect current perceptions on seismicity in Wyoming based on available science. In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased further 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.

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 regional and county analyses. This conservative approach is in the interest of public safety.

Figure 4.17. 2500-year Probabilistic Acceleration Map (2% Probability of Exceedance in 50 Years) – Region 4 in Oval



Source: Wyoming Multi-Hazard Mitigation Plan, 2014

Potential Magnitude

Minor but various damages have been documented in the Region from historic earthquakes. Because of the limited historic record, however, it is possible to underestimate the seismic hazard in the Region if historic earthquakes are used as the sole basis for analysis. Earthquake and ground motion probability maps give a more reasonable estimate of damage potential in areas with or

without exposed active faults at the surface. 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 northwest to the east. More specifically, the probability-based worst-case scenario could result in the following damage at points throughout the counties in the Region, expressed in terms of earthquake Modified Mercalli Intensity:

Intensity VII Earthquake Areas: 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 un-reinforced masonry buildings. Some chimneys will be broken.

Lincoln
- Star Valley Ranch
- Thayne
- Alpine
- Afton
- Kemmerer

Sweetwater
- Atlantic City
- Rock Springs

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

Lincoln
- La Barge
- Diamondville
- Opal
- Kemmerer

Sweetwater
- Green River
- Granger
- Wamsutter

Intensity V Earthquake Areas: Intensity V earthquakes are characterized by moderate shaking with very light damage. Dishes and windows can break and plaster can crack. Unstable objects may overturn. Tall objects such as trees and power poles can be disturbed.

Sweetwater
- Baroil
- South Superior

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According to the Uinta County Hazard Mitigation Plan, “Twenty-three magnitude 1.5 and greater earthquakes have been recorded in Uinta County.” The HMPC provided anecdotal evidence of additional earthquakes occurring between 2010 and 2016.

Vulnerability Assessment

The Wyoming State Geological Survey conducted a study in 2011 to model loss estimations for 16 earthquake scenarios in order to quantify the magnitude of earthquake impacts around the state. The scenarios included four random event scenarios run on the basis of data from historic earthquakes that occurred near Casper, Gillette, Laramie Peak, and Estes Park, Colorado. Each of the historic, random event earthquake scenarios registered a 6.0 magnitude. The Estes Park Scenario was based on an event occurring in 1882, the Casper area event in 1897, and the Gillette and Laramie Peak events in 1984 *(Source: Wyoming Geological Survey, “Wyoming Earthquake Hazard and Risk Analysis: HAZUS-MH Loss Estimations for 16 Earthquake Scenarios, 2011)*

HAZUS (Hazards U.S.) 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.

The study included information regarding the likelihood of damage to local and regional infrastructure, including fire stations, police stations, sheriffs’ departments, schools, and hospitals. The scenarios reflect anticipated functionality of each infrastructure system immediately following the scenario earthquake, on day seven following the earthquake and one month after the earthquake. Additional information provided includes anticipated households displaced or seeking temporary shelter, electrical outages anticipated, number of households without potable water, debris generated by the scenario and economic losses resulting from three categories: buildings, transportation and utilities.

The following figure shows epicenter locations of the scenarios, sized by total loss. Epicenters on map are labeled with total loss and if applicable, life-threatening injuries and fatalities.

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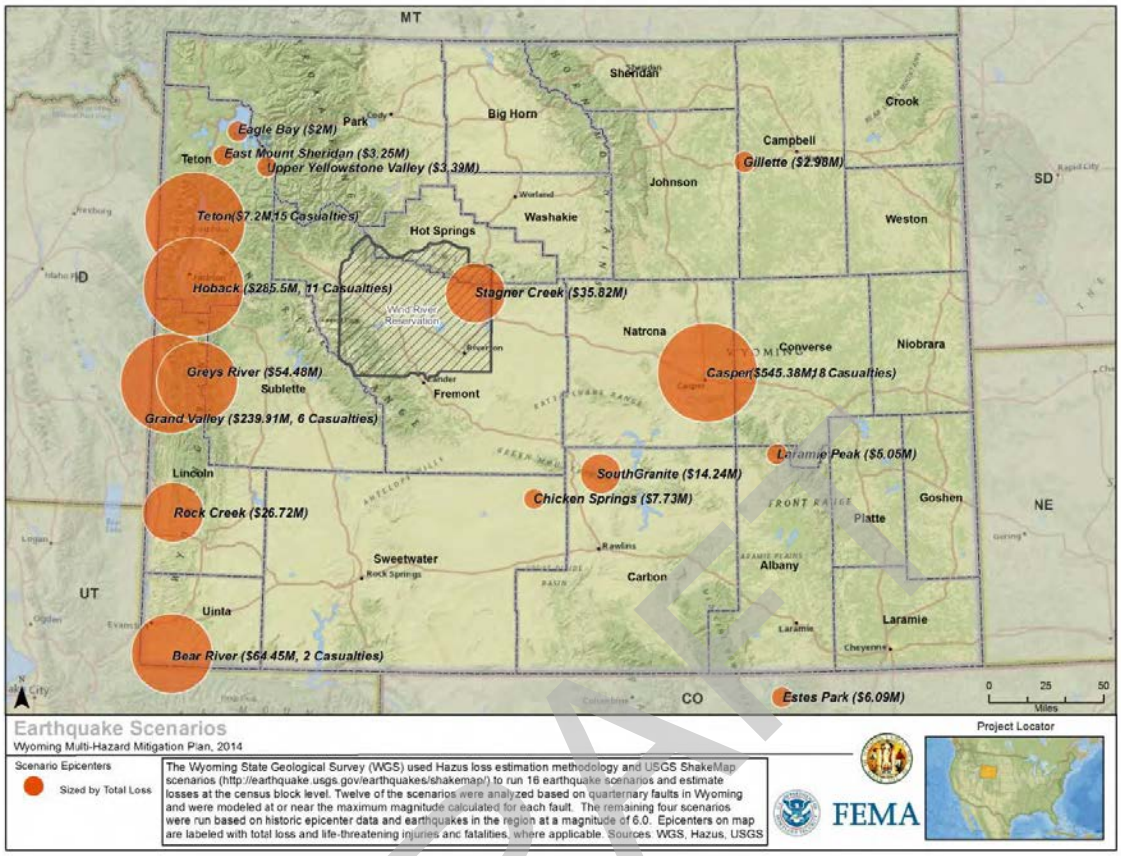
Figure 4.18. HAZUS-MH Earthquake Scenarios for Wyoming, 2011



Source: Wyoming Multi-Hazard Mitigation Plan, 2014

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Fault Based Scenario – Region 4 (Bear River Fault)

Of the 16 modeled scenarios, the Bear River Fault scenario and the Chicken Springs Fault Scenario had the most impact on the Region.

The earthquake scenario for the Bear River fault system was modeled at magnitude 6.9. The earthquake would cause damage in Lincoln, Sweetwater, and Uinta counties. Scenario results show that very light damage would be expected as far as 55 miles from the epicenter, near Granger. Light damage would be expected within 40 miles, out to Ft. Bridger. Moderate to heavy damage is likely within 15 miles of the fault, which includes the city of Evanston where ground accelerations of 18-34% gravity (g) would be expected. Beartown and Hilliard would expect the highest amount of shaking, with ground acceleration modeled between 34 and 65%g (MMI VIII). These are also the places where damage would be expected to be the greatest.

The total population in the scenario region is 19,814 according to the 2000 census. The scenario results estimate that of the 19,814 people, 116 households would be displaced, and 80 people would seek temporary shelter.

There are 9,180 buildings in the area, and the scenario shows that 1,147 of those would sustain at least moderate damage from the earthquake. The earthquake would generate 25,000 tons of debris.

Essential facilities

Essential facilities include fire stations, hospitals, police stations, and schools. There are 31 essential facilities that would experience damaging ground motions: 7 fire stations, 2 hospitals, 5 police stations, and 17 schools. Of the seven fire stations at risk of damage, the Hilliard fire station would have a greater than 50% risk of being at least slightly damage. Both hospitals would experience up to 20%g ground accelerations and there is a 60% chance that both would be at least slightly damaged.

There are five police stations at risk for damage from an earthquake. Of the five police stations only the two in Evanston, Uinta County Sheriff Headquarters and the Evanston Police Dept. Headquarters, would be at risk for very strong shaking. The Uinta County Sheriff Headquarters would have a probability of 41% to receive at least slight damage, while the Evanston PD HQ would have a 36% chance of sustaining at least slight damage. There are 17 school buildings vulnerable to damage from the earthquake. As with other essential facilities, schools in the Evanston area would experience the most shaking and highest probability of damage, while schools in Mountain View and Lyman would have a small probability of damage. Of the Evanston schools, Aspen Elementary would experience the strongest shaking (22%g), while North Evanston Elementary would experience slightly weaker ground motion (19%g). School buildings in Evanston would have a 30-50% chance of at least slight damage and a 2-20% chance of at least moderate damage.

Buildings

Direct economic losses for buildings, which include structural and content damage, would total $64.448 million dollars for the region. Uinta County would experience the most damage at $64.447 million, while Sweetwater County would have about a thousand dollars in direct economic loss for buildings. Lincoln County would not be expected to suffer any direct economic loss from building damage.

Transportation

Lincoln and Sweetwater Counties would not be expected to have any direct economic losses for transportation systems. Uinta County would experience a direct economic loss of $2.451 million dollars. The losses reflect damage to highways, bridges, and railways.

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Utilities

The regional direct economic loss for utilities would be $20.872 million dollars. Lincoln County would account for $45,000 of damage to potable water, waste water, and natural gas pipelines. Sweetwater County would account for $44,000 in damage to the same infrastructure. As seen in the two previous categories, Uinta County would account for the greatest economic loss. The direct economic loss for utilities in Uinta County would be $20.782 million dollars. Potable water, waste water, and natural gas pipelines would suffer damage, waste water, natural gas, and communication facilities would also likely be damaged.

Fault Based Scenario – Region 4 (Chicken Springs Fault)

The Chicken Springs fault system is located in Sweetwater County, Wyo. There are, at minimum, a dozen separate fault strands concentrated in an 8-by 15-km area (USGS, 2004). The average strike of the faults, according to the USGS, is 281 degrees, and no dip is recorded. According to Case et al. (2002), the Chicken Springs fault system has a maximum credible magnitude of 6.5. The slip-rate for this fault is less than 0.2 mm/yr.

The earthquake scenario was modeled at magnitude 6.5. The earthquake would cause 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. Light damage would be expected in Jeffery city and up to 30 miles from the epicenter. Moderate damage would be possible in Bairoil and areas within 15 miles of the epicenter, while moderate to heavy damage would be seen within 5 miles. Bairoil is the closest town to the epicenter and would experience ground motions of 18-34%g (MMI VII).

The total population in the scenario region is 46,034 according to the 2000 census. The scenario results estimate that of the 46,034 people, 1 household would be displaced and no one would require temporary shelter.

Of the 27,657 buildings in the area, the scenario shows that 215 would sustain at least moderate damage from the earthquake. The earthquake would generate 4,000 tons of debris.

Essential facilities

Essential facilities include fire stations, hospitals, police stations and schools. There are 23 essential facilities which would experience damaging ground motions: 6 fire stations, 1 hospital, 6 police stations, and 10 schools. Of the six fire stations that would experience damaging shaking, the Bairoil Fire Department would have a 60% probability of sustaining at least slight damage and would experience very strong ground motions (23%g). The other five fire stations would expect moderate to strong shaking but would have a less than 15% chance of sustaining at least slight damage. There is only one hospital vulnerable to damaging shaking in the scenario region. The Memorial Hospital of Carbon County would expect moderate shaking, but very little 18 damage, if any. Six police stations would be susceptible to damaging shaking from an earthquake on the

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Chicken Springs fault system. Of the six police stations, only the Bairoil Police Department Headquarters would have a significant chance to sustain at least slight damage (63%). The Bairoil Police Department Headquarters would experience up to 24%g ground accelerations which would cause very strong perceived shaking. There are 10 school buildings susceptible to damage from the earthquake. The elementary school in Bairoil would experience very strong motions (31%g) and would have a 58% chance of sustaining at least slight damage. There is a 22% chance that the Bairoil elementary school would sustain at least moderate damage. The other nine schools in the region would experience light to moderate shaking, but would have a small chance (<10%) of sustaining damage.

Buildings

Direct economic losses for buildings, which include structural and content damage, would total $7.737 million dollars for the region. Sweetwater County would experience the most damage at $3.561 million dollars, and Carbon County would experience $3.320 million dollars in direct economic losses for buildings. Fremont County would sustain the third greatest amount of damage at $771,000, while Natrona County would have the lowest projected losses at $85,000.

Transportation

The direct economic loss for transportation would total $348,000. Carbon County would experience the highest losses at $321,000. The majority of the losses in Carbon County would be from damage to airport facilities and highway bridges. Fremont, Natrona, and Sweetwater counties would each have direct economic losses for transportation of less than $20,000.

Utilities

The regional direct economic loss for utilities would be $2.807 million dollars. Sweetwater County would have the highest loss at $1.359 million dollars. The losses would come from damage to potable water, waste water, and natural gas pipelines as well as damage to natural gas facilities. Carbon County would have the next highest loss for utilities at $822,000, from damages to potable water, waste water, and natural gas pipelines, and wastewater and natural gas facilities. There are $565,000 of losses in Fremont County, based on damage to potable water, waste water, and natural gas pipelines and facilities. Natrona County loss estimates show $61,000 of economic loss for potable water, waste water, and natural gas pipelines.

Probabilistic Scenario

In the Wyoming Multi-Hazard Mitigation Plan, HAZUS 2.1 was used to develop losses associated with a 2,500 year probabilistic earthquake scenarios for each county in the State of Wyoming. This scenario uses USGS probabilistic seismic contour maps to model ground shaking with a 2% probability of being exceeded in 50 years (or a 2,500 year event). Total losses include building, contents, inventory, and income-related losses.

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The following table lists total loss, loss ratio (total loss/total building inventory value), and ranges of casualties within severity levels. HAZUS provides casualty estimates for 2 a.m., 2 p.m., and 5 p.m. to represent periods of the day that different sectors of the community are at their peak occupancy loads. The casualty ranges represent the lowest to highest casualties within these times of day. Casualty severity levels are described as follows;

Level 1: Injuries will require medical attention but hospitalization is not needed
Level 2: Injuries will require hospitalization but are not considered life-threatening
Level 3: Injuries will require hospitalization and can become life-threatening if not promptly treated
Level 4: Victims are killed by the earthquake

The table is sorted and ranked by total loss.

There are two methods for ranking counties to determine where earthquake impacts may be the greatest. Either loss ratios or total damage 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, since it gives an indication of the percent of damage to buildings.

Table 4.25. 2500-year Probabilistic Scenario Loss Estimates, 2015 Valuations

Rank	County	Total Loss ($M)	Loss Ratio	Casualties Level 1	Casualties Level 2	Casualties Level 3	Casualties Level 4
1	Teton	$654	27%	150-300	40-90	0-20	30-Oct
2	Lincoln	$528	63%	190-220	50-60	0-20	20-Oct
3	Natrona	$268	11%	50-60	10	0	0
4	Uinta	$247	18%	90-120	20-30	0-10	0-10
5	Sweetwater	$181	19%	50	10	0	0
6	Fremont	$115	25%	20	0	0	0
7	Laramie	$105	4%	20	0	0	0
8	Sheridan	$84	9%	20	0	0	0
9	Albany	$81	21%	20	0	0	0
10	Campbell	$79	14%	20	0	0	0
11	Park	$79	1%	20	0	0	0
12	Sublette	$74	6%	20	0-10	0	0
13	Carbon	$64	1%	10	0	0	0
14	Converse	$50	28%	10	0	0	0
15	Washakie	$28	1%	10	0	0	0

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Rank	County	Total Loss ($M)	Loss Ratio	Casualties Level 1	Casualties Level 2	Casualties Level 3	Casualties Level 4
16	Big Horn	$26	4%	0-10	0	0	0
17	Johnson	$25	1%	0-10	0	0	0
18	Platte	$20	3%	0	0	0	0
19	Hot Springs	$20	1%	0	0	0	0
20	Goshen	$11	1%	0	0	0	0
21	Weston	$7	0%	0	0	0	0
22	Crook	$5	1%	0	0	0	0
23	Niobrara	$4	1%	0	0	0	0
	Total	**$2,755**					

Source: Wyoming State Hazard Mitigation Plan 2016

The total damage figure by itself does not reflect the percentage of building damage, since small damage to a number of valuable buildings may result in a higher total damage figure than may be found in a county with fewer, less expensive buildings, with a higher percentage of damage.

In this model, Each of the three counties included in the region ranked among the top 5 counties with the highest risk for the 2500 year probabilistic scenario. Lincoln, Uinta, and Sweetwater are each expected to have more than $150 million in losses with Lincoln County's losses reaching $528 million.

The four counties at highest risk to earthquake according to the 2500-year analysis are Lincoln, Teton, Uinta, and Sublette.

The Wyoming State Mitigation Plan explains that Lincoln and Uinta Counties are experiencing some of the most significant growth. "In the event of a significant earthquake, those counties experiencing greater growth within their boundaries will have greater need of critical infrastructure like hospitals, police and fire departments, which are likely to be operating at a decreased capacity. The draw on critical infrastructure from surrounding areas may also be taxed."

In this scenario, critical infrastructures at highest risk are listed. The tables show the top 25 infrastructures of each category that are at risk to 2,500-year earthquake scenarios (Sorted by lowest to highest functionality on day 1 after earthquake).

The following table displays the top 25 schools at risk and lists nine schools in Lincoln County. Among other tables, Lincoln County has two care facilities at great risk, ten police stations, and five fire stations.

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Uinta County ranked 4th out of the 23 counties in potential losses and would have four schools at risk, one care facility, four police stations, and six fire stations.

Sweetwater County ranked 5th in potential losses. One care facility and one police station would be at great risk.

Table 4.26. Top 25 at Risk to 2,500-year Earthquake Scenarios

Schools (Sorted by lowest to highest functionality on day 1 after earthquake)

Name	City	County	Number of Students	On Day 1	On Day 2
Swift Creek Learning Center	Afton	Lincoln	772	2%	8%
Osmond Elementary	Afton	Lincoln	287	2%	8%
Star Valley High School	Afton	Lincoln	704	2%	8%
Star Valley Middle School	Afton	Lincoln	366	2%	8%
Afton Elementary	Afton	Lincoln	396	2%	8%
C-Bar-V Ranch	Wilson	Teton	125	4%	17%
Region V Boces	Wilson	Teton	25	4%	17%
Cokeville High School	Cokeville	Lincoln	90	4%	12%
Cokeville Elementary	Cokeville	Lincoln	122	4%	12%
Holdaway Elementary	Thayne	Lincoln	327	4%	13%
Kelly Elementary	Kelly	Teton	446	5%	20%
Jackson Elementary	Jackson	Teton	420	5%	23%
Journeys School Of The Teton Science		Teton	151	6%	23%
Metcalf Elementary	Etna	Lincoln	259	6%	16%
Wilson Elementary	Wilson	Teton	227	9%	31%
Bondurant Elementary	Bondurant	Sublette	379	11%	26%
Colter Elementary	Jackson	Teton	344	11%	35%
Jackson Hole High School	Jackson	Teton	637	11%	35%
Jackson Hole Middle School	Jackson	Teton	493	11%	35%
Summit High School	Jackson	Teton	50	11%	35%
Jackson Hole Christian Academy	Jackson	Teton	190	11%	35%
Davis Middle School	Evanston	Uinta	337	11%	27%
Evanston High School	Evanston	Uinta	847	11%	27%
Clark Elementary	Evanston	Uinta	209	11%	27%
Uinta Meadows Elementary	Evanston	Uinta	446	11%	27%

Source: Wyoming State Hazard Mitigation Plan 2016

Liquefaction Vulnerability

There have been little, if any, reported damages from liquefaction in Wyoming. Given that ground motions associated with Intensity VIII or larger are usually needed to trigger liquefaction, and that

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only small areas of the Region would experience that level of shaking during the 2% event (2% probability of exceedance in 50 years), liquefaction would be a rare occurrence in the Region. If it were to occur it would most likely affect isolated areas of Lincoln County and Uinta County.

The Wyoming State Mitigation Plan shows the county rankings for building exposure values tied to liquefaction prone areas. "A single earthquake event would not likely cause liquefaction in all potential areas of an individual county. As a result, the county figures are useful primarily for comparison of potential between counties. The values do reflect the value of buildings exposed to the hazard."

Table 4.27. Exposure by County, Liquefaction

County	Exposure Value
Teton	$1,858,921,520
Uinta	$310,025,710
Lincoln	$285,254,565
Fremont	$50,055,350
Carbon	$33,893,155
Sublette	$21,003,175
Washakie	$15,386,060
Hot Springs	$9,519,420
Bighorn	$9,099,015
Park	$3,597,420
Albany	$0
Campbell	$0
Converse	$0
Crook	$0
Goshen	$0
Johnson	$0
Laramie	$0
Natrona	$0
Niobrara	$0
Platte	$0
Sheridan	$0
Sweetwater	$0
Weston	$0
TOTAL	**$2,596,755,390**

Source: Wyoming State Hazard Mitigation Plan 2016

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Future Development

Future development in the Region is not anticipated to significantly change vulnerability to earthquakes.

Summary

In summary, within Region 4, Lincoln County has the highest risk due to the closer proximity of potentially active faults within and near the Region. It is estimated that if a worst-case event occurred in Lincoln County, $528 million in combined capital stock and income losses could occur. Though the probability is low, WSGS studies indicate the possibility of a 6.5 magnitude earthquake could occur anywhere in the state, and the potential for even large earthquakes exists in the Region.

Table 4.28. Earthquake Hazard Risk Summary

County	Likelihood	Spatial Extent	Potential Magnitude	Significance
Lincoln	Likely	Significant	Critical	High
Sweetwater	Occasional	Limited	Limited	Medium
Uinta	Occasional	Limited	Limited	Medium

4.2.6 Expansive Soils

Hazard Description

Soils and swelling bedrock contain clay which causes the material to increase in volume when exposed to moisture and shrink as it dries. They are also commonly known as expansive, shrinking and swelling, bentonitic, heaving, or unstable soils and bedrock. In general, the term refers to both soil and bedrock contents although the occurrence of the two materials may occur concurrently or separately. The difference between the materials is that swelling soil contains clay, while swelling bedrock contains claystone.[3]

The clay materials in swelling soils are capable of absorbing large quantities of water and expanding 10 percent or more as the clay becomes wet. The force of expansion is capable of exerting pressures of 15,000 pounds per square foot or greater on foundations, slabs, and other confining structures.[4] The amount of swelling (or potential volume of expansion) is linked to five main factors: the type of mineral content, the concentration of swelling clay, the density of the materials, moisture changes in the environment, and the restraining pressure exerted by materials on top of the swelling soil. Each of these factors impact how much swelling a particular area will experience, but may be modified, for better or worse, by development actions in the area.

Low—This soils class includes sands and silts with relatively low amounts of clay minerals. Sandy clays may also have low expansion potential, if the clay is kaolinite. Kaolinite is a common clay mineral.

[3] Colorado Geological Survey Department of Natural Resources, *A Guide to Swelling Soils for Colorado Homebuyers and Homeowners*. (Denver, Colorado.) 1997. p 15-16.
[4] Ibid., p 17.

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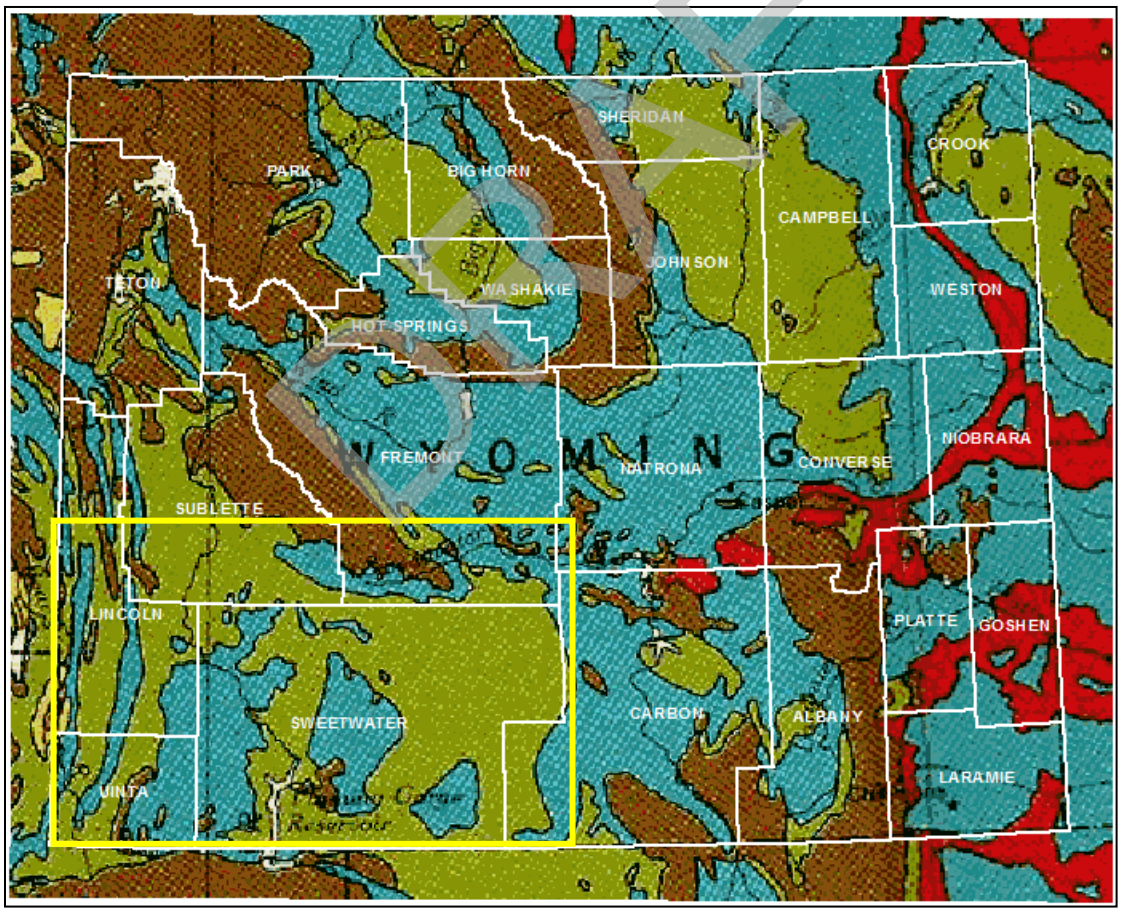
Moderate—This class includes silty clay and clay textured soils, if the clay is kaolinite, and also includes heavy silts, light sandy clays, and silty clays with mixed clay minerals.
High—This class includes clays and clay with mixed montmorillonite, a clay mineral which expands and contracts more than kaolinite.

Geographical Area Affected

Expansive soils are known to be present in multiple areas in the Region. Figure 4.18 and Figure 4.19 illustrate possible expansive soils locations in Wyoming. Figure 4.19 is based on select geologic formations from the Love and Christiansen 1985 Geologic Map of Wyoming. Those formations selected have characteristics that could lead to expansive soils where they outcrop. Based on these figures, all three counties within the region have moderate and likely potential for swelling. Deposits of calcium montmorillonite can also contribute to swelling problems, but these areas have not been completely mapped. Based on the figures below, expansive soils are estimated to affect a limited portion of the planning area.

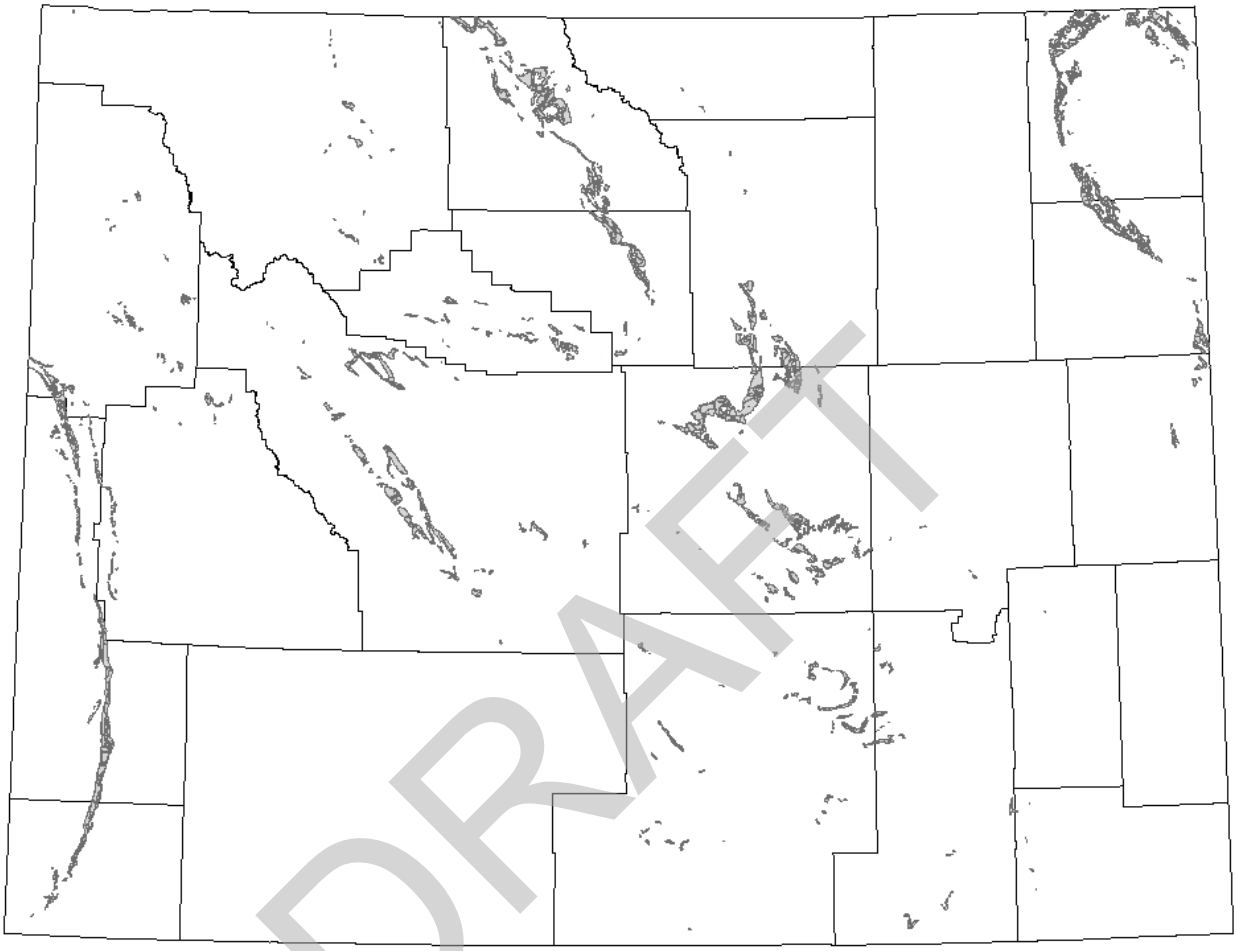
Figure 4.19. Expansive Soil Potential in Wyoming



Source: The map above is based upon "Swelling Clays Map of the Conterminous United States" by W. Olive, A. Chleborad, C. Frahme, J. Shlocker, R. Schneider and R. Schuster. It was published in 1989 as Map I-1940 in the USGS Miscellaneous Investigations Series. Land areas were assigned to map soil categories based upon the type of bedrock that exists beneath them as shown on a geologic map. In most areas, where soils are produced "in situ", this

method of assignment was reasonable. However, some areas are underlain by soils which have been transported by wind, water or ice. The map soil categories would not apply for these locations.

Figure 4.20. Wyoming Mapped Formations with Potential for Expansive Soils



Source: State of Wyoming Multi-Hazard Mitigation Plan 2008

During the HMPC meetings, Sweetwater County noted expansive soils issues around the town of Superior.

Past Occurrences

Very little data exists on expansive soil problems and damages in Wyoming. Studies on the issue have not been performed and no database exists to catalog occurrences. Damages due to expansive soils such as cracking in foundations, sidewalks, roads or parking lots, or longer-term damage to supply lines, railways, bridges and utilities may occur, but are generally handled by individual property owners or occur over time, and are not reported as an expansive soils hazard incident. The 2016 State of Wyoming Multi-Hazard Mitigation Plan lists no known events in the region.

Likelihood of Future Occurrence

Expansive soils will most likely be an occasional problem for the counties in Region 4.

Potential Magnitude

The potential magnitude of expansive soils events and damages is estimated to be negligible for the counties in the Region. Minor impacts related to expansive soils have been reported thus far. Because damages from expansive soils tend to happen over an extended period of time, it is difficult to estimate the potential severity of a problem. Many deposits of expansive soils do not inflict damage over large areas. Instead, these deposits can often create localized damage to individual structures and supply lines, such as roads, railways, bridges and power lines. The mapped areas containing expansive soils in the planning area appear to run alongside multiple highways including I-80, Highway 191 and Highway 189, so these roads could potentially be damaged over time.

Vulnerability Assessment

According to the Wyoming State Multi-Hazard Mitigation Plan (2008), "there are two measurements used for calculating future impacts, historic dollar damages and building exposure values. There are not enough current data to accurately estimate historic damages.

The Wyoming State Geological Survey (WSGS) calculated the building exposure values for buildings that may occur within the areas of expansive soils. All expansive soils mapped have been digitized and the expansive soil layer was then digitally crossed with the Census block building values. In the event of an expansive soil boundary dissecting a census block, the proportional value of the buildings in the census block will be assigned to the expansive soil. IN a case where a census block is within an expansive soil, the combined values of all the buildings in the census block are assigned. The values derived by county are shown in Figure 4.20. These damage estimates assume an instantaneous event, which would damage all of the property of suspected expansive areas at one time.

This scenario is extremely unlikely, meaning that the exposed damage estimates most likely are vastly overstated. It is far more likely that damage from these soils will be individual events, which will cause damage to a small number of buildings or road segments over time."

According to the Wyoming State Mitigation Plan, an estimated $23,500,000 worth of structures and infrastructure in Lincoln County may be at risk to expansive soils. $283,000 worth of structures and infrastructure in Uinta County may be at risk. Sweetwater County does not have any recorded estimates in the Wyoming State Mitigation Plan. The worst impacts would likely be to road infrastructure and possibly historic buildings that were not constructed to accommodate expansive soils.

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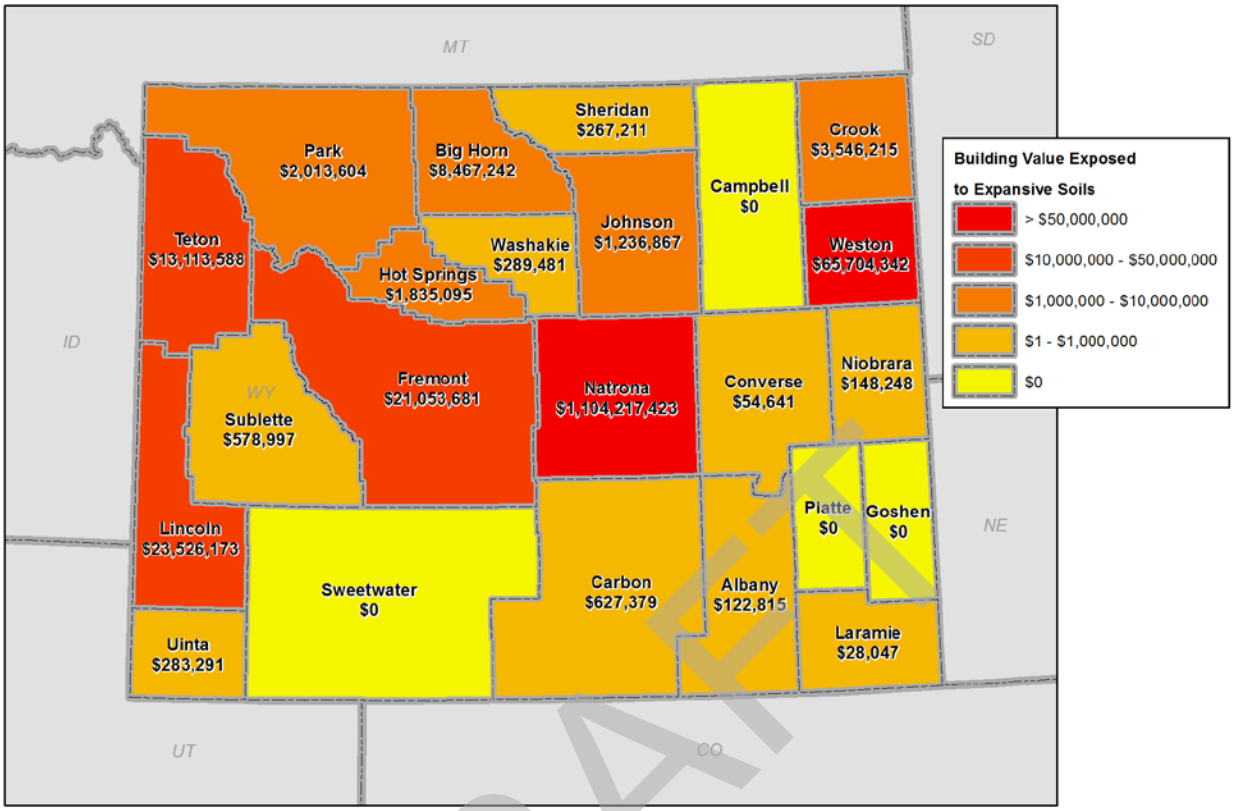
Figure 4.21. Wyoming Exposure to Shrinking/Swelling Soils by County



Source: State of Wyoming Multi-Hazard Mitigation Plan

Future Development

Modern building practices incorporate mitigation techniques, provided proper geotechnical testing is employed to identify expansive soils. If areas prone to expansive soils are identified, future areas for development will need to take this hazard into account. Specifically, the town of Superior in Sweetwater County identified expansive soils as something that must be taken into account for all new development.

Summary

Overall, expansive soils are a low significance hazard for the counties in the region.

Table 4.29. Expansive Soil Hazard Risk Summary

County	Likelihood	Spatial Extent	Potential Magnitude	Significance
Lincoln	Occasional	Limited	Limited	Low
Sweetwater	Occasional	Limited	Negligible	Low
Uinta	Occasional	Limited	Limited	Low

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Municipalities Impacted: Sweetwater County – Town of Superior

4.2.7 Flood

Hazard Description

Floods can and have caused significant damage in Region 4, and are one of the more significant natural hazards in the Region. 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, 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. Causes of flooding relevant to the Region include:

- Rain in a general storm system
- Rain in a localized intense thunderstorm
- Melting snow
- Rain on melting snow
- Ice Jams
- Dam failure
- Levee Failure
- Urban stormwater drainage
- Rain on fire damaged watersheds

Region 4 is susceptible to multiple types of floods including riverine flooding, flash floods, slow rise floods and dam or levee failure.

Riverine flooding is defined as when a watercourse exceeds its "bank-full" capacity and is usually the most common type of flood event. Riverine flooding generally occurs as a result of prolonged rainfall, or rainfall that is combined with soils already saturated from previous rain events. Slow rise floods associated with snowmelt and sustained precipitation usually are preceded with adequate warning, though the event can last several days.

The area adjacent to a river channel is its floodplain. In its common usage, "floodplain" most often refers to that area that is inundated by the 100-year flood, the flood that has a 1 percent chance in any given year of being equaled or exceeded. Other types of floods include general rain floods, thunderstorm generated flash floods, alluvial fan floods, snowmelt and rain on snow floods, dam failure floods, and local drainage floods. The 100-year flood is the national standard to which communities regulate their floodplains through the National Flood Insurance Program.

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. Even flash floods are usually preceded with warning from the National Weather Service in terms of flash flood advisories, watches, and warnings.

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Floods can occur for reasons other than precipitation or rapidly melting snow. They can also occur because of ice jams. An ice jam is a stationary accumulation of ice that restricts flow. Ice jams can cause considerable increases in upstream water levels, while at the same time downstream water levels may drop. Types of ice jams include freeze up jams, breakup jams, or combinations of both. These types of floods can be slow or fast rising, but generally develop over a period of many hours or days.

Levee failure can also cause a flash flood. A levee is an earthen embankment constructed along the banks of rivers, canals and coastlines to protect adjacent lands from flooding by reinforcing the banks. By confining the flow, levees can also increase the speed of the water. Levees can be natural or man-made. A natural levee is formed when sediment settles on the river bank, raising the level of the land around the river. To construct a man-made levee, workers pile dirt or concrete along the river banks, creating an embankment. This embankment is flat at the top, and slopes at an angle down to the water. For added strength, sandbags are sometimes placed over dirt embankments. Natural disasters such as Hurricane Katrina demonstrate that, although levees can provide strong flood protection, they are not failsafe. Levees can reduce the risk to individuals and structures behind them, but they do not eliminate risk entirely. Levees are designed to protect against a specific flood level; severe weather could create a higher flood level that the levee cannot withstand. Levees can fail by either overtopping or breaching. Overtopping occurs when floodwaters exceed the height of a levee and flow over its crown. As the water passes over the top, it may erode the levee, worsening the flooding and potentially causing an opening, or breach, in the levee. A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning. Unfortunately, in the rare occurrence when a levee system fails or is overtopped, severe flooding can occur due to increased elevation differences associated with levees and the increased water velocity that is created. It is also important to remember that no levee provides protection from events for which it was not designed, and proper operation and maintenance are necessary to reduce the probability of failure.

The potential for flooding can change and increase through various land use changes and changes to land surface. A change in the built environment can create localized flooding problems inside and outside of natural floodplains by altering or confining watersheds or natural drainage channels. These changes are commonly created by human activities. Flooding in the communities in Region 4 could be exacerbated by inadequate drainage and channel systems that would not stand up to the 1% annual chance flood. Inadequate culverts and drainage systems can cause flooded roads and flood adjacent properties. Refer to the County Annexes for a description of localized problems.

Increased flooding can also be created by other events such as wildfires. Wildfires create hydrophobic soils, a hardening or “glazing” of the earth’s surface that prevents rainfall from being absorbed into the ground, thereby increasing runoff; erosion, and downstream sedimentation of channels.

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Geographical Area Affected

All counties within the planning region have the potential for flooding. The extent of the flooding varies based on the location of the county, and on what part of the county is being examined. Detailed geographic flood assessments are provided in each County's attached annex.

Region 4 lies in three major drainage basins. The largest geographical area of the region lies in the Green River Basin. The Green River Basin's rivers and streams drain areas of Lincoln, Uinta and Sweetwater Counties to the Green River. It flows through portions of Lincoln and Sweetwater counties and through the communities of La Barge and Green River. Green River Basin includes the Great Divide Basin, a closed basin that does not contribute runoff to the Green River. This encompasses a portion of the northeastern section of Sweetwater County. Sources of flooding in this basin include the Green River and Bitter Creek in the Town of Green River and Bitter Creek and its tributaries through Rock Springs. According to the Wyoming Multi-Hazard Mitigation Plan, Sweetwater County is one of the top three counties with the highest number of buildings within the floodplain. In Lincoln County, tributaries affect the Towns of Opal, Kemmerer and Diamondville. In Uinta County the communities of Lyman and Mountain View are impacted by the Green River tributaries of Smiths Fork River and North Creek.

The western portion of Region 4 is the Bear River Basin. The Bear River Basin is located in northeast Utah, southeastern Idaho and southwestern Wyoming. In Wyoming, the Bear River flows through two counties in Region 4, the western part of Uinta County and the southwestern portion of Lincoln County. From its source the Bear River flows north, cutting across the southwest corner of Wyoming, through the communities of Evanston and Bear River in Uinta County then weaving along the Utah-Wyoming state line as it flows north through the community of Cokeville in Lincoln County.

The northern portion of Lincoln County is in the Snake/Salt River Basin. The Salt River is a small river that originates on the western slope of the Salt River Mountain Range just south of the town of Afton. It flows north through the communities of Thayne and Alpine into Palisades Reservoir at its confluence with the Snake River.

The geographic extent rating for Region 4 is significant, meaning that a flood event could impact 10-50% of the planning area. The following sections detail the extent and history of flood hazards in the Region.

Figure 4.21 illustrates the 100-year floodplains in Region 4.

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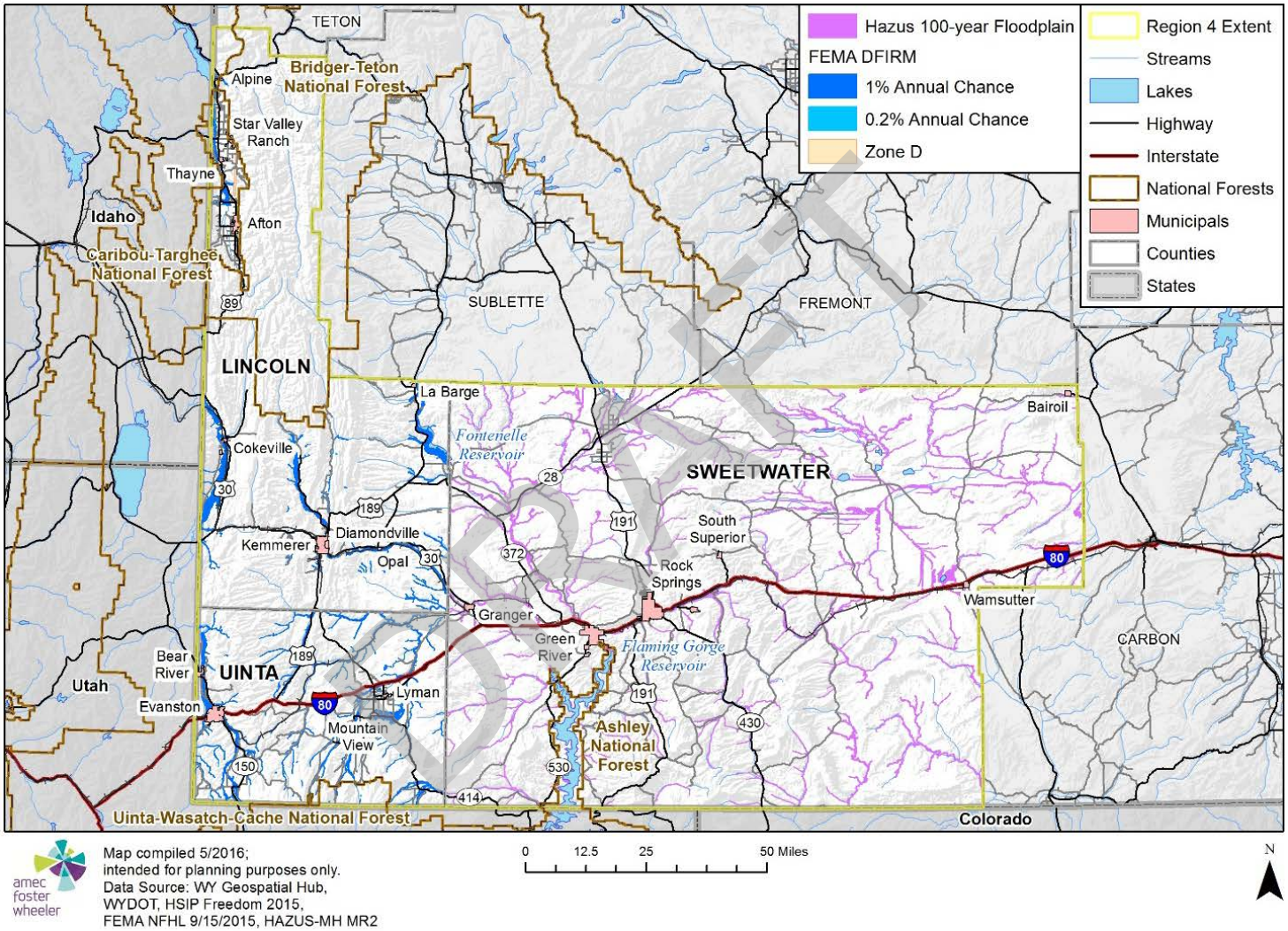
Figure 4.22. Region 4 Flood Hazards



Past Occurrences

The abbreviated flood history below 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 and the SHELDUS database. Other sources include the U.S. Army Corps of Engineers Ice Jam Database, the FEMA Flood Insurance Studies for each County and relevant communities and HMPC accounts. Table 4.30 summarizes the number of flood events and period of record for the counties in Region 4.

The documented flood history for Region 4 extends back to 1918, when a flood occurred along the Green River in Sweetwater County. This flood is the maximum flood of record, discharging 22,000 cfs, measured at the Town of Green River, and a recurrence interval of 50 years.

On July 11, 1937 heavy rains caused a large number of floods, the most destructive being in the vicinity of Rock Springs. In this area floods occurred on the 11th-12th. During the flood on the 11-12th more than 500 homes were inundated and more than 2,000 people rendered temporarily homeless. Crops suffered severely from hail and floods, but there were compensating benefits from the excess moisture. The heavy downpour caused severe floods in Sweetwater County that caused great loss of property and interrupted railway and highway traffic. In addition to the damage to homes, highway, railway and mine property was severely damaged and railway service was suspended for 24 hours. Property damage in Sweetwater County amounted to more than $100,000 ($1.72 million in 2016 dollars).

On the afternoon of August 19, 1956, rain and hail followed by a flash flood caused extensive damage, primarily due to flooding in a new section of the city known as White Mountain. Floodwaters reached a depth of five feet in some low areas. About 200 telephones were put out of order. Refuse from a nearby garbage dump and debris from boardwalks and fences littered the streets. In a few places, silt was deposited to a depth of 12 to 18 inches.

In 1984 an ice jam on the Bear River at Evanston which caused agricultural flooding and damage to pavement, buildings, and bridges. Restriction at the bridge caused water to back up. No damage amount reported.

In January, 1985, an ice jam formed along the Bear River near Evanston, flooding fields and the county road which is the primary access to the community. The County removed ice from about a half mile reach for $22,000 ($50,200 in 2016 dollars), relieving the problem.

On July 12, 1989, a torrential rain-producing thunderstorm hit Rock Springs on the late afternoon and early evening. The heaviest precipitation occurred just south of the town. The Rock Springs airport recorded 0.88 inch of rain along with wind gusts up to 52 mph. Dime-sized hail covered the ground to 1.5 feet deep 5 miles south of the community. As a result of Rock Springs being low relative to the terrain to their south, a tremendous surge of water and mud up to 3 to 4 feet deep invaded the town between 1700 MST and 1830 MST. This surge came northward into the south part of town by way of Dead Horse Canyon Creek. The water and mud rapidly inundated the

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downtown section of the community. The result was catastrophic losses to homes, businesses, and cars. Vehicles were washed down streets onto lawns and basements flooded. Not including costs associated with automobiles, a preliminary total damage figure of more than $1.5 million ($3.0 M in 2016 dollars) was reported by county and city officials. A storm-related death occurred to a conductor who was on a westbound Union Pacific Railroad engine cab that struck a stationary, empty rail car. The combination of the flooding waters and strong winds caused the car to lean over to the tracks that the engine cab was traveling on.

On September 12, 1998 and estimated rainfall of 1 to 2 inches in less than an hour fell over a small area, caused by slow-moving, intense thunderstorms. Water reported to be 4 to 5 feet deep in some areas, primarily western sections of Rock Springs. Property damage was not reported.

In December 16, 2005, a freeze-up ice jam on the Salt River was reported following very cold air temperatures. The jam caused the river to overflow its banks between Freedom and Etna. Three to five homes were threatened, with water coming to within several feet from the homes, and horses and cattle were stranded. The homes were protected with sandbags and large hay bales (which worked well when air temperatures kept them frozen, but were too porous when air temperatures warmed up). Property damages were not reported.

On August 17, 2007 heavy rainfall on the south side of the Town of Green River produced a flash flood. Within 25 minutes, between 1.25 inches and 1.75 inches of rain was measured in this area of town. A fence at the landfill was washed out by a wall of water six feet high. The water and mud caused extensive damage to a scale mechanism at the landfill. Additionally, several basements were flooded, South Hill on State Highway 530 had mud and debris across it, and a pool near one school was completely inundated by mud. Many yards and streets on the south side of Green River were covered with six to eight inches of mud. $250,000 property damage ($294,000 in 2016 dollars).

On June 7, 2010 a combination of snowmelt and heavy rainfall caused flooding in far southwest Wyoming in the first week of June, with the largest rises observed on the Black's Fork River. Flooding occurred on both the Black's Fork and the Smith's Fork Rivers, with flooding reported near both Robertson and Mountain View, Wyoming, though not much damage was reported. The Black's Fork river gauge rose the most during this event, peaking at 3642 cfs. $10,000 in damage ($11,000 in 2016 dollars).

On May 15, 2011, low elevation snowpack in the mountains bordering the west side of Star Valley in Lincoln County melted rapidly as temperatures climbed into the 60s. The result was flooding along the Salt River and its tributaries. This caused flooding of Spring, Tin Cup, Crow, Jack Knife, and Stump creeks along the western edge of Star Valley. A few homeowners were forced to sandbag around their homes, build temporary levees, or dig trenches to provide relief from the rising flood waters. Lowlands near the Salt River were inundated with water, especially north of Thayne to around the Double L Ranch near Etna. Crop Damage $150,000 ($163,000 in 2016 dollars). Property Damage $50,000 ($54,300 in 2016 dollars).

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The flood in the spring of 2011 resulted in a Presidential Declaration for Uinta County on the county roads by Evanston (Bear River and tributaries) and county roads and bridge on Blacks Fork River in Bridger Valley. The declaration resulted in $227,314.91; Federal Share $170,486.18, State Share was $48,304.42 and Local Share was $48,524.31.

On June 25, 2011 the warmest temperatures of the season led to increased snowmelt along the west side of the Salt River Range. The water flowed fast and high enough to cause flooding in Star Valley Ranch. Active snowmelt in the Salt River Range caused a flood along a normally dry ditch in Star Valley Ranch. The narrow drainage near Prater Canyon brought enough water to wash out part of a road and three culverts. The high water also exposed and damaged a water line in the community. $167,000 in property damage ($181,500 in 2016 dollars).

On July 6, 2015 thunderstorms erupted within a moist atmosphere in place over Sublette and Sweetwater counties. The result was heavy rain and eventually flash flooding in the city of Rock Springs in Sweetwater County. Rainfall of approximately 0.60 to 0.85 inches fell in and around downtown Rock Springs in about 30 minutes. The result was street flooding and accumulating water in one trailer park on the east side of town. The Rock Springs Police Department reported flooding in a trailer park on 9th Street near the South Side Belt Route. Up to 3 feet of water collected in low-lying areas of the park and displaced some residents before the water receded shortly after 2100MST. $20,000 in property damage ($20,024 in 2016 dollars).

On the following day, July 7, 2015, a nearly stationary thunderstorm first developed around 1400MST over the city of Rock Springs. Rainfall totals in the hardest hit areas generally ranged from 1.5 to 2 inches, most of which fell in about 30 minutes before a second round began around 1500MST. This rain fell on soil already saturated from thunderstorm rains the previous day. The result was flash flooding of downtown businesses, city streets, numerous residential basements, and low-lying areas in the business district. In addition, numerous cars were stranded in flood waters both on city streets and in large parking lots. $250,000 property damage ($250,300 in 2016 dollars).

In addition, locals have recounted several additional flooding events in Lincoln County; flooded homes in the early 1980's in Diamondville and Frontier; two structures flooded in 1983 in Cokeville; a flash flood in Stewart Canyon in the Star Valley in 1993; a beaver dam flood of the Ham's Fork in Diamondville in 2005; and ice jam and spring runoff flooding in the Star Valley in 2005. Damage information was not available for any of these incidents.

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Table 4.30. Flood Events by County in Region 4

County	Events	Period of Record
Lincoln	13	1984-2016
Sweetwater	19	1918-2016
Uinta	5	1965-2016

Likelihood of Future Occurrence

Judging by the historical flood record for the Region, a flood of at least minimal magnitude occurs roughly every 2.5 to 10 years on average somewhere in the planning area. Most of these floods were less than the 100-year flood; the chance of a 100-year flood occurring within any 30-year period is 26%. The chance of a 100-year flood occurring in any 100-year period is approximately 63%. Using the formula in Section 4.2, this yields probabilities of 10% to 40%. This corresponds to a likely occurrence rating, meaning that a flood has a 10-100 percent chance of occurrence in the next year somewhere in the Region.

Potential Magnitude

Magnitude and severity can be described or evaluated in terms of a combination of the different levels of impact that a community sustains from a hazard event. Specific examples of negative impacts from flooding on Region 4 span a comprehensive range and are summarized as follows:

- Floods cause damage to private property that often creates financial hardship for individuals and families;
- Floods cause damage to public infrastructure resulting in increased public expenditures and demand for tax dollars;
- Floods cause loss of personal income for agricultural producers that experience flood damages;
- Floods cause loss of income to businesses relying on recreational uses of regional waterways;
- Floods cause emotional distress on individuals and families; and
- Floods can cause injury and death.

The magnitude and severity of the flood hazard is usually determined by not only the extent of impact it has on the overall geographic area, but also by identifying the most catastrophic event in the previous flood history. Sometimes it is referred to as the "event of record." The flood of record is almost always correlated to a peak discharge at a gage, but that event may not have caused the worst historic flood impact in terms of property damage, loss of life, etc.

The flood of record for Hams Fork in Lincoln County occurred on May 11, 1923. This flood had a discharge of 3250 cubic feet per second, which is representative of less than a 50-year frequency flood. (Source: FIS)

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In Uinta County, principal floods of record in Evanston have occurred on June 14, 1921, with a flow of 3,690 cubic feet per second (cfs), on May 27, 1923, with a flow of 3,460 cfs, on April 16, 1937, with a flow of 3,420 cfs, and on May 16, 1984, with a flow of 3,680 cfs. The June 10, 1965, flood is the largest recorded flood in the Town of Mountain View with a discharge of 3,550 cfs at the East Fork of Smiths Fork gage. (Source: Uinta County FIS)

In Sweetwater County, the 1918 flood is the maximum flood of record in Green River. It had a discharge of 22,200 cfs, measured at Green River, and a recurrence interval of 50-years. The greatest flood of record in Rock Springs occurred in July 1937, a result of intense rainfall over the Killpecker Creek drainage area on July 11 and 12 and over the upper Bitter Creek drainage area on July 12. Peak flow in Bitter Creek upstream from the mouth of Killpecker Creek was estimated to be about 10,000 cfs. During the flood, approximately 2000 residents of the East Flat and West Flat areas were evacuated, rail and highway traffic was interrupted due to destruction of roadbed and bridges, and the bridges on Pilot Butte Avenue and Center and Elk Streets were threatened. (Source: Sweetwater County FIS)

One method of examining the magnitude and severity of flooding in the region is to examine the damage losses and payments from the National Flood Insurance Program (NFIP). This information is not comprehensive, because it only reflects the communities which participate in the NFIP, but it is a useful overview of flood damages in the region. The information in the following table represents the composite of unincorporated and community-specific policies, claims and payments. Individual community information is found in the corresponding county annex.

Table 4.31. NFIP Claims and Payments 1978 - 2016

County	Policies	Claims	Total Paid Claims	Payments
Lincoln	37	7	5	$36,200.51
Sweetwater	132	21	6	$893,648.62
Uinta	81	5	1	$10,132.57
Total	250	33	12	$939,981.70

Source: FEMA Policy and Claim Statistics http://www.fema.gov/policy-claim-statistics-flood-insurance

The potential magnitude for a flood event in Region 4 is estimated to be limited. An event of limited magnitude would result in some injuries, a complete shutdown of critical facilities for over a week, and damages to more than 10% of the planning area. This is consistent with the flood event history in the Region. The flood history indicates that damaging floods have occurred consistently in Region 4. On average, a flood occurs every 2.5 to 10 years somewhere in the Region. There has, unfortunately, been a loss of one life in the Region due to flooding.

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Vulnerability Assessment

Population

Vulnerable populations in Region 4 include residents living in known flooding areas or near areas vulnerable to flash floods. Certain populations are particularly vulnerable. This may include the elderly and very young; those living in long-term care facilities; mobile homes; hospitals; low-income housing areas; temporary shelters; people who do not speak English well; tourists and visitors; and those with developmental, physical, or sensory disabilities. These populations may be more vulnerable to flooding due to limitations of movement, fiscal income, challenges in receiving and understanding warnings, or unfamiliarity with surroundings.

As part of this plan's preparation, an estimate of the population exposed to flooding was created using a GIS overlay of existing DFIRMs on potentially flooded parcels. The flood-impacted population for each county in the region was then calculated by taking the number of residential units in the 100-year and 500-year floodplains and multiplying that number by the average household size based on the Census Bureau's estimate for the county. The average household factor was 2.75 in Lincoln County, 2.63 in Sweetwater County, and 2.75 in Uinta County. The results are displayed below.

Table 4.32. Vulnerable Population in Region 4

Flood Type	Total Building Count	Population Estimate
1% Annual Chance	1,497	3,176
0.2% Annual Chance	108	278
Total flood	1,605	3,454

Property and Economic Losses

GIS analysis was used to estimate Region 4's potential property and economic losses. The four county parcel layers were used as the basis for the inventory of developed parcels. In some cases, there are parcels in multiple flood zones, such as Zone A and X 500. GIS was used to create a centroid, or point, representing the center of each parcel polygon, which was overlaid on the floodplain layer. The centroid was placed over the existing structure within the parcel. In most cases, the building footprint spatial file was utilized to determine where the structure was located; in other cases, the aerial imagery was utilized. For the purposes of this analysis, the flood zone that intersected the centroid was assigned as the flood zone for the entire parcel. Another assumption with this model is that every parcel with an improved value greater than zero was assumed to be developed in some way. Only improved parcels, and the value of those improvements, were analyzed and aggregated by property type and flood zone. The parcels were segregated and analyzed for each county in the region, unincorporated only, along with the incorporated cities. The summarized results for the Region are shown below. The summarized results for each community are shown in the tables and maps provided within each County Annex.

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Table 4.33 shows the count and improved value of parcels in the region, broken out by each county, that fall in a floodplain, by 100yr. flood, 500yr. flood, and total flood (100yr. and 500yr. floods combined). The table also shows Loss Estimate values which are calculated based upon the improved value and estimated contents value. The estimated contents value is 50% of the improved value; the total value is the sum of the improved and estimated contents values; the loss estimate is 20% of the total value 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).

Table 4.33. Floodplain Building Exposure in Region 4

Jurisdiction	Flood Type	Building Count	Improved Value	Estimated Contents Value	Total Exposure	Potential Loss
Lincoln	1% Annual Chance	305	$31,585,449	$18,073,225	$49,658,674	$12,414,669
	0.2% Annual Chance	12	$2,154,696	$1,344,191	$3,498,887	$874,722
Sweetwater	1% Annual Chance	740	$124,791,999	$102,024,020	$226,816,019	$56,704,005
Uinta	1%Annual Chance	452	$65,227,652	$37,022,178	$102,249,830	$25,562,458
	0.2% Annual Chance	96	$9,057,350	$5,684,263	$14,741,613	$3,685,403
Total	**1% Annual Chance**	**1,497**	**$221,605,100**	**$157,119,423**	**$378,724,523**	**$94,681,132**
	0.2% Annual Chance	**108**	**$11,212,046**	**$7,028,454**	**$18,240,500**	**$4,560,125**

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Based on this analysis, the Region 4 planning area has significant assets at risk to the 100-year and greater floods. There are 1,497 improved parcels within the 100-year floodplain for a total value of $221,605,100. There are 108 improved parcels within the 500-year floodplain for a total value of $11,212,046. Overall, Region 4 counties potentially face over $99 million in losses from flooding; approximately $94.7 million of that is based on damage estimates from the 1% annual chance flood, with the remaining $4.5 million in damages resulting from the 0.2% annual chance flood.

HAZUS-MH Flood Loss Estimation

HAZUS, FEMA's loss-estimation software program, was also used to calculate potential losses from flooding in Region 4. Ultimately, the DFIRM analysis above was used for this plan where available, as DFIRM results tend to be more accurate than HAZUS. However, HAZUS is able to

capture certain economic losses that DFIRM cannot. Therefore, the subject still merits discussion for the purposes of this plan.

Planning level flood loss estimates were made available for every county in Wyoming starting 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 Lincoln, Sweetwater and Uinta Counties, 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. There could also be errors and inadequacies associated with the hydrologic and hydraulic modeling of the HAZUS-MH model. 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 DFIRMs could be used in the future to refine and improve the accuracy of the results.

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Reports, Maps and Results

A series of maps and analysis results were compiled for each county in Region 4 by the State of Wyoming, which are summarized here. More detailed information and community maps are provided in each County's Annex. Building and contents value loss estimates, income-related loss estimates, and displaced population and shelter needs estimates are included in Table 4.34: HAZUS Flood Loss by County. These loss estimates have been grouped by county to demonstrate how the risk varies across the region. 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 4.34. HAZUS Flood Loss by County

	Bldg. Loss ($K)	Contents Loss ($K)	Inventory Loss ($K)	Reloca-tion Loss ($K)	Capital Related Loss ($K)	Wages Loss ($K)	Rental Income Loss ($K)	Total Loss ($K)	# of Displaced People	# of People Needing Short Term Shelter
Lincoln	6,465	10,130	564	10	27	136	6	17,338	603	92
Sweetwater	65,079	96,836	7,841	190	251	918	109	171,224	2,230	1,550
Uinta	13,764	14,895	624	59	63	139	20	29,564	1,439	922
TOTAL	**85,308**	**121,861**	**9,029**	**259**	**341**	**1,193**	**135**	**218,126**	**4,272**	**2,564**

Table 4.35. HAZUS Additional Analysis

	2009 Popu-lation*	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 ($)
Lincoln	16,995	1,704,435	6,465	1,029,590	0.6%	10,130	674,845	1.5%	17,338	1,020
Sweetwater	41,226	4,124,615	65,079	2,472,401	2.6%	96,836	1,652,214	5.9%	171,224	4,153
Uinta	20,927	1,996,588	13,764	1,198,394	1.1%	14,895	798,194	1.9%	29,564	1,413
TOTAL	**79,148**	**7,825,638**	**85,308**	**4,700,385**	**1.81%**	**121,861**	**3,125,253**	**3.9%**	**21,8126**	**2,756**

According to the HAZUS model output, the counties in Region 4 would suffer a total of $218,126,000 in total direct economic loss to buildings and 2,756 people would be displaced in the event of a region wide 100-year flood. There would be a total of 706 damaged buildings, 231 of which would be substantially damaged (>50% damaged).

According to statistics from the National Flood Insurance Program (http://www.fema.gov/policy-claim-statistics-flood-insurance/policy-claim-statistics-flood-insurance/policy-claim-13) there have been a total of 33 flood insurance claims filed between 1/1/1978 and 5/11/2016. The total of the payments made on these claims is $939,981.70. As of 4/30/2016, there were 250 flood insurance policies in force in the Region for a total coverage of $47,861,700. More details on the National Flood Insurance Program can be found within specific county annexes.

According to Mr. Kim Johnson, State of Wyoming National Flood Insurance Program Coordinator, there are no repetitive loss structures in the Region. These are defined as an NFIP-

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insured structure that has had at least two paid flood losses of more than $1,000 each in any 10-year period since 1978.

None of the communities in the Region are currently enrolled in the National Flood Insurance Program's (NFIP) Community Rating System (CRS). This is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions.

Critical Facilities and Community Assets

GIS analysis of flood hazards in Region 4 indicates that there are 161 critical facilities and/or community assets that are potentially exposed to flood hazards. There are 160 facilities in the 100-year floodplain and one in the 500-year floodplain. The following tables summarize the facilities that are potentially at risk.

Table 4.36. Critical Facilities within 1% Chance FEMA/HAZUS

County	Facility Type	Facility Count
Lincoln	Bridge	28
	Communications	7
	Total	**35**
Sweetwater	Bridge	49
	Communications	6
	Day Care Center	2
	HAZMAT	4
	Public School	1
	Total	**62**
Uinta	Bridge	59
	Day Care Center	2
	Scour Critical Bridge	2
	Total	**63**
	Grand Total	**160**

Table 4.37. Critical Facilities within 0.2% Chance FEMA

County	Facility Type	Facility Count
Uinta	Bridge	1
	Total	**1**

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Natural, Historic, and Cultural Resources

Natural resources are generally resistant to flooding except where natural landscapes and soil compositions have been altered for human development or after periods of previous disasters such as drought and fire. Wetlands, for example, exist because of natural flooding incidents. Areas that are no longer wetlands may suffer from oversaturation of water, as will areas that are particularly impacted by drought. Areas recently suffering from wildfire damage may erode because of flooding, which can permanently alter an ecological system.

No specific natural, cultural, or historic resources were identified in either the 100-year or 500-year flood zone. However, tourism and outdoor recreation is an important part of the Region's economy. If part of the planning area were damaged by flooding, tourism and outdoor recreation could potentially suffer.

Future Development

For NFIP participating communities, floodplain management practices implemented through local floodplain management ordinances should mitigate the flood risk to new development in floodplains.

Summary

Overall, flooding presents a medium risk for the counties and communities of Region 4.

Table 4.38. Flood Hazard Risk Summary

County	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/ Severity	Overall Significance
Lincoln	Significant	Likely	Limited	Medium
Sweetwater	Significant	Likely	Limited	Medium
Uinta	Significant	Likely	Limited	Medium

Municipalities Impacted:
Unincorporated Lincoln County, Afton, Cokeville, Diamondville, Kemmerer
Unincorporated Sweetwater County, Green River, Rock Springs
Unincorporated Uinta County, Evanston, Bear River, Mountain View

4.2.8 Hail

Hazard Description

Damaging hail events occur sporadically throughout Region 4, usually associated with severe summer storms and wind events. Hailstones form when a super-cooled droplet collects a layer of ice and continues to grow, sustained by an updraft. Once the hailstone cannot be held up any

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longer by the updraft, it falls to the ground. Hail up to 1.75 inches in diameter has been reported in the Region. Hail causes more than a billion dollars of property damage nationally each year, mostly to crops, but also can decimate structural siding, take out windows, peel paint, and severely damage automobiles and equipment not protected or stored inside.

Geographical Areas Affected

Hail can strike anywhere in the Region.

Past Occurrences

Climatologically, Wyoming averages five to nine days of hail annually. A comprehensive history of damaging hailstorms historically affecting the counties in Region 4 is included in Table 4.38. The data was derived from the monthly Storm Data reports generated and released by the National Oceanic and Atmospheric Administration's National Climate Center.

The NCDC records any hail events with hailstones that are ¾ inch or larger in diameter, or any hail of a smaller diameter which causes property and/or crop damage, or casualties. According to the NCDC definition, there have been 29 hailstorms affecting the three counties in the region since 1980, recorded at 40 separate locations. No deaths or injuries have been associated with these storms in the region during this timeframe according to NCDC. Statewide, 4 injuries have been reported since 1955. One injury was to a boy seeking shelter from the storm; he ran through a glass door and severely lacerated his arm. The other three causes of injury were not recorded, though they all occurred during the storm. Nationwide, most hail-related injuries are suffered by people caught unsheltered when hail begins to fall. Most hail-related injuries are minor and go unreported.

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Table 4.39. Hail History, Region 4 (Lincoln, Sweetwater, Uinta): 1980 - 2015

Number of Events	Injuries	Fatalities	Total Recorded Property Damage	Total Recorded Crop Damage
40	0	0	$760,000	$250,000

Source: National Climactic Data Center

Table 4.40. Hail Incidents by County: 1980 - 2015

Lincoln	Sweetwater	Uinta
29	10	1

Table 4.41. Region 4 Hail History 1980 - 2015

County	Location	Date	Time	Hail Size	Deaths	Injuries	Property Damage	Crop Damage
Sweetwater		08/08/80	1940	0.75	0	0	$ -	$ -
Lincoln		08/21/83	1435	0.75	0	0	$ -	$ -
Lincoln		08/21/83	2110	1.75	0	0	$ -	$ -
Sweetwater		07/21/87	1915	0.75	0	0	$ -	$ -
Sweetwater		07/12/89	1800	0.75	0	0	$ -	$ -
Lincoln	Afton	07/12/95	900	1	0	0	$ -	$ -
Lincoln	Kemmerer	06/21/96	1740	1	0	0	$ -	$ -
Lincoln	Afton	06/05/97	1535	1	0	0	$ -	$ -
Lincoln	Thayne	06/05/97	1548	1.5	0	0	$ -	$ -
Lincoln	Bedford	07/19/97	1400	1	0	0	$ -	$ -
Sweetwater	Green River	06/21/98	1355	0.75	0	0	$ -	$ -
Lincoln	Afton	07/30/98	1925	0.75	0	0	$ -	$ -
Lincoln	Alpine	07/30/98	2010	0.75	0	0	$ -	$ -
Lincoln	Auburn	08/18/00	1515	1.25	0	0	$ -	$ -
Lincoln	Auburn	08/18/00	1520	0.75	0	0	$ -	$ -
Sweetwater	Rock Springs	07/06/01	1429	0.75	0	0	$ -	$ -
Lincoln	Kemmerer	09/13/01	1207	0.75	0	0	$ -	$ -
Lincoln	Kemmerer	09/13/01	1315	1.75	0	0	$ -	$ -
Sweetwater	Green River	07/25/03	1330	0.75	0	0	$ -	$ -
Uinta	Evanston	08/08/03	1715	0.88	0	0	$ -	$ -
Lincoln	Smoot	06/18/04	1705	1.25	0	0	$ -	$ -
Lincoln	Diamondville	06/18/04	1939	0.75	0	0	$ -	$ -
Sweetwater	Point of Rocks	06/18/04	2139	1	0	0	$ -	$ -
Sweetwater	Green River	06/20/04	1518	1	0	0	$ -	$ -
Lincoln	Fontenelle	07/23/04	1425	0.75	0	0	$ -	$ -
Lincoln	Thayne	06/14/06	855	1	0	0	$ -	$ -
Sweetwater	Rock Spgs	10/20/06	1640	0.75	0	0	$ -	$ -
Lincoln	Star Valley Ranch	08/09/08	1635	0.75	0	0	$ -	$ -
Sweetwater	Wamsutter	04/25/09	1525	1.75	0	0	$ 700,000	$ -
Lincoln	Thayne	06/06/10	1824	0.88	0	0	$ -	$ -
Lincoln	Bedford	08/15/11	1405	1.5	0	0	$ -	$ -
Lincoln	Auburn	08/15/11	1435	1	0	0	$ -	$ 250,000
Lincoln	Afton Muni Airport	08/15/11	1435	1	0	0	$ 10,000	$ -
Lincoln	Grover	08/15/11	1440	1	0	0	$ 50,000	$ -
Lincoln	Star Valley Ranch	07/06/13	1825	1	0	0	$ -	$ -
Lincoln	Afton	09/17/13	1708	0.88	0	0	$ -	$ -
Lincoln	Diamondville	08/07/14	1530	0.88	0	0	$ -	$ -

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County	Location	Date	Time	Hail Size	Deaths	Injuries	Property Damage	Crop Damage
Lincoln	Smoot	09/18/14	1811	1.5	0	0	$ -	$ -
Lincoln	Star Valley Ranch	06/15/15	1610	1.75	0	0	$ -	$ -
Lincoln	Afton	06/15/15	1855	1	0	0	$ -	$ -
				Total	**0**	**0**	**$760,000**	**$250,000**

Source: National Climactic Data Center

While most storms don't have much impact, history shows a few outliers, summarized below:

On April 25, 2009, a severe thunderstorm traveled along Interstate 80 approximately 40 miles through eastern Sweetwater County. The storm produced large hail, damaging wind, and a funnel cloud. Damage was most intense around Wamsutter, where the combination of wind and hail obliterated vinyl siding and broke windows at numerous homes and businesses. NCDC recorded $700,000 in property damage for this storm.

On August 15, 2011, severe thunderstorms over eastern Idaho moved across central and southern sections of the Star Valley. Large hail was observed in and near the communities of Afton, Bedford, Grover, and Auburn. Homes, vehicles, and crops were damaged as the storms rolled east across the valley. Approximately 600 acres of mature grain crop near Auburn were severely damaged by one inch diameter hail; damage was recorded at $250,000.

Likelihood of Future Occurrence

Since 1996, the three counties in Region 4 have experienced at least one hail event per year somewhere within the boundaries of the region with hail diameter greater than .75 inches. If this trend continues, it is reasonable to expect the region to suffer a severe hail incident annually. Each county can expect a severe hail incident at least every three years.

Based on historical data, an average hail event in the Region occurs in between June and August, somewhere between 12 p.m. and 5 p.m. It drops hail with a diameter between zero and two inches. While most historical hail storms in the Region don't result in major damage, recordable damage to property and crops could be in the hundreds of thousands of dollars. Insured loss related to hail storms could be in the millions, depending on the location and parameters of the storm.

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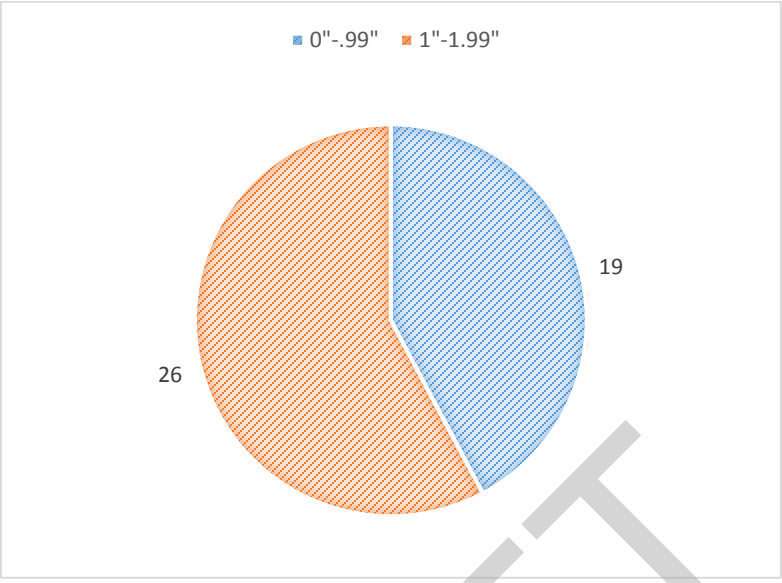
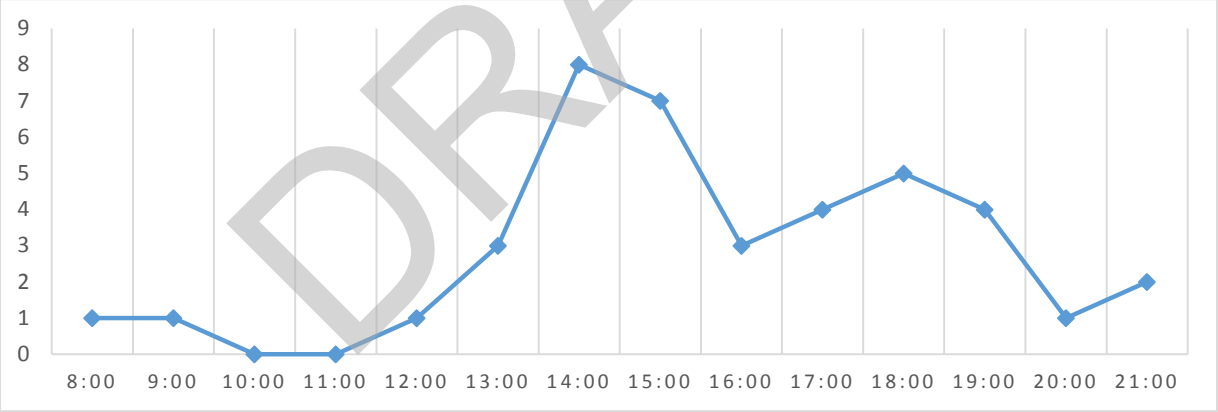
Figure 4.23. Hail Incidents by Diameter in Region 4: 1980 - 2015



Source: National Climactic Data Center

Figure 4.24. Time of Day Hail Events in Region 4 1980 - 2015



Source: National Climactic Data Center

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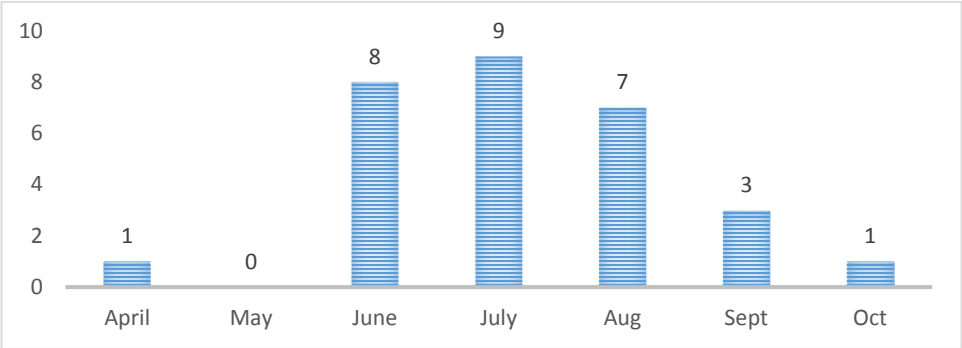
Figure 4.25. Hail Events by Month of Occurrence in Region 4: 1980 - 2015



Source: National Climactic Data Center

Potential Magnitude

Most public and personal property damage from hail is insured under private property insurance or crop insurance policies, serviced by multiple insurance providers; it is very difficult to get a true cumulative estimate of damage costs caused by hail events. Data collection regarding dollar damage to public and personal property holds significant gaps for this reason. There have been no FEMA disaster or state declarations for the counties in the Region related to damaging hail, and no USDA disaster declarations as a result of hail damage were found. Agricultural losses and claims met by crop insurance carriers due to hail damage are difficult to determine.

The incident of record occurred near Wamsutter in Sweetwater County. Hail up to 1.75 inches in diameter caused $700,000 in damages to vinyl siding and windows at numerous homes and businesses.

Vulnerability Assessment

In general, all crops, buildings, and vehicles in the Region are to some degree vulnerable to hail damage. The essential functions of critical facilities are not likely to be impacted by hail. Risk is uniform across the entire population of the Region. Livestock can be exposed as well. Hail is a geographically isolated event that affects only several square miles at any one time. In terms of property losses, the actual damages will depend on the housing density and density of automobiles in the impacted area. This is highly variable across the Region. In terms of crop losses, the actual damages that occur will depend on the type of crop and the growth stage of the plants when the hail occurs. A hailstorm in a rural area in the early spring when the plants are just emerging will have much less of an impact than a storm of the same intensity occurring later in the growing season when the plants are more susceptible to damage and when there is no time to replant if the crop is a total loss. Historically, hail storms have presented the largest threat to citizens and property between the months of June and August, between two and three p.m. Average hail diameter is an inch. Most damage caused by the storms is covered by insurance. Based on historical data, the counties in Region 4 can expect a hail event annually.

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Future Development

Hail can strike anywhere in the county, so any growth or new development in Lincoln, Sweetwater or Uinta counties will increase exposure to hail damage. Insurance will be an important tool to offset the potentially substantial dollar losses associated with hail.

Summary

The counties in Region 4 will continue to experience hail on an annual basis. Hail damage to property is expected to be highest in the municipalities; much of the damage to both property and crops is covered under insurance policies.

Table 4.42. Hail Hazard Risk Summary

	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Lincoln	Limited	Likely	Negligible	Low
Uinta	Limited	Likely	Negligible	Low
Sweetwater	Limited	Likely	Negligible	Low

4.2.9 Hazardous Materials

Hazard Description

Generally, a hazardous material is a substance or combination of substances which, because of 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. Hazardous material incidents can occur while a hazardous substance is stored at a fixed facility, or while the substance is being transported.

The U.S. Department of Transportation, U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) all have responsibilities in regards to hazardous materials and waste.

The U.S. Department of Transportation has identified the following classes of hazardous materials:

- Explosives
- Compressed gases: flammable, non-flammable compressed, poisonous
- Flammable liquids: flammable (flashpoint below 141 degrees Fahrenheit) combustible (flashpoint from 141 - 200 degrees)
- Flammable solids: spontaneously combustible, dangerous when wet
- Oxidizers and organic peroxides
- Toxic materials: poisonous material, infectious agents

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- Radioactive material
- Corrosive material: destruction of human skin, corrodes steel

Region 4 is home to several gas plants, refineries and mines, and numerous pipelines and rail lines run across the Region, specifically along I-80, creating a likely potential for hazardous materials releases.

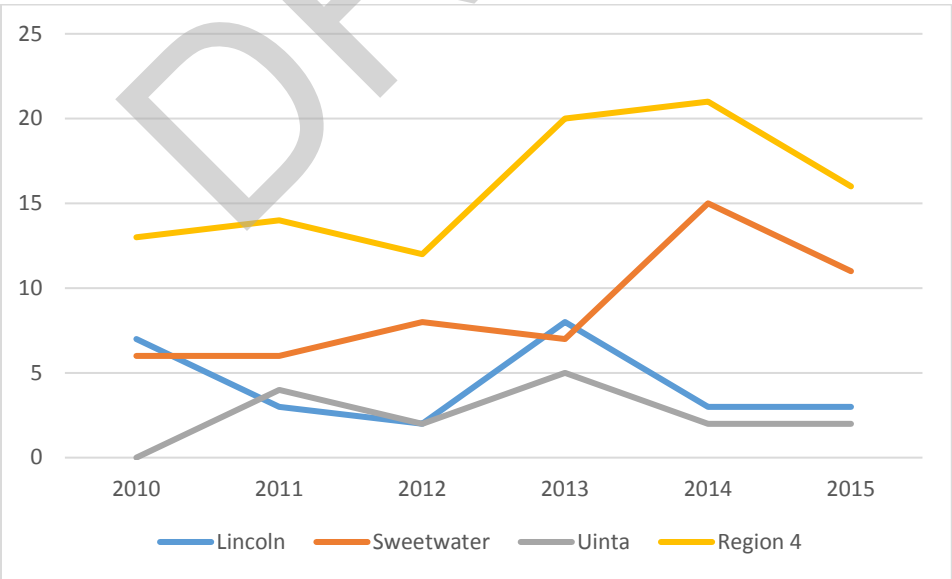
Geographical Areas Affected

Hazmat incidents can occur at fixed facilities, or during transportation. Hazardous materials facilities are identified and mapped by the counties they reside in, along with the types of materials stored there. Transportation routes include roads and rails, including along Interstate 80 in Sweetwater and Uinta Counties, and Highways 30 and 89 in Lincoln County. Some facilities contain extremely hazardous substances; these facilities are required to generate Risk Management Plans (RMPs), and resubmit these plans every five years. RMP facility information can be found within individual county annexes.

Past Occurrences

There are a variety of mechanisms to get an idea of the number and types of historical hazardous materials spills in the Region. One such repository is the catalog of hazardous materials spill and accident reports at the National Response Center (NRC) as part of the Right to Know Network (RTK NET). The table below shows a five-year record for reported incidents in the three counties of Region 4.

Figure 4.26. Hazardous Materials Spills Reported to the NRC in Region 4: 2010 - 2015



Source: http://www.rtknet.org/db/erns

According to the data, during the time period between 2010 and 2015 the Region saw anywhere from 12-21 NRC-reported incidents per year, which means that each county can reasonable expect

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multiple hazardous materials responses annually. The county data is further broken down in the table below:

Table 4.43. NRC-reported Incidents by county: 2010 - 2015

	2010	2011	2012	2013	2014	2015	6-Year Total
Lincoln	7	3	2	8	3	3	**26**
Sweetwater	6	6	8	7	15	11	**53**
Uinta	0	4	2	5	2	2	**15**
Region 4 Total	13	14	12	20	21	16	**96**

Source: http://www.rtknet.org/db/erns

According the NRC site, the incident types with the highest rates of reports included fixed-site incidents, pipeline incidents, railroad incidents and mobile incidents.

In addition to local first responders, eight Regional Emergency Response Teams across the State of Wyoming respond to a variety of incidents, including those incidents involving hazardous materials. The Region 4 RERT is located in Rock Springs, in Sweetwater County. The following table shows records of Region 4 RERT mission assignments pertaining to hazardous materials releases, according the 2016 Wyoming State Hazard Mitigation Plan.

Table 4.44. Region 4 RERT Mission Assignments: 2004 - 2015

Type	Number
Fixed Facility	6
Truck/Highway	5
Rail	2
Pipeline	-
Aircraft	-
Orphan Drum	1
Total	**13**

Source: 2016 Wyoming State Hazard Mitigation Plan

According to the HMPCs, small-level hazardous materials incidents occur frequently throughout the year in Region 4. During discussions, the committees noted roads, rail and pipelines throughout the county. The groups noted that Interstate 80 is a heavily trafficked hazardous materials route, and a specific vulnerability for transportation-related hazmat releases.

The Uinta County planning team noted multiple fuel/diesel spills in the county, a train derailment in 2015 and a beer truck accident as examples of recent incidents. May 1997 Near the Wyoming Port of Entry Pioneer Pipeline had a unleaded gas leak in an 8 inch Metal pipeline with over 1200 psi about 1500 barrels was released and drained to a creek that ran into Bear River. There were no fires, injuries or evacuations but oil booms and dams were deployed to catch as much product as possible. Pioneer had to monitor water and soil for years after the spill.

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Likelihood of Future Occurrence

Each county in the Region experience multiple hazardous materials incidents each year, with various degrees of impact. Hazardous material spills and releases, both from fixed facilities and during transport, will continue to occur in each county in Region 4 annually.

Potential Magnitude of Impacts

Impacts that could occur from hazardous waste spills or releases include:

- Injury
- Loss of life (human, livestock, fish and wildlife)
- Evacuations
- Property damage
- Air pollution
- Surface or ground water pollution/contamination
- Interruption of commerce and transportation

Numerous factors go into the ultimate impacts of a hazardous materials release, including method of release, the type of material, location of release, weather conditions, and time of day. This makes it difficult to nail down precise impacts. Materials found in Region 4 will have at least one of the impacts listed above, and probably more.

Vulnerability Assessment

The counties in Region 4 have energy pipelines, railroad tracks which carry many types of hazardous materials, state highways and an Interstate Highway (I-80) running through Sweetwater and Uinta counties. A variety of hazardous materials originating in the Region or elsewhere are transported along these routes, and could be vulnerable to accidental spills.

Some facilities contain extremely hazardous substances; these facilities are required to generate Risk Management Plans (RMPs), and resubmit these plans every five years. There are 88 RMP facilities located in the three counties in Region 4, as noted in the table below.

Table 4.45. RMP Facilities in Region 4

County	Community	Number of Facilities
Lincoln	Kemmerer	6
	La Barge	1
	Opal	3
Sweetwater	Bairoil	1
	Granger	2
	Green River	4
	Rock Springs	7
	Wamsutter	3
Uinta	Evanston	10
	Lyman	1
	Total	**38**

Source: http://www.rtknet.org/db/erns

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Potential losses can vary greatly for hazardous material incidents. For even a small incident, there are cleanup and disposal costs. In a larger scale incident, cleanup can be extensive and protracted. There can be deaths or injuries requiring doctor's visits and hospitalization, disabling chronic injuries, soil and water contamination can occur, necessitating costly remediation. Evacuations can disrupt home and business activities. Large-scale incidents can easily reach $1 million or more in direct damages.

Future Development

Stationary facilities with hazardous materials are identified and mapped. Transportation routes are also identified. Special care should be taken to cross-reference any new development areas with identified sources for potential hazardous materials incidents. If an uptick in oil and gas development and extraction occurs, this could result in greater exposure for transportation incidents.

Summary

Overall, hazardous materials are a medium significance hazard to counties in the Region, though Sweetwater has more risk than Lincoln or Uinta counties.

Table 4.46. Hazardous Material Hazard Risk Summary

County	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Lincoln	Significant	Highly Likely	Limited	Medium
Uinta	Significant	Highly Likely	Limited	Medium
Sweetwater	Significant	Highly Likely	Limited	High

4.2.10 High Winds and Downbursts

Hazard Description

Wind, because of its constant presence in Wyoming, can be overlooked as a hazard. Upon analysis, wind can be a damage-inducing hazard and warrants review in Region 4. Wyoming's wind is also becoming an economic factor as renewable wind energy is developed around the state.

This profile examines the hazard that high winds present including downbursts, a subcategory of high winds. A downburst is a strong down draft which causes damaging winds on or near the ground. Downbursts are much more frequent than tornadoes, and for every one tornado there are approximately 10 downburst damage reports. Downbursts can be associated with either a heavy precipitation or non-precipitation thunderstorm (dry or wet downbursts), and often occur in the dissipating stage of a thunderstorm. Microbursts and macrobursts are categories of downbursts, classified by length of duration, velocity of wind, and radius of impact.

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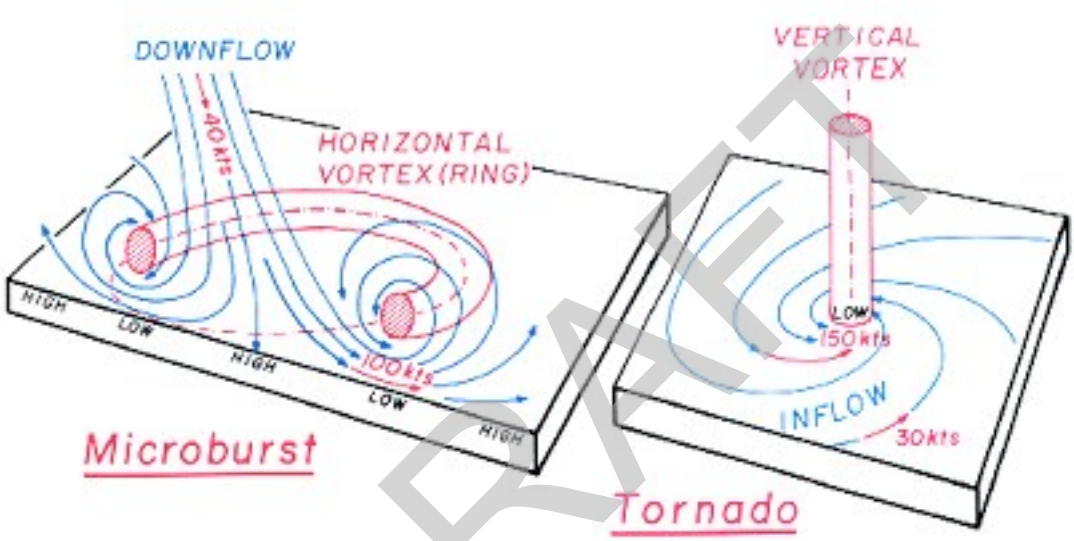
Microbursts generally last between five and 15 minutes, and impact an area less than three miles wide. Macrobursts can last up to 30 minutes with winds up to 130 miles per hour, and can impact areas larger than three miles in radius. Microbursts and macrobursts may induce dangerous wind shears, which can adversely affect aircraft performance, cause property damage and loss of life.

A downburst can occur when cold air begins to descend from the middle and upper levels of a thunderstorm (falling at speeds of less than 20 miles an hour). As the colder air strikes the Earth's surface, it begins to 'roll' outward. As this rolling effect happens, the air expands causing further cooling and having the effect of pulling the shaft of air above it at higher and higher speeds.

Figure 4.27. Schema of Microburst and Tornado



Source: www.erh.noaa.gov

Downbursts can be mistaken for tornadoes by those that experience them since damages and event characteristics are similar. Tornado winds can range from 40 mph to over 300 mph. Downbursts can exceed winds of 165 mph and can be accompanied by a loud roaring sound. Both downbursts and tornadoes can flatten trees, cause damage to homes and upend vehicles. In some instances, aerial surveying is the best method to determine what kind of event has taken place.

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Figure 4.28. Aerial Image of Downburst Damage

Source: T. Fujita

In this photograph, trees are blown down in a straight line - a very strong indication of a downburst as opposed to a tornado.

Geographical Areas Affected

All areas in the Region suffer the effects of high winds.

Past Occurrences

In the counties in Region 4, most documented wind events causing damage typically range between 55 and 70 mph; max wind speeds of up to 100 mph have been recorded. It should be noted that the data is limited by what the NCDC is able to record, and what equipment was in place at the time, and that the timespan of available records for each county differs. The HMPCs noted that wind is a consistent issue in the three counties.

Table 4.47. Summary of Wind Weather Events and Impacts

Total Number of High Wind Events	Total Property Damage	Total Fatalities	Total Injuries	Average Recorded Max Wind Speed
118	$474,000	0	39	65 mph
Lincoln County (1973-2015)				
24	$366,000	0	28	64 mph
Sweetwater County (1957-2015)				

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78	$58,000	0	11	64 mph
Uinta County (1989-2014)				
16	$50,000	0	0	66 mph

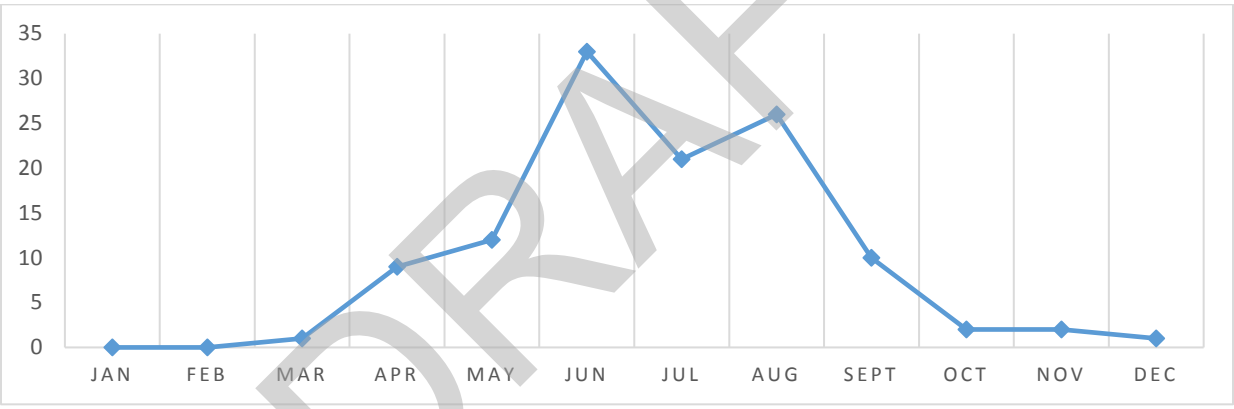
Source: NCDC

NCDC also records wind damage on a zonal basis; while these zones show up in search results, they are not always tied to specific counties. NCDC records an additional 244 wind incidents from 1957 to 2015 in these zones.

Likelihood of Future Occurrence

NCDC records 118 confirmed and documented high wind incidents specifically impacting the Region since 1957. This means that the region can expect multiple high wind incidents each year; each of the county HMPCs noted that the high wind data did not represent all high wind incidents in the region.

Figure 4.29. High Wind Events by Month in Region 4: 1957 - 2015



Source: NCDC

The Region experiences an average of two significant high wind events per year somewhere in the three counties, with a damaging event being recorded by NCDC approximately once every 4.5 years. Based on NCDC data, incidence of events appears to spike between May and September.

Specific examples from high wind incidents that caused damages or casualties include:

Rock Springs, Sweetwater County, August 2000 – A large tent at the county fairgrounds was blown over by high wind, causing minor injuries.

Rock Springs, Sweetwater County, March 2013 – High wind gusts knocked over a tree, causing it to fall and crush a police car underneath it.

Afton, Lincoln County, 1993 – A massive wind and rainstorm struck the fairgrounds, blowing over two tents and shredding a third. Up to 28 people received minor injuries.

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Lincoln County, June 2010 – A severe thunderstorm caused extensive tree damage near Star Valley. Several hundred trees were downed on hillsides bordering a forest service road in Willow Creek Canyon east of Turnerville. The trees completely blocked passage of vehicles and individuals to the area.

Potential Magnitude

The incident of record in Region 4 occurred on June 6, 2010 near Turnerville, Lincoln County. The incident caused $350,000 worth of damage to several hundred trees on hillsides bordering a forest service road in Will Creek Canyon, blocking passage of vehicles and individuals to the area.

An average recorded damaging wind-related incident causes a little over $36,000 in damage.

Vulnerability Assessment

Vulnerability as it relates to location is random, as damaging winds have occurred everywhere in the Region. Damage from high winds is often described in regional or broad areas, but downburst damage will impact a small area most generally less than three miles in diameter. Because state or presidential emergency or disaster declarations have not been necessary in the aftermath of wind events in the Region, and because damage to personal property is dealt with by numerous private insurance companies, it is difficult to estimate actual monetary impacts that have occurred due to damaging winds. NCDC has no record of damage to crops in the Region due to wind.

Specific vulnerabilities from high wind events include damage to poorly constructed buildings, building collapse and damage, flying debris, semi rollovers and car accidents, and downed power lines and electric system damage. Cascading hazards caused by high winds can include power loss; depending on the time of year, winds can also exacerbate snow and blizzards by creating deep snow drifts over roads and affecting the normal flow of traffic. Damages recorded by the NCDC for the county include downed power lines, torn off roofs and building damage, and downed tree limbs and debris.

According to the Spatial Hazards and Losses Database for the United States (SHELDUS) and the 2014 Wyoming Hazard Mitigation Plan, Region 4 suffered 82 damage causing wind events between 1960 and 2012, and a cumulative $522,633 in damage as a result of these events ($10,050/event average).

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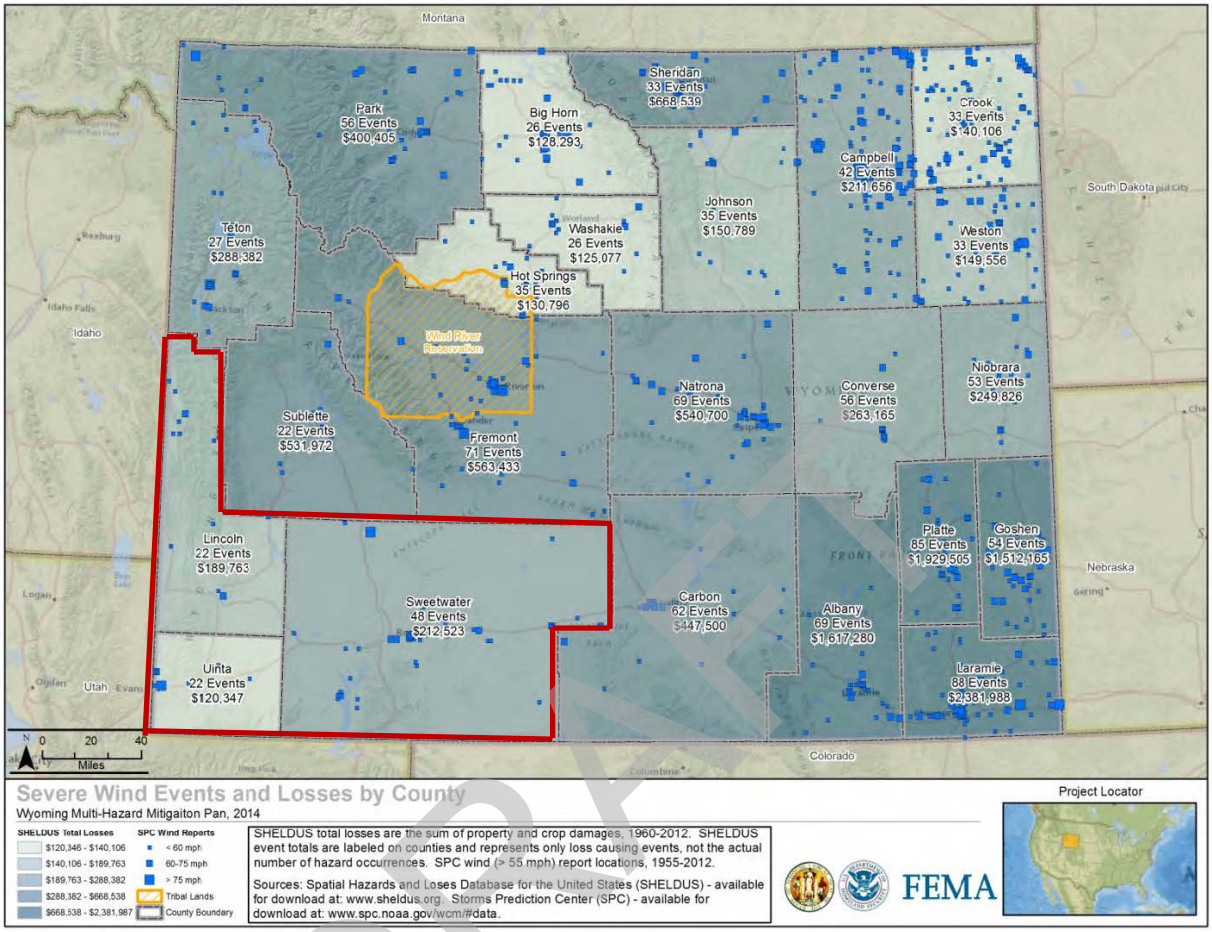
Figure 4.30 Wind Events and Losses, Wyoming 1960 – 2012



Source: Wyoming Multi Hazard Mitigation Plan, 2016

Future Development

Historical data demonstrates that the most critical area of the state for high wind hazards is the eastern one third, excluding the counties of Region 4. According to the Wyoming Hazard Mitigation Plan, each county in Region 4 administers their own building codes. The Emergency Management coordinator of Uinta County noted that the county does not have an enforceable building code; however the Uinta County Planning and Zoning Office does however recommend that buildings be built to withstand winds up to 90 mph and snow loads up to 40 lbs/sq ft.

Summary

The counties of Region 4 has a history occasional damaging wind events that average $36,000 per incident. Primary damage is structural and to power utilities, which can lead to cascading impacts. Although minimal deaths and injuries have been reported, the frequency of occurrence is due

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consideration, as well as the hazard to rural citizens and town populations from falling trees, power poles, and flying debris. Cumulative losses due to wind damage have been negligible.

Table 4.48. Hazard Risk Summary Table

	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Lincoln	Limited	Likely	Negligible	Low
Uinta	Limited	Likely	Negligible	Low
Sweetwater	Limited	Likely	Negligible	Low

4.2.11 Landslide/Rockfall/Debris Flow

Hazard Description

A landslide is a general term for a variety of mass movement processes that generate a downslope movement of soil, rock, and vegetation under gravitational influence. Landslides are a serious geologic hazard common to almost every state in the United States. It is estimated that nationally they cause up to $2 billion in damages and from 25 to 50 deaths annually. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly. Gravity is the force driving landslide movement. Factors that allow the force of gravity to overcome the resistance of earth material to landslide include: saturation by water, erosion or construction, alternate freezing or thawing, earthquake shaking, and volcanic eruptions.

Landslides are typically associated with periods of heavy rainfall or rapid snow melt and tend to worsen the effects of flooding that often accompanies these events. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Generally significant landsliding follows periods of above-average precipitation over an extended period, followed by several days of intense rainfall. It is on these days of intense rainfall that slides are most likely.

Areas that are generally prone to landslide hazards include existing old landslides; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used. Landslides are often a secondary hazard related to other natural disasters. Landslide triggering rainstorms often produce damaging floods. Earthquakes often induce landslides that can cause additional damage.

Slope failures typically damage or destroy portions of roads and railroads, sewer and water lines, homes and public buildings, and other utility lines. Even small-scale landslides are expensive due to clean up costs that may include debris clearance from streets, drains, streams and reservoirs; new or renewed support for road and rail embankments and slopes; minor vehicle and building damage; personal injury; and livestock, timber, crop and fencing losses and damaged utility systems.

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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 4.29 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.

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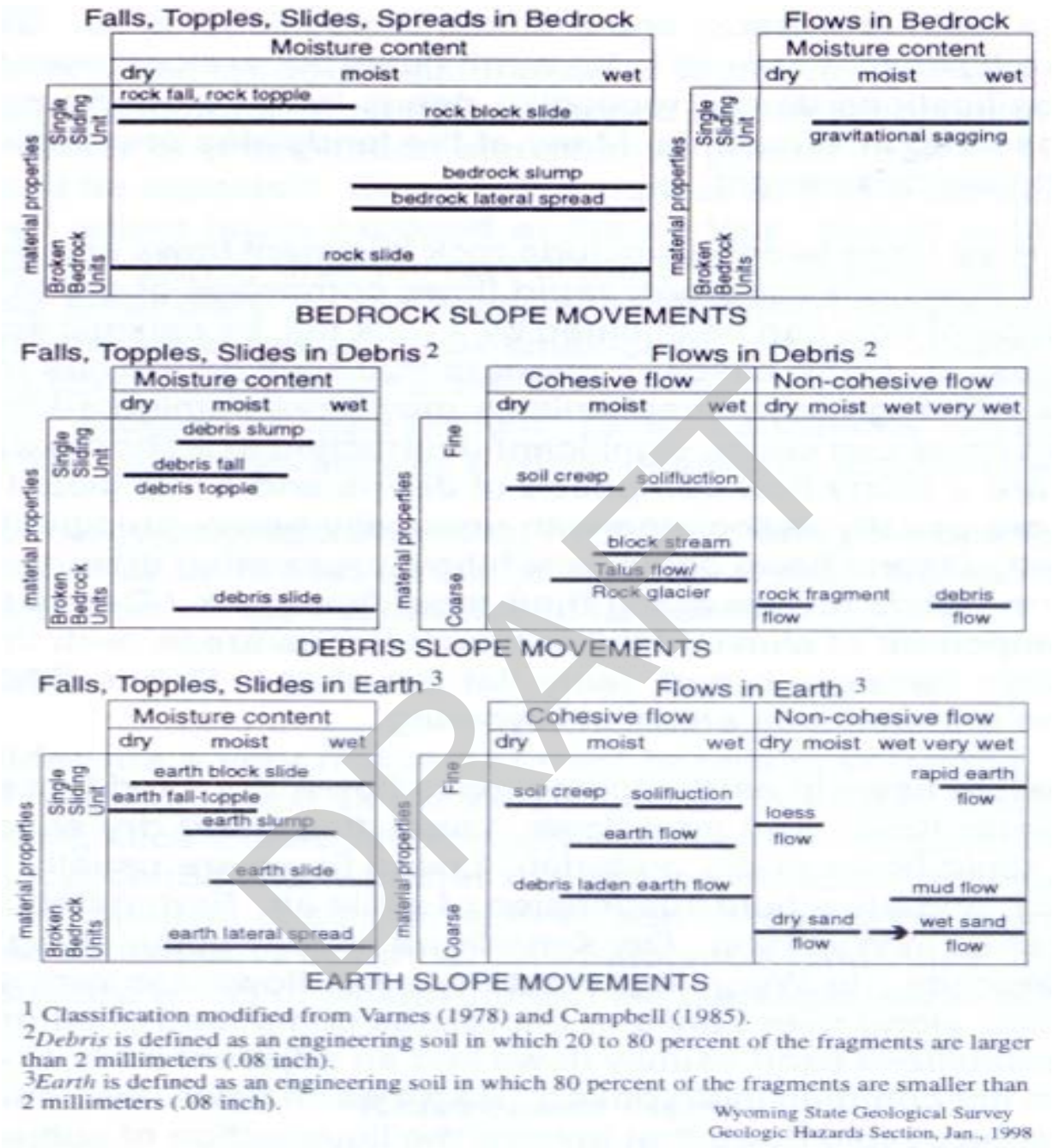
Figure 4.31. Wyoming Landslide Classifications



Rockfall

A rockfall is the falling of a detached mass of rock from a cliff or down a very steep slope. Weathering and decomposition of geological materials produce conditions favorable to rockfalls. Rockfalls are caused by the loss of support from underneath through erosion or triggered by ice wedging, root growth, or ground shaking. Changes to an area or slope such as cutting and filling activities can also increase the risk of a rockfall. Rocks in a rockfall can be of any dimension, from

the size of baseballs to houses. Rockfall occurs most frequently in mountains or other steep areas during the early spring when there is abundant moisture and repeated freezing and thawing. Rockfalls are a serious geological hazard that can threaten human life, impact transportation corridors and communication systems and result in other property damage.

Spring is typically the landslide/rockfall season in Wyoming as snow melts and saturates soils and temperatures enter into freeze/thaw cycles. Rockfall and landslides are influenced by seasonal patterns, precipitation and temperature patterns. Earthquakes could trigger rockfalls and landslides too.

Debris Flow

Debris flows, sometimes referred to as mudslides, mudflows, lahars, or debris avalanches, are common types of fast-moving landslides. They are a combination of fast moving water and a great volume of sediment and debris that surges down slope with tremendous force. These flows generally occur during periods of intense rainfall or rapid snowmelt and may occur with little onset warning, similar to a flash flood. They usually start on steep hillsides as shallow landslides that liquefy and accelerate to speeds that are typically about 10 miles per hour, but can exceed 35 miles per hour. Figure 4.30 describes identifying characteristics of debris flows. The consistency of debris flow ranges from watery mud to thick, rocky mud that can carry large items such as boulders, trees, and cars. Debris flows from many different sources can combine in channels, and their destructive power may be greatly increased. When the flows reach flatter ground, the debris spreads over a broad area, sometimes accumulating in thick deposits that can wreak havoc in developed areas. Mudflows are covered under the National Flood Insurance Program; however, landslides are not.

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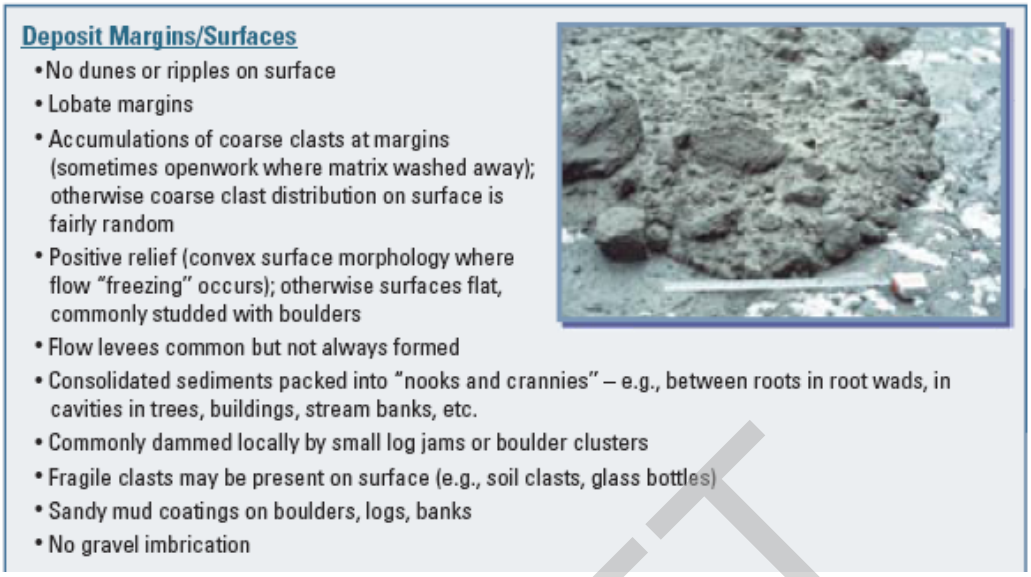
Figure 4.32. Field Evidence of Debris Flow



Geographical Area Affected

Landslides are one of the most common geologic hazards in Wyoming, with some of the highest landslide densities found in Region 4 counties notably Lincoln County. The figure below shows in Wyoming. Note the relatively high concentration of landslide deposits in Lincoln County and northwestern Wyoming in general. Many of these slide areas have been studied by the Wyoming Geological Survey, WYDOT and others.

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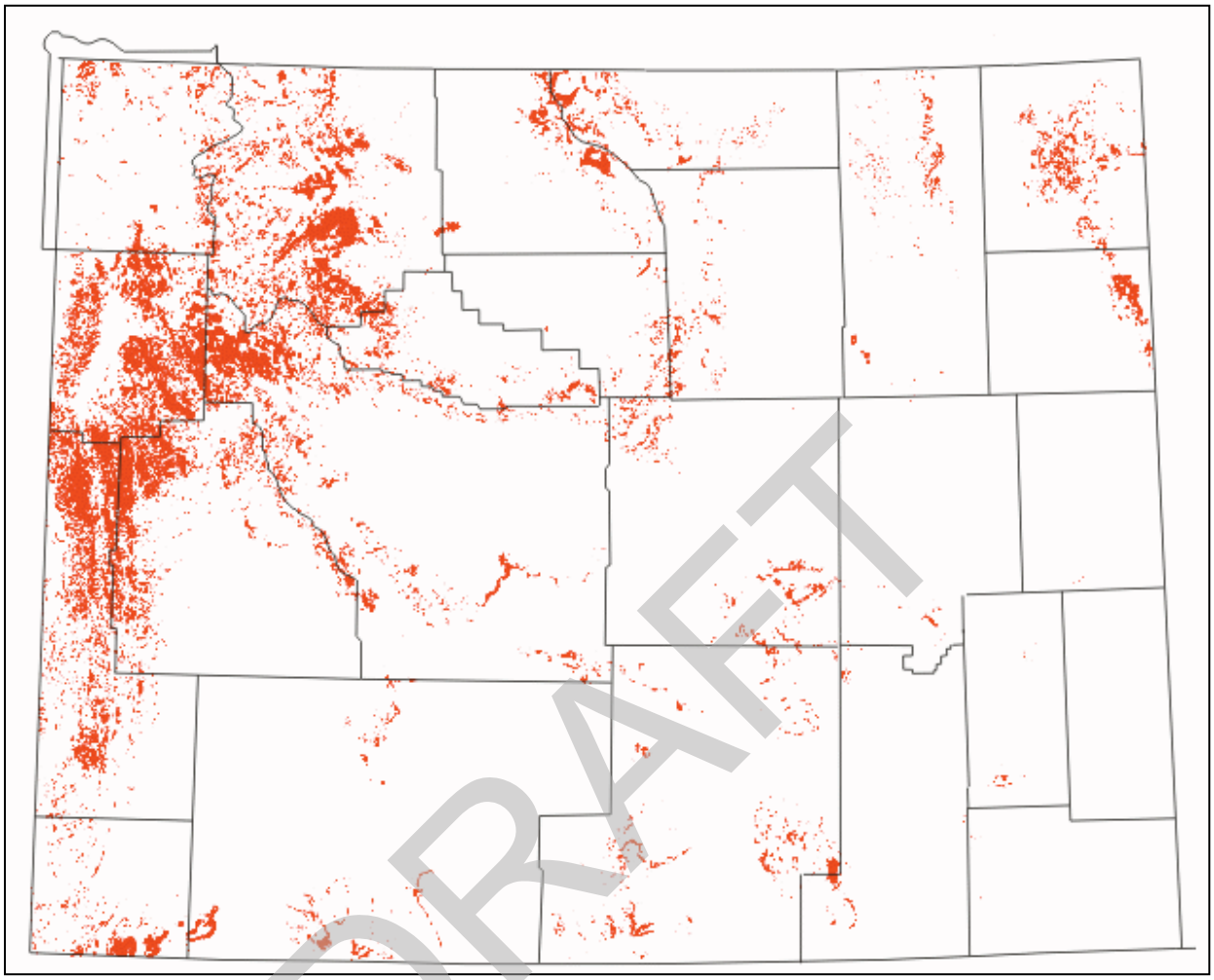
Figure 4.33. Landslide History in Wyoming



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Past Occurrences

Since landslides, debris flows, and rockfalls occur regularly in Wyoming, previous occurrences are limited to those that caused a particular high amount of damage or incurred some other cost or unique impact. Selected incidents that occurred in or near the planning area are profiled below.

On July 22, 2011, President Obama declared a major disaster for the State of Wyoming for emergency work and the repair or replacement of facilities damaged by the severe storms, flooding, and landslides in Albany, Big Horn, Carbon, Crook, Fremont, Goshen, Johnson, Lincoln, Platte, Sheridan, Sublette, Teton, Uinta, Washakie, and Weston Counties, and the Wind River Indian Reservation. This declaration made Public Assistance funding available.

Past landslides are present on 84 quadrangles in the county and are visually evident in many locations around the county. The analysis of landslide risk for each quadrangle is on file in the

Lincoln County Office of Homeland Security and Emergency Preparedness. A large landslide occurred over Highway 89 in the area known as the Narrows in Star Valley in the 1980's. The highway department quickly constructed a short bypass around the slide area so that traffic could resume.

Also in the mid-1980s, a slump/flow complex destabilized at Fossil Butte National Monument in Lincoln County. The landslide moved downslope and destroyed the main rail line of the Union Pacific Railroad over a few hundred feet. The line was closed for a number of days, and all rail traffic that would normally be routed through the area had to be diverted through Colorado.

In May 2011 a landslide occurred on Highway 89 between Afton and Jackson and affected many residents of Lincoln County. The landslide represented an economic hardship for local residents. Residents living in Afton and working in Jackson were forced to take a 75 mile detour around the landslide into Idaho and over two mountain passes to get to work as Highway 89 is the only direct route between the two towns.

Likelihood of Future Occurrence

The probability of a landslide causing damage in the Region is difficult to determine because of the poor historic data. However given it is reasonable to assume that damaging events have between 10 and 100 percent chance of occurrence in next year, or a recurrence interval of 10 years or less. Therefore, landslides, rockfalls or debris flows are likely to occur. Hazard areas discussed in the Landslide Hazard Attachment note that heavy periods of precipitation or significant development could have an effect on slope stability. Typically there is a landslide/rockfall 'season' that coincides with increased freeze-thaw cycles and wetter weather in the spring and early summer.

Potential Magnitude

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. In general terms, landslides can threaten human life, impact transportation corridors and communication systems, and cause damage to property and other infrastructure. Actual losses can range from mere inconvenience to high maintenance costs where very slow or small-scale destructive slides are involved. The potential magnitude of landslides, rockfall and debris flows would typically be isolated in most counties in the region or limited. However even a small isolated event has potential to close state or US highways in the region that can result in long detours for days or weeks. With the added cost of detours, and the potential for life safety impacts, some landslides could have greater costs.

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Vulnerability Assessment

Population

The overall vulnerability of population is low. The general population is not overly vulnerable to landslides, but rockfall can cause serious injury or death. According to the Wyoming State Mitigation Plan, "The most significant impact tends to be when no alternative route exists between populated areas and access is blocked by the presence of a landslide."

General Property

During the 2016 development of this regional plan a GIS analysis of exposure to landslide hazard areas was performed. The following table summarizes landslide exposure in the county, based on an intersect of improved parcels with landslide hazard areas. The greatest risk to general property in the region is in Lincoln County.

Table 4.49 Building Exposure Values for Landslides by County

County	Landslide Building Exposure Value (2010)
Lincoln	$47,827,380
Uinta	$8,161,984
Sweetwater	$696,541

Essential Infrastructure, Facilities, and Other Important Community Assets

Transportation networks are the most exposed aspect of the Region to rockfall, landslide and debris flow incidents. Residents and visitors alike are impacted by landslides when roads are damaged by landslides. The loss of transportation networks could potentially cause secondary damage to the overall Region's infrastructure, including revenue, transportation availability, emergency response mechanisms and other essential capabilities by preventing the means of these resources from activating or moving between locations.

During the 2016 development of this regional plan a GIS analysis of highway and county road infrastructure risk was conducted. The exposure to landslide hazard areas was estimated by overlaying road networks on hazard areas and summarizing results. The results are summarized by county in the following tables.

Future Development

The severity of landslide problems is directly related to the extent of human activity in hazard areas. Human activities such as property development and road construction can also exacerbate the occurrence of landslides. Landslide areas tend to be picturesque and often within mountainous

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locations and therefore attract development. Development in landslide areas frequently consists of vacation homes and represents a potential risk for injury, loss of life and property. Future development in these areas should be done carefully 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

Overall, landslides, rockfalls and debris flows are low to medium significance hazards in the region. Landslides have the potential for direct property impacts including residential structures but more likely infrastructure corridors including roads and highways, power line corridors, and gas lines. Secondary impacts could include landslide dams forming on creeks and overtopping, causing flash flooding in valleys below. Landslide areas around reservoirs can also result in seiche waves that could stress or overtop dams.

Table 4.50. Landslide Hazard Risk Summary

County	Geographic Extent	Potential Magnitude/Severity	Probability of Future Occurrences	Significance
Lincoln	Significant	Critical	Likely	High
Sweetwater	Limited	Limited	Occasional	Med
Uinta	Negligible	Negligible	Occasional	Low

Municipalities impacted: Star Valley (direct impacts), Diamondville, Rock Springs, Green River

4.2.12 Lightning

Hazard Description

Lightning is a danger across Wyoming. 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.

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. Wyoming is #1 in the nation in lightning deaths per capita.

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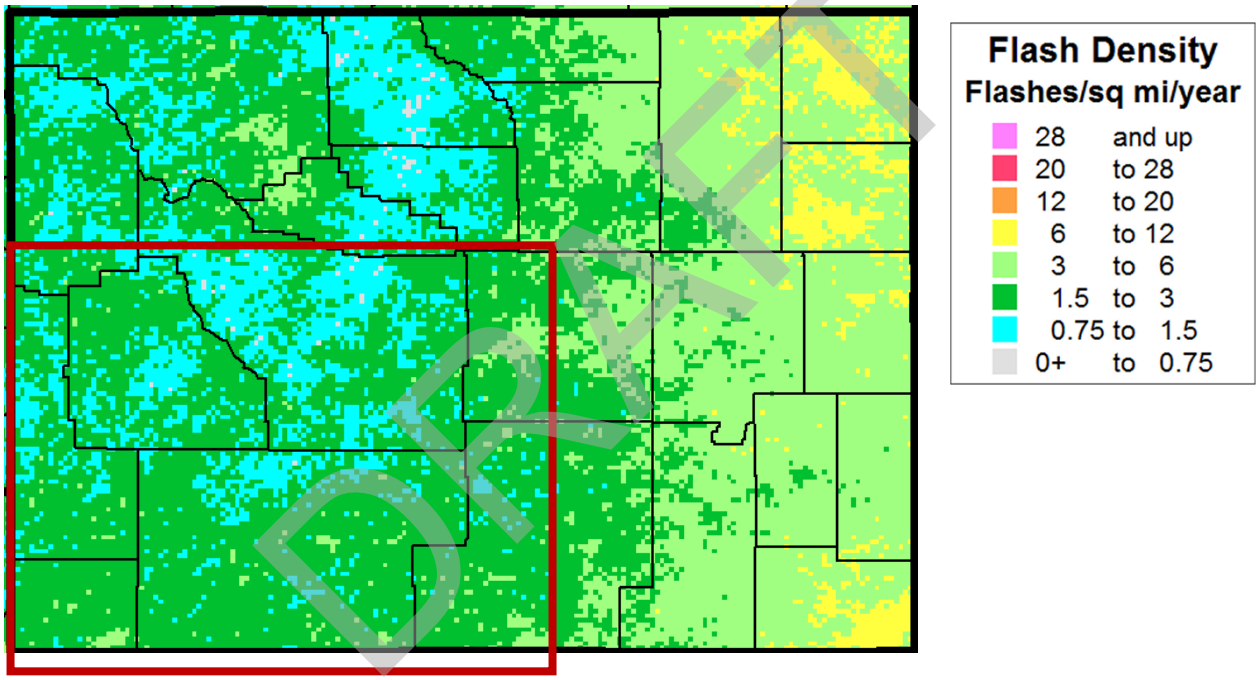
Geographical Areas Affected

Nationwide, lightning strikes are routinely monitored by Vaisala, Inc. with accuracies to within a 0.625-mile (1 kilometer) resolution. The Wyoming annual lightning strike frequency is depicted in Figure 10.1 for the period of 2005 through 2014. Clearly the eastern plains have more than three times the cloud to ground lightning strikes as the western half of the state. Region 4's flash density is relatively low, ranging from 0.75 to 3 flashes per square mile per year across most of the planning area. A few isolated spots have slightly higher flash densities. Despite annual variation, 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).

Figure 4.34. Average Annual Lightning Flash Density (flashes/sq. mi./year), 2005 - 2014



Source: Vaisala Inc.

Past Occurrences

Vaisala's National Lightning Detection Network (NLDN) recorded 347,035 cloud to ground lightning flashes in Wyoming in 2015; they also record an average of 279,632 cloud to ground lightning flashes per year between 2006 and 2015 for the state. This ranks Wyoming 39th nationally for flashes per square mile, averaging 2.9 cloud to ground lightning flashes per square mile, per year.

Nationally, Wyoming ranks 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). According to the NCDC,

lightning has been responsible for 8 deaths, 75 injuries, over $1 million in property damage, and $91,000 in crop damage in Wyoming between 1996 and 2015.

The following table includes lightning events that have caused deaths, injuries, and damage in the three counties of Region 4; this list encompasses all recorded lightning incidents for the Region. Uinta County had no lightning incidents recorded by the NCDC during this timeframe.

Table 4.51. Region 4 Lightning History 1997 - 2015

County	Location	Date	Time	Deaths	Injuries	Property Damage	Crop Damage
Lincoln County	Alpine	09/10/1997	13:30	0	3	$0	$0
Sweetwater County	Reliance	05/24/2014	13:45	0	1	$0	$0
	TOTALS			**0**	**4**	**$0**	**$0**

According to the planning teams of the three counties, the lightning impacts noted by NCDC underrepresent the lightning history in the region. The committees noted multiple lightning injuries and fatalities not recorded by the NCDC.

The HMPC of Uinta County specifically noted one incident which did not result in any injuries and fatalities, but electrical damage. On June 6, 2016, lightning knocked out power in Evanston until 8:30 am. Lightning also hit a Uinta County Deputy's home and fried electronics and ruined wiring in the home. It also knocked some siding off the house.

Likelihood of Future Occurrence

Lightning occurs thousands of times a year during thunderstorms; most of this lightning is intra-cloud, and stays in the sky without causing any damage on the ground. Since 1997, the NCDC records two lightning strikes with impacts in the counties in Region 4; using only the lightning strikes recorded, this means that one of the three counties in Region 4 experiences an impactful lightning strike once every nice years. Lightning may strike in outlying areas, without leaving any trace or impact.

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.

While the HMPC noted additional instances of lightning strikes, it is still reasonable to assume that impactful lightning strikes are rare.

Potential Magnitude

Lightning caused 4 recorded injuries in the Region between 1997 and 2015; these injuries were to people caught unprotected during a lightning storm. According to the county planning teams, this

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number is underreported, as they related additional fatalities and injuries during the planning process.

Lightning doesn't just strike unprotected people, as the counties reported that lightning also causes the death of unprotected livestock in open areas. Lightning can also have many secondary impacts, including power failure and ignition of wildfires.

Vulnerability Assessment

Anyone who is outside during a thunderstorm is at risk of being struck by lightning. Aspects of the population who rely on constant, uninterrupted electrical supplies may have a greater, indirect vulnerability to lightning. As a group, the elderly or disabled, especially those with home health care services relying on rely heavily on an uninterrupted source of electricity. Resident populations in nursing homes, Community Based Residential Facilities, or other special needs housing may also be vulnerable if electrical outages are prolonged. If they do not have a back-up power source, rural residents and agricultural operations reliant on electricity for heating, cooling, and water supplies are also especially vulnerable to power outages.

General infrastructure, essential infrastructure and facilities can be impacted by lightning. Emergency responders, hospitals, government services, schools, and other important community assets are not more vulnerable to lightning than the general vulnerabilities established for property and population. Some aspects of infrastructure are constructed of materials and/or located in places that increase their vulnerability to lightning. Sometimes, communications and infrastructure are interrupted by lightning strikes. These events raise the vulnerability of the essential functions by delaying response times, hindering interagency communication efforts, or endangering or damaging communication networks.

Future Development

Buildings and other structures are attractive targets for lightning strikes. Future buildings and critical facilities should be built with grounding when possible to prevent the ignition of structure fires.

Summary

Because of Region 4's location in western Wyoming and its mountainous terrain, it will remain vulnerable to lightning strikes for the foreseeable future. Unsheltered outdoor workers, outdoor enthusiasts and livestock will remain susceptible to lightning strikes. Lightning-caused wildland fires may result in more extensive damage.

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Table 4.52. Lightning Hazard Risk Summary

County	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Lincoln	Negligible	Likely	Limited	Low
Sweetwater	Negligible	Likely	Limited	Low
Uinta	Negligible	Likely	Limited	Low

4.2.13 Mine Subsidence

Hazard Description

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.

Geographical Area Affected

The following maps show mined-out areas and mine subsidence in Wyoming. Gray areas represent mined-out areas with subsidence. Subsidence problems have occurred in Lincoln County (Kemmerer), Sweetwater County (Rock Springs, Superior and Reliance) and Uinta County (Evanston).

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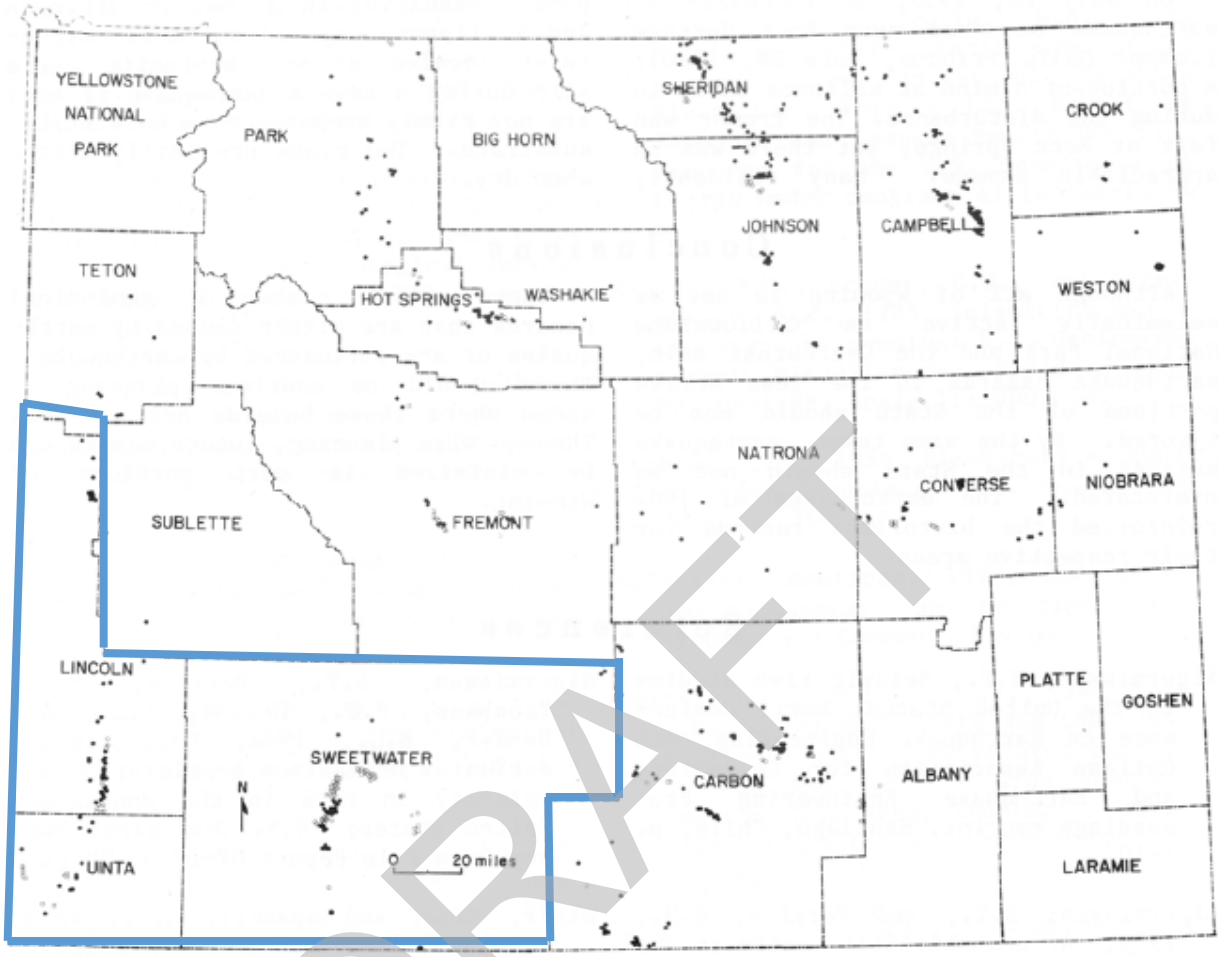
Figure 4.35. Mine Subsidence in Wyoming



Solid areas represent mined-out areas with no known subsidence; Region 4 counties outlined in blue.
Source: 2016 Wyoming Multi-Hazard Mitigation Plan

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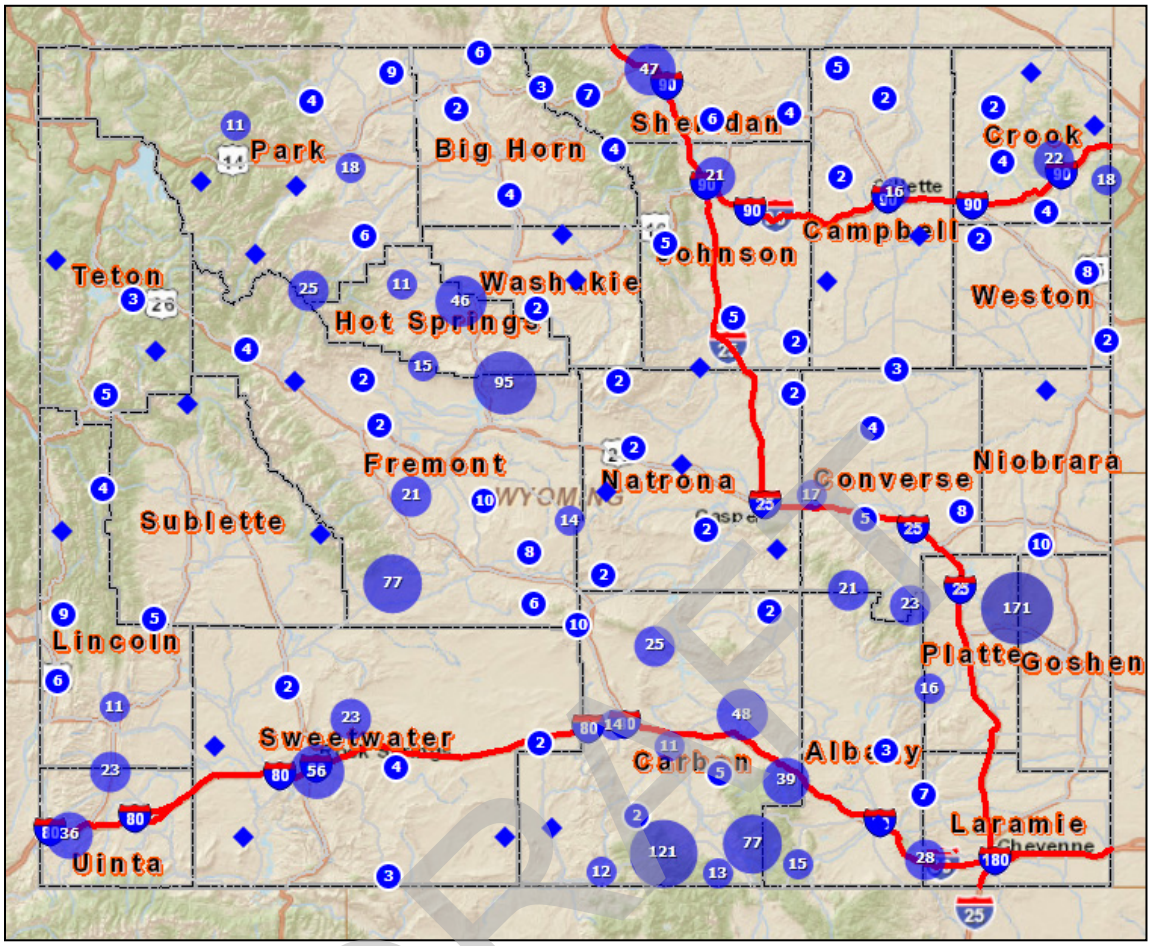
Figure 4.36. Abandoned Mine Sites with Subsidence-Prone Underground Workings



There are numerous abandoned mine sites in Lincoln County. The hard rock mining districts below are organized by topographic quadrangle.

<u>Big Park Quadrangle:</u>
Ferney Gulch mine T27N R117 ½W Section 1

<u>Porcupine Creek Quadrangle:</u>
Contag Prospect T28N R117 ½W Section 36 NE
Griggs Mine T28N R117W Section 7
Spring Lake Creek adit T28N R117 ½W Section 24 SE

<u>Blind Bull Creek Quadrangle:</u>

Alpine Mine T35N R116W Section 35
Blind Bull Mine T34N R116W Section 1
Dead Man Mine T35N R116W Section 36
Dead Man Gulch Mine T35N R116W Section 26
Vail Mine T35N R116W Section 36

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West Mine T34 R116W Section 10

Cumberland Gap Quadrangle:
Brilliant Mine #8 T19N R116W Sections 17 and 18
Cumberland #1 Mine T19N R116W Sections 29,31,32
Cumberland #2 Mine T19N R116W Sections 18,19,30
Lee Mine T19N R116W Section 20

Elkol Quadrangle:

Blazon Mine T19N R116W Sections 4 and 5 T20N R116W 29,32,33
Brilliant Mine #8 T19N R116W Sections 17 and 18
Elkol Mine T20N R116W Sections 10,11,15
Lincoln Star Mine T20N R116W Section 28
Pacific Coal Mine T20N R116W Sections 3 and 4

Kemmerer Quadrangle (1:62,500):
Conroy Mine T21N R116W Section 20
Diamondville Mine #1 T21N R116W Sections 23-26
Diamondville Mine #2 T21N R116W Sections 25,26,35,36
Kemmerer Mine #1 T21N R116W Sections 11-14
Kemmerer Mine #3 T21N R116W Sections 13 and 14
Kemmerer Mine #4 T22N R116W Section 36
Kemmerer Mine #5 T23N R116W Section 1
Kemmerer Mine #5A T22N R116W Section 25
Kemmerer #5 South Gromer T22N R116W Section 13
Kemmerer Mine #6 T22N R116W Section 12
Kemmerer #6 South Mine T22N R116W Section 13
Hoddenham Mine T22N R116W Section 1
New Twin Creek Mine T21N R116W Sections 7
Twin Creek Mine #1 T21N R116W Sections 17
Twin Creek Mine #2 T21N R116W Sections 7

Although some of these 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.

Past Occurrences

According to the 2016 Wyoming Hazard Mitigation Plan, subsidence problems have occurred in Rock Springs, Hanna, Glenrock, Superior, Reliance, Evanston, Kemmerer, Sheridan, and Gillette. Over the past several years, in addition to a large number of traditional mine reclamation projects on both coal and non-coal mine sites, the Wyoming Abandoned Mine Lands (AML) Program at Wyoming Department of Environmental Quality (DEQ) has funded two or three large subsidence mitigation projects annually, along with smaller projects to protect individual homeowners, done at the request of individual homeowners. Recent subsidence mitigation projects have focused on

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protecting critical infrastructure. In the Rock Springs area, the community's water tank, and water supply lines have been protected, and Interstate 80 north of Rock Springs has also been protected.

Likelihood of Future Occurrence

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 as discussed in the next section.

Vulnerability Assessment

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 AML Program 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 (Wyoming Hazard Mitigation Plan 2016).

Future Development

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.

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.

Summary

Overall, mine subsidence is a medium significance hazard to counties in the Region, though Sweetwater County has a higher significance rating than Lincoln or Uinta.

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Table 4.53. Mine Subsidence Hazard Risk Summary

County	Geographic Extent	Potential Magnitude/Severity	Probability of Future Occurrences	Significance
Lincoln	Limited	Limited	Occasional	Medium
Sweetwater	Extensive	Critical	Likely	High
Uinta	Limited	Limited	Occasional	Low

Municipalities impacted: Kemmerer, Evanston, Rock Springs, Superior, Reliance

4.2.14 Tornadoes

Hazard Description

A tornado is a swirling column of air extending from a thunderstorm to the ground. Maximum winds in tornadoes are often confined to extremely small areas, and vary tremendously over very short distances, even within the funnel itself. Tornadoes can have wind speeds from 40 mph to over 300 mph, the majority displaying wind speeds of 112 mph or less. Erratic and unpredictable, they can move forward at up to 70 miles per hour, pause, slow down and change directions. Most have a narrow path, less than 100 yards wide and a couple of miles long. However, damage paths from major tornadoes can be more than a mile wide and 50 miles long.

Based on national statistics for 1970 – 1980, for every person killed by a tornado, 25 people were injured and 1,000 people received some sort of emergency care. Tales of complete destruction of one house next to a structure that is totally unscathed are well documented. Within a building, flying debris or missiles are generally stopped by interior walls. However, if a building has no partitions or has any glass, brick or other debris blown into the interior, the tornado winds can be life threatening. In order to examine tornado activity and the potential impact on Region 4 and its residents, it is important to understand how tornadoes are rated.

Rating a Tornado

In 1971, Dr. T. Theodore Fujita of the University of Chicago devised a six-category scale to classify U.S. tornadoes into intensity categories, F0 through F5. These categories are based upon the estimated maximum winds occurring within the funnel. The Fujita Tornado Scale (or the "F Scale") became the definitive scale for estimating wind speeds within tornadoes based upon the damage done to buildings and structures. It was used extensively by the National Weather Service in investigating tornadoes, and by engineers in correlating damage to building structures and techniques with different wind speeds caused by tornadoes.

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Table 4.54. Fujita Scale Description

F-Scale Number	Intensity Phrase	Wind Speed	Type of Damage Done
F0	Gale tornado	40-72 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages signboards.
F1	Moderate tornado	73-112 mph	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	Significant tornado	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	Severe tornado	158-206 mph	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted
F4	Devastating tornado	207-260 mph	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible tornado	261-318 mph	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged.

Recent Changes to Tornado Rating Scale

Devastating tornadoes in Jarrell, Texas on May 1997 and Moore/Oklahoma City on May 1999 demonstrated to that the wind estimates in the original F-scale may be too high. From 2000 to 2004, the Wind Science and Engineering Research Center at Texas Tech University, in cooperation with numerous expert meteorologists, civil engineers and the National Weather Service (NWS), developed an Enhanced Fujita Scale, or EF-scale. In addition to improving the ranking process, it was essential to the development team that the new EF-scale support and be consistent with the original F-scale. The EF-scale documentation includes additional enhanced descriptions of damage to multiple types of structures and vegetation with photographs, a PC-based expert system, and enhanced training materials.

In February 2007, the Enhanced Fujita scale replaced the original Fujita scale in all tornado damage surveys in the United States. The following table compares the estimated winds in the original F-scale with the operational EF-scale that is currently in use by the NWS.

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Table 4.55. The Enhanced Fujita Tornado Scale

FUJITA SCALE			OPERATIONAL EF-SCALE	
F Number Fastest	Fastest 1/4 – mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85
1	73-112	79-117	1	86-110
2	113-157	118-161	2	111-135
3	158-207	162-209	3	136-165
4	208-260	210-261	4	166-200
5	261-318	262-317	5	Over 200

Geographical Area Affected

The entire area of the Region is susceptible to tornadoes. While some areas may see more tornadoes than others, this is more of a statistical anomaly than a causal result.

Past Occurrences

Tornado statistics, especially prior to the 1970s, must be viewed as incomplete since many twisters have occurred without being witnessed. Wyoming's open rangelands experience little if any damage from these storms, so many go unreported. Many documented tornadoes occurring in the counties in Region 4 are given low ratings on the Fujita Scale (F0s and F1s) simply because these tornadoes are often formed over open land and result in little or no damage. The most damaging tornado in Region 4 occurred in Sweetwater County in 2000, causing $30,000 of damage in James Town on April 14th of that year.

Since 1950, there have been 32 recorded tornadoes in the three counties in Region 4, as documented by the National Climatic Data Center. The total recorded property damage was $85,060.

Table 4.56. Summary Tornado History, Region 4 (Lincoln, Sweetwater, and Uinta): 1950 - 2015

County	Number of Events
Lincoln	6
Sweetwater	22
Uinta	4
Total	32

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Table 4.57. Tornado History, Region 4: 1950 - 2015

Location (City or County)	Date	Time	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
Uinta	5/10/1950	1300	F2	0	0	$30	0
Sweetwater	6/9/1960	1600	F0	0	0	0	0
Uinta	5/24/1962	2000	F0	0	0	$2500	0
Lincoln	6/10/1969	1320	F0	0	0	0	0
Sweetwater	9/9/1973	1628	F1	0	0	0	0
Sweetwater	6/27/1974	1600	F1	0	0	$25000	0
Sweetwater	7/31/1978	1558	F1	0	0	0	0
Sweetwater	8/14/1979	1300	F0	0	0	0	0
Sweetwater	8/14/1979	1400	F0	0	0	0	0
Sweetwater	8/14/1979	1400	F0	0	0	0	0
Lincoln	7/24/1980	1400	Unknown	0	0	$25000	0
Sweetwater	6/14/1982	1200	F0	0	0	$30	0
Sweetwater	5/30/1989	1225	F0	0	0	0	0
Sweetwater	5/30/1989	1335	F0	0	0	0	0
Uinta	5/30/1989	1335	F0	0	0	$2500	0
Sweetwater	7/24/1990	1603	F0	0	0	0	0
Sweetwater	8/4/1990	1530	F0	0	0	0	0
Lincoln	5/2/1991	1736	F0	0	0	0	0
Lincoln	9/9/1991	1740	F0	0	0	0	0
Sweetwater	9/9/1991	1756	F0	0	0	0	0
Sweetwater	5/15/1992	2205	F0	0	0	0	0
Sweetwater	5/25/1995	1330	F0	0	0	0	0
Sweetwater (Rock Springs)	6/10/1997	1345	F0	0	0	0	0
Lincoln (La Barge)	6/14/1997	1525	F0	0	0	0	0
Sweetwater (James Town)	4/14/2000	1235	F1	0	0	$30000	0
Sweetwater (James Town)	4/20/2001	1145	F1	0	0	0	0
Lincoln (Opal)	7/10/2001	1345	F1	0	0	0	0
Uinta (Fort Bridger)	7/19/2002	1345	F0	0	0	0	0
Sweetwater (Rock Springs)	6/24/2003	1230	F0	0	0	0	0
Sweetwater (Eden)	9/15/2013	1611	EF0	0	0	0	0
Sweetwater (Eden)	5/7/2014	1408	EF0	0	0	0	0
Sweetwater (Red Desert)	7/7/2015	1430	EF0	0	0	0	0
	TOTALS			**0**	**0**	**$85,060**	**$0**

Source: National Climatic Data Center

Likelihood of Future Occurrence

On average, at least one of the counties in Region 4 experiences a tornado every two years. Recorded tornadoes in Region 4 occurred during the months of April through September, between 11 a.m. and 10 p.m. Historical ratings vary between F0 and F2 on the F-scale; after the advent of the EF-scale, the Region has experienced 3 EF0 tornadoes.

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Figure 4.37. F-Scale Tornadoes by Rating: 1950 - 2015

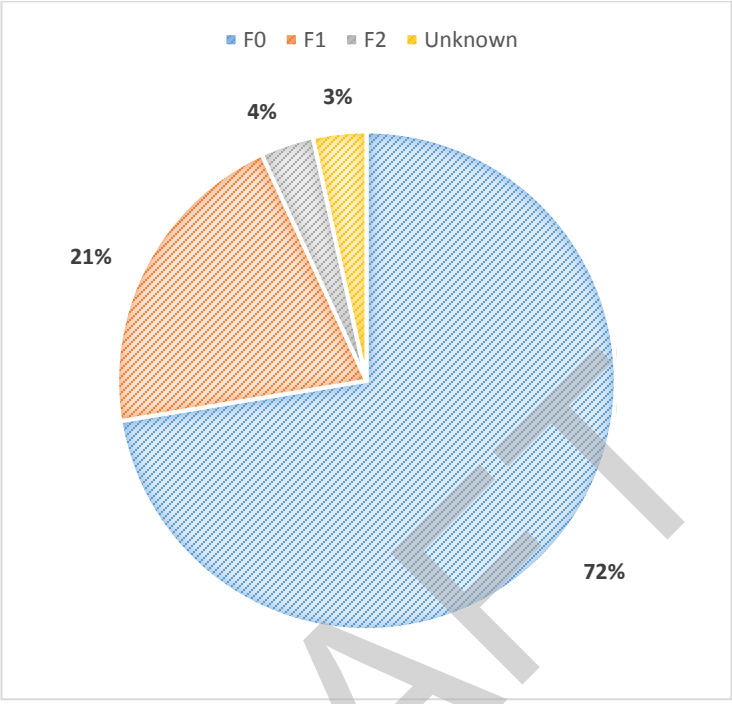

Figure 4.38. Rated Tornadoes by County: 1950 - 2015

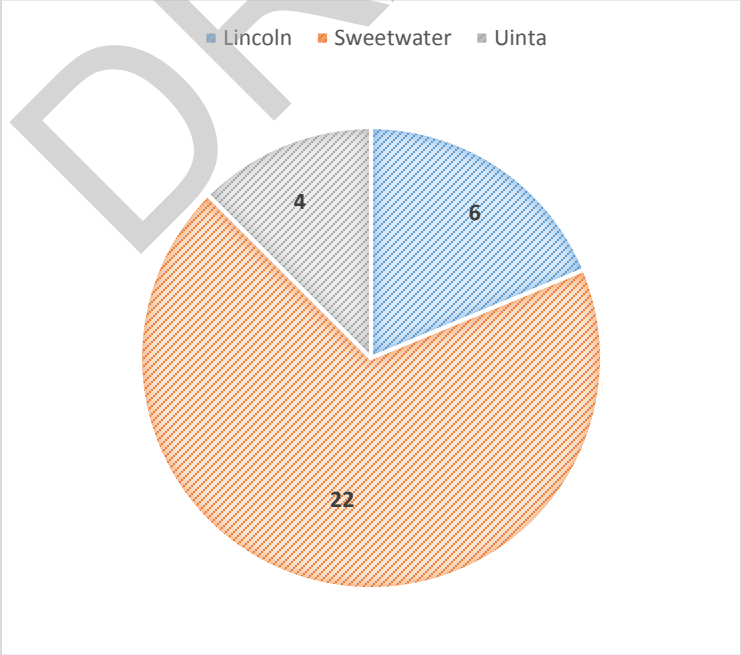

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Figure 4.39. Historical Tornadoes by Month: 1950 - 2015

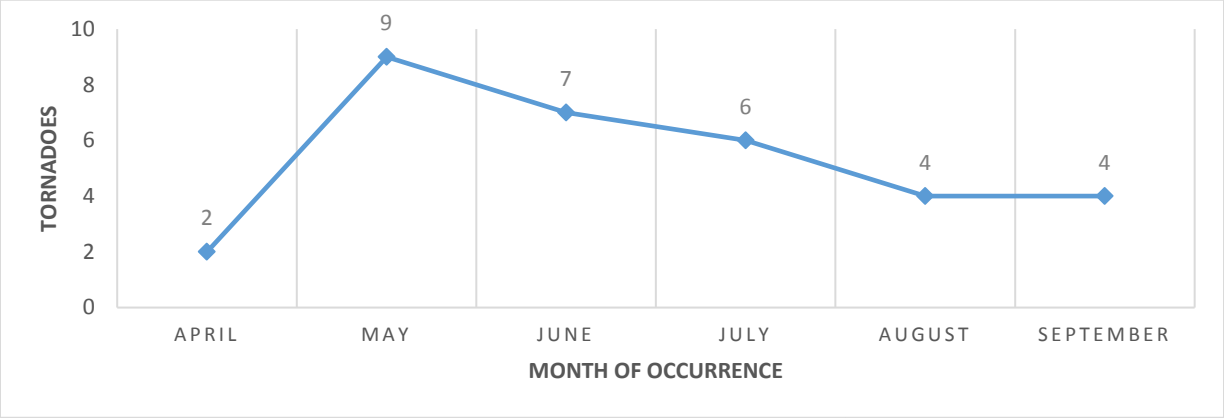
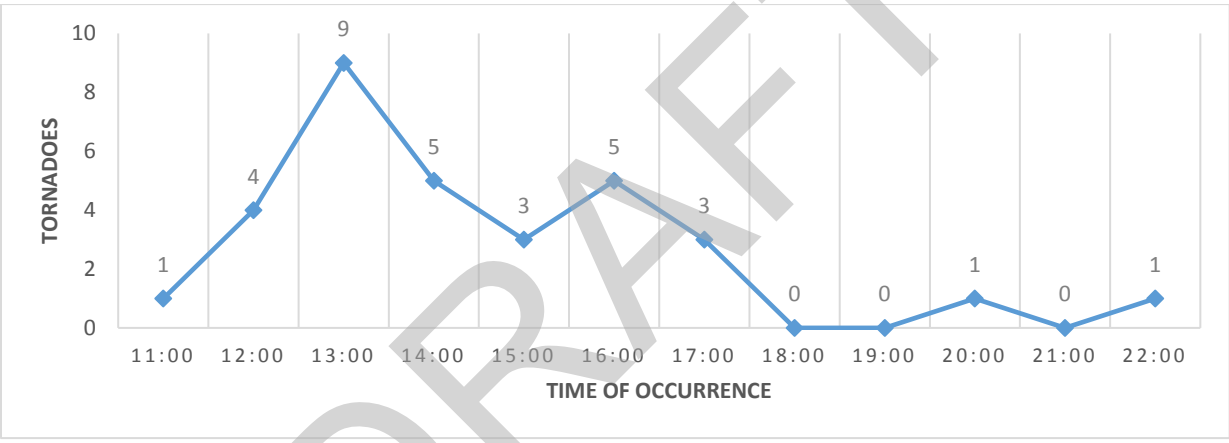


Figure 4.40. Historical Tornadoes by Time of Day: 1950 - 2015



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Based on data provided by the NCDC, a tornado in at least one of the three counties in the Region on average every other year. It occurs in late spring in the afternoon, is rated EF-0 or EF-1, and causes less than $25,000 worth of damage to property, though it mostly strikes rural areas causing no damage. This is due more to chance than any environmental factor, however, as inhabited areas are statistically equally at risk of a tornado strike; the potential for injuries, fatalities and damage in these areas is much greater.

Potential Magnitude

The National Weather Service considers tornadoes to be among nature's most violent storms. The most violent tornadoes are capable of tremendous destruction with wind speeds of 250 mph or more. Tornadic winds can cause people and autos to become airborne, rip ordinary homes to shreds, and turn broken glass and other debris into lethal missiles. Even weaker tornados can cause large economic damages.

According to NCDC records, the storm of record for the Region occurred in Sweetwater County on April 14, 2000 in James Town, when an F1 tornado accumulated $30,000 in damage. Lincoln County's incident of record occurred July 24, 1980, when an F0 storm caused $25,000 in damage. Uinta County has experienced up to $2,500 in damages due to one storm.

Though the strength of the tornado often dictates the impacts, it is important to remember that the location (rural or urban) of the tornado is just as important when assessing these risks. Impacts can vary depending on multiple factors, including the size and strength of a tornado, and its path.

Vulnerability Assessment

Because of its mostly rural composition, people or property within the Region have not had a history of being severely impacted during past tornado incidents. While the F-Scale ratings of historical tornadoe in the counties in the Region are low, those ratings are partially based on recorded damage. Recorded damage may have been much more substantial if these tornadic events had impacted one of the communities in the Region, rather than timber, outlying range, and farm acreage.

NCDC has not recorded any injuries or fatalities that are attributed to these tornadoes. Cumulatively, the storms have caused $85,060 in recorded property damage, and no recorded crop damage. Property damage has been described as downed tree limbs and power outages, damage to homes, sheds and outbuildings to include roofs and chimneys, and downed timber on forest lands. Of the 32 tornadoes that have been recorded by the NCDC in Region 4 from 1950 to 2015, 6 of those have caused property damage, and none have caused crop damage. Historical property damage per incident has been between $3,000 and $30,000 dollars.

According to the Lincoln County 2004 Hazard Mitigation Plan, Lincoln County has seen four injuries caused by tornadoes, but no deaths. These fatalities were not noted by NCDC.

Tornadoes occur at random locations throughout the Region; for that reason all exposed communities, structures, critical facilities, essential services, and populations are considered vulnerable.

Future Development

Any future development that is exposed and above ground will be vulnerable to a direct or indirect hit by a tornado. In order to better withstand impacts from tornadoes or other high wind events, future residential or commercial buildings built to code should be able to withstand wind speeds of at least 150 miles per hour.

Summary

Tornadoes are a credible threat, and will continue to occur in the counties in Region 4. Depending on a tornado's size, ferocity and path, it can cause devastating damage to people, property and

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infrastructure. While historic tornadoes in Region 4 have been rated relatively low on the intensity scale and have caused relatively little damage, the possibility of larger, more damaging tornadoes is ever present.

Table 4.58. Tornado Hazard Risk Summary

	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Lincoln	Negligible	Likely	Negligible	Low
Uinta	Negligible	Likely	Negligible	Low
Sweetwater	Negligible	Likely	Negligible	Low

4.2.15 Severe Winter Weather

Hazard Description

The National Weather Service defines a storm as "any disturbed state of the atmosphere, especially affecting the Earth's surface, and strongly implying destructive and otherwise unpleasant weather." Winter storms occur during the winter months and produce snow, ice, freezing rain, sleet, and/or cold temperatures. Winter storms are an annual occurrence in climates where precipitation may freeze and are not always considered a disaster or hazard. Disasters occur when the severe storms impact the operations of the affected community by damaging property, stalling the delivery of critical services, or causing injuries or deaths among the population.

Winter storm watches and warnings may be helpful for determining the difference between a seasonal winter storm and a severe winter storm. Warnings are issued if the storm is producing or suspected of producing heavy snow or significant ice accumulations. Watches are usually issued 24 to 36 hours in advance for storms capable of producing those conditions, though criteria may vary between locations. Winter Weather Advisories are issued when a low pressure system produces a combination of winter weather that presents a hazard but does not meet warning criteria.[5]

Heavy snow can immobilize the counties in Region 4, isolating communities, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can collapse roofs and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. The cost of snow removal, damage repair, and business losses can have a tremendous impact on cities and towns. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days until

[5] This information is drawn from the National Weather Association Online Glossary, which may be accessed at http://www.weather.gov/glossary/

damages are repaired. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

Some winter storms are accompanied by strong winds, creating blizzard conditions with blinding wind-driven snow, severe drifting, and dangerous wind chills. Strong winds with these intense storms and cold fronts can knock down trees, utility poles, and power lines. Blowing snow can reduce visibilities to only a few feet in areas where there are no trees or buildings. Serious vehicle accidents can result with injuries and deaths.

Winter storms in the counties of the Region, including strong winds and blizzard conditions, may cause localized power and phone outages, closures of streets, highways, schools, businesses, and non-essential government operations, and increase the likelihood of winter-weather related injury or death. People may be stranded in vehicles or other locations not suited to sheltering operations or isolated from essential services, especially along Interstate 80 and other heavily trafficked areas. A winter storm can escalate, creating life threatening situations when emergency response is limited by severe winter conditions. Other issues associated with severe winter storms include the threat of physical overexertion that may lead to heart attacks or strokes. Snow removal costs can pose significant budget impacts, as can repairing the associated damages caused by downed power lines, trees, structural damages, etc. Heavy snowfall during winter can also lead to flooding or landslides during the spring if the area snowpack melts too quickly.

Extreme Cold

Extremely cold temperatures often accompany severe winter weather. NCDC records six incidents of severe cold between 1996 and 2015 for Region 4, though none of these events had any recorded impact. According to the three county HMPCs, while the counties in Region 4 do experience extremely cold temperatures, these instances usually don't cause any detrimental impacts and the public is prepared for them. The HMPCs noted that since cold is an annual occurrence, people are normally prepared for incidents and know what to do when they occur. Recorded temperatures have dropped as low as -60 degrees. The HMPCs noted occasional impacts from extreme cold including broken pipes, agriculture damage, power outages and sheltering needs for vulnerable populations during this time. Because of the prevalence of extreme cold events and the relatively low impacts during incidents and the region's resiliency, this hazard was not profiled separately.

Geographical Area Affected

Winter storms are a yearly feature of the Wyoming climate and may occur anywhere in the state. Generally, severe winter storm events are considered regional, which implies the storms impact multiple counties simultaneously, often for extended time periods. It is possible for the geographic extent of the hazard to vary significantly within a single county- a regional storm may directly impact only a small portion of the planning area while still extending over a large portion of the surrounding area. However, even in these instances, the impacts and effects of a regional hazard are still felt within the planning area. Therefore, while the percent of the planning area directly affected ranges from less than 10% to 100% depending on the specific circumstances, if any

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portion of the planning area is impacted by the storm, then the entire planning area suffers indirect impacts.

Past Occurrences

The NCDC data for winter weather in Lincoln, Sweetwater and Uinta counties goes back to 1996. Data for blizzards, winter storms and winter weather was searched. Between the three counties, the Region experienced 165 separate days with a severe winter-related weather between 1996 and 2015. Snow totals have been recorded up to thirty inches in some spots.

There have been very few winter storms in the counties in the Region that have caused recorded damage, long-term economic impact, and brought about changes in livestock practices. The data records no injuries and no fatalities as a direct result of the storms within the boundaries of the three counties. The NCDC records $30,000 in damage since 1996, mostly property and infrastructure damage caused by snow and wind. Recorded damages included:

October 11, 2008 – Evanston received 3.5 inches of new snow, and several large trees were knocked down outside Evanston, blocking some county roads.

April 8, 2013 – A large window was blown in at the aquatic center at Western Wyoming Community College in Rock Springs, where 1,200 customers lost power when a power pole was damaged. Additionally, damage was reported to docks at the Buckboard Marina at Flaming Gorge Reservoir.

Likelihood of Future Occurrence

Winter storms are an annual occurrence in Wyoming, often occurring multiple times each winter, and affecting entire regions in their size and scope. Since 1996, the Region has averaged almost nine days with a recorded severe winter incident per year.

Potential Magnitude

The damages caused by severe winter storms and blizzards very and are dependent on several factors: the duration of the storm; the geographic extent; the time of year; meteorological factors such as wind, moisture content of the snow, ground and air temperatures; and the advance warning of the storm. Impacts from the storm dictate the magnitude of the event, emphasizing that the amount snow may not always directly correlate to how bad the storm is. Damaged power lines and dangerous or impassable roadways may forestall the delivery of critical services such as medical and emergency assistance, the delivery of food supplies and medications, or even the provision of basic utilities such as heat and running water. When events happen with a long warning time, it is possible to pre-mitigate the effects of insufficient supply levels or to pre-test emergency generators, which may prevent some of the previously described impacts from occurring. Unanticipated storms increase the number of people stranded, both in cars and at public locations, which may increase the number of injuries and deaths attributed to the event (often

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caused by exposure) and place uneven and unanticipated strains on public sheltering capacities. The weight of the snow, driven by the water content of the fall, increases the potential for damages caused to structures and trees. Lighter snow caused by extreme cold increases the damages caused to livestock, agriculture and landscaping due to freezing conditions. Winter storms which go through periods of thaw and freeze prolong dangerous icy conditions, increasing the likelihood of frozen and damaged water pipes, impassable or dangerous roadways, damaged communication lines, or more extensive damages to infrastructure and structures caused by seeping water freezing under roofs, porches, patios, inside sidings, or causing damage to vehicles.

Winter storms usually cover a significant part of the State, and as such are easier to describe regionally than on a county by county basis.

Vulnerability Assessment

Population

The threat to public safety is typically the greatest concern during severe winter storms. While virtually all aspects of the population are vulnerable to severe winter weather, there are segments of the population that are more vulnerable to the potential indirect impacts of a severe winter storm than others, particularly the loss of electrical power. As a group, the elderly or disabled, especially those with home health care services that rely heavily on an uninterrupted source of electricity. Resident populations in nursing homes or other special needs housing may also be vulnerable if electrical outages are prolonged. If they do not have a back-up power source, rural residents and agricultural operations reliant on electricity for heating and water supplies are also especially vulnerable to power outages.

Severe winter weather also increases the vulnerability of the commuting population. While there is no way to quantify which of these accidents occur during severe winter storms versus regular winter storms, the numbers indicate that winter driving conditions raise the vulnerability of the commuting population.

General Property

Property vulnerabilities to severe weather include damage caused by high winds, ice, or snow pack and subsequently melting snow. Vehicles may be damaged by the same factors, or temporarily un-useable due to the driving conditions created by severe winter weather. Contents of homes, storage units, warehouses and storefronts may be damaged if the structures are compromised or fail due to the weather, or during potential flooding caused by melting snow. Very wet snow packs down densely and is very heavy. This may create strains on structures, causing partial or entire collapses of walls, roofs, or windows. This is impacted both by architecture and construction material, and should be assessed on a building-by-building basis. These records are probably tracked via insurance or other private vendors. Crops, livestock and other agricultural operations are also highly vulnerable to severe winter storms.

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Essential Infrastructure, Facilities, and Other Important Community Assets

The physical structures which comprise essential infrastructure are as vulnerable as those outlined in the General Property subsection of this profile. Severe winter weather may also disrupt the availability of services from essential infrastructure, including utility delivery (gas, electric and water), telephone service, emergency response personnel capabilities, road plowing, and childcare availability. Severe winter storms may even halt the operation of the county for periods of time, making the vulnerability of the counties even higher.

As mentioned previously, ice or heavy accumulations of snow, particularly with blowing and drifting, can temporarily impact the roadway system. These accumulations also require vast amounts of overtime for county and local highway and streets departments to remove snow and melt ice. Ice storms or high winds in winter storms can cause extensive loss of overhead utility lines due to buildup either on the lines or on adjacent trees that either collapse due to the weight or blow down onto the utility lines. Services such as telephone, electricity, and cable TV are frequently affected by winter storms. The overall vulnerability of essential infrastructure is medium.

The HMPCs for Uinta and Sweetwater Counties noted that a major impact of severe winter weather can be the closing of Interstate 80. When this happens, communities along the interstate become rest stops for travelers. This can occur even when the severe winter weather doesn't impact either county directly.

Natural, Historic and Cultural Resources

Natural resources may be damaged by the severe winter weather, including broken trees and death of unsheltered wildlife. Unseasonable storms may damage or kill plant and wildlife, which may impact natural food chains until the next growing season. Historical areas may be more vulnerable to severe winter storms due to construction and age of structures. Cultural resources generally experience the same vulnerabilities outlined in General Property, in addition to lost revenue impacts due to transportation impacts. The overall vulnerability of these resources is medium.

Future Development

Where building codes are applicable, future residential or commercial buildings built to code should be able to withstand snow loads from severe winter storms. Future power outages or delays in power delivery to future developments may be mitigated by construction considerations such as buried power lines. Future development will also require future considerations for snow removal capacity including equipment, personnel, and logistical support. Adequate planning will help establish the cost-effective balance.

Public education efforts may help minimize the risks to future populations by increasing knowledge of appropriate mitigation behaviors, clothing, sheltering capacities, and decision making regarding snow totals, icy roads, driving conditions, and outdoor activities (all of which

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are contributors to decreased public safety during severe winter storms). New establishments or increased populations who are particularly vulnerable to severe winter storms (such as those with health concerns or those who live in communities that may be isolated for extended periods of time due to the hazard) should be encouraged to maintain at least a 72-hour self-sufficiency as recommended by FEMA. Encouraging contingency planning for businesses may help alleviate future economic losses caused by such hazards while simultaneously limiting the population exposed to the hazards during commuting or commerce-driven activities.

Summary

Overall, severe winter weather is a **medium** hazard to the Region.

Table 4.59. Severe Winter Weather Risk Summary

	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Lincoln	Extensive	Highly Likely	Limited	Medium
Sweetwater	Extensive	Highly Likely	Limited	Medium
Uinta	Extensive	Highly Likely	Limited	Medium

4.2.16 Wildfire

Hazard Description

Wildfire is defined as a highly destructive fire or any instance of uncontrolled burning in grasslands, brush or woodlands. Wildfire has encroached into urban interface situations as more people move closer to forest settings. 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. The term “wildland/urban interface” or WUI is widely used within the wildland fire management community to describe any area where man-made 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.

Wildfires can occur at any time of the year, but are most likely to occur during the spring, summer or fall. Thunderstorms that contain lightning frequently start wildfires, but they can also be caused by humans. Wyoming’s semi-arid climate and rural character make the state vulnerable to catastrophic wildland fires, which comprise more than 50% of all fires in Wyoming.

As the population and the wildland/urban interface in Wyoming increases, the more significant the risk of wildland fire hazard. The past 100 years of wildland fire suppression has led to heavy vegetation growth and thus has 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. Fires have historically played a natural role on

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western landscapes. For example, some species of trees occupy sites following fire until replaced by more shade-tolerant species. In some cases, regeneration of vegetation can be enhanced by fire. Fires may have positive or negative effects, or both, depending upon the resources at risk in the fire area.

Geographical Area Affected

Certain areas of the counties in Region 4, because of their semi-arid climate and availability of fuel, are vulnerable to catastrophic wildland fires, and, of the all fires in Wyoming, over 50% involve wildland areas. The entire Region could potentially burn from wildfires, with the exception of areas above the tree line. According to the methodology for characterizing spatial extent, a significant portion of the planning area is affected by wildfires.

The wildland and wildland-urban interface areas are of most concern and are shown in Figure 4.1, based on the Wildland Urban Interface Hazard Assessment. This assessment was produced by a joint venture of the Wyoming State Forestry Division, USFS, BLM, NPS, and other interested parties. This Geographic Information System (GIS)-based mapping effort builds 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. With the mapping analysis evaluating areas of varying wildfire vulnerability, the final output results in a Risk, Hazard, and Value (RHV) map displaying areas of concern (Redzones) for catastrophic wildland fires.

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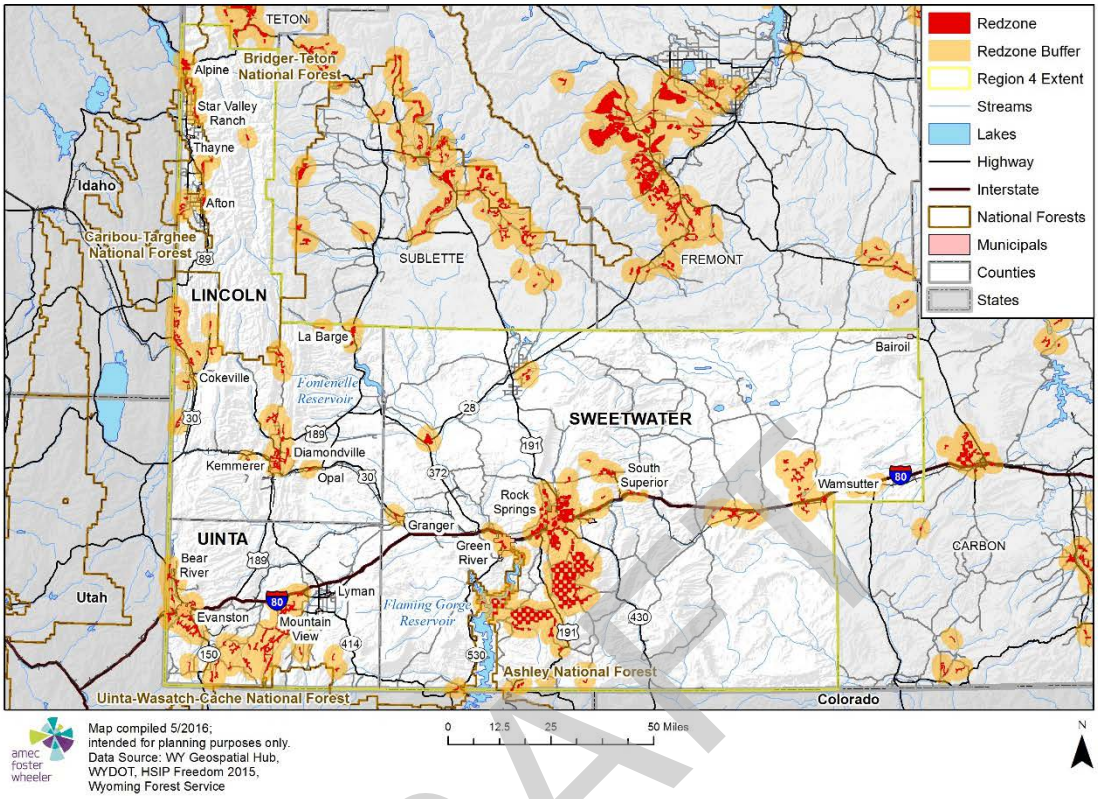
Figure 4.41. Redzone Fire Vulnerability – Region 4



Past Occurrences

Federal Wildland Occurrence Database was used to analyze fire history in Region 4. Some of the largest recorded fires occurred in the Northwest part of the Region in Lincoln County and south central Sweetwater County.

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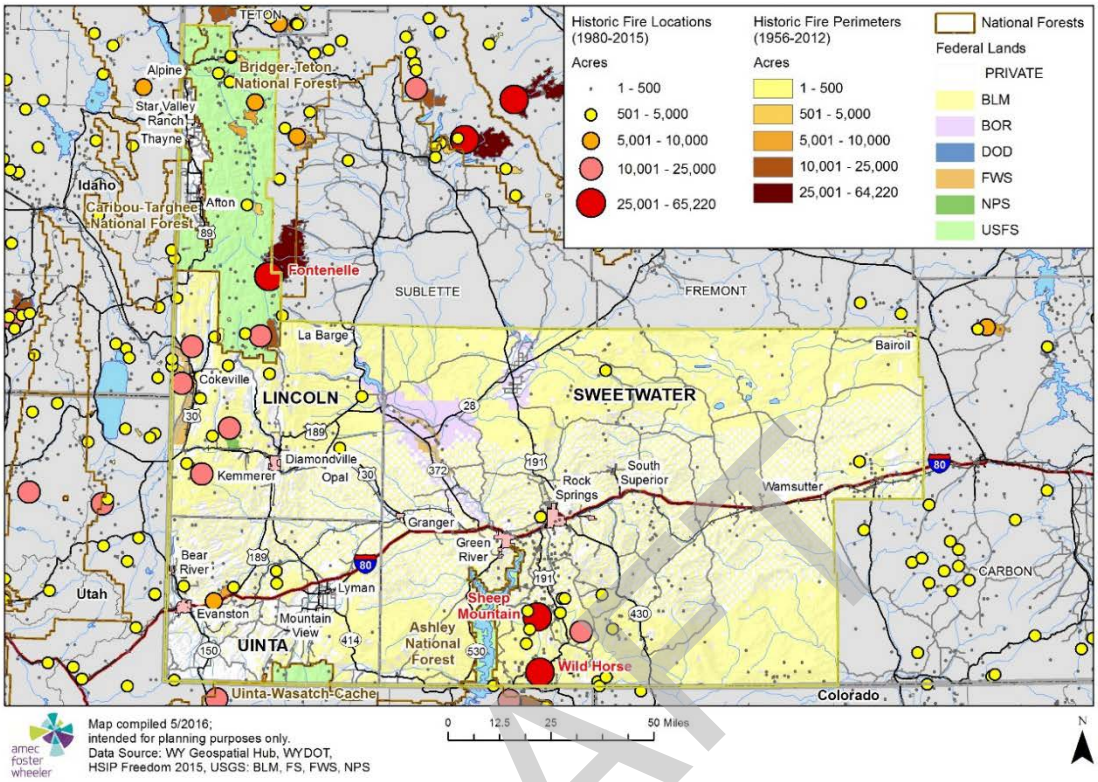
Figure 4.42. Wildland Fire Occurrences in Region 4, 1956 - 2015



Lincoln

The readily available wildfire history data in Lincoln County ranges from 1980 to 2015. Data for this section was obtained from Federal Wildland Fire Occurrence database housed with the US Geological Survey. Data from the Federal Wildland Fire Occurrence database is compiled from several federal agencies including the BIA, BLM, FWS, NPS, and USFS. According to this data, a total of 223 fires burned 222,953 acres between 1980 and 2015. Many of these fires were relatively small, burning only a few acres. 2012 in particular was one of the worst wildfire years for Lincoln County. Two of the largest wildland fires occurred in 2012. The two fires in Fontenelle burned 112,636 acres. 0 describes Lincoln County wildfires that burned 500 or more acres between 1980 and 2015.

Table 4.60. Wildfires over 1,000 acres in Lincoln County: 1956 - 2015

Wildfire Name	Year	Acres Burned
Cliff Creek	2016	16,863
Fontenelle	2012	65,220
Fontenelle	2012	47,416
Shingle Mill WFU	2008	1,381
Middle	2007	2,714

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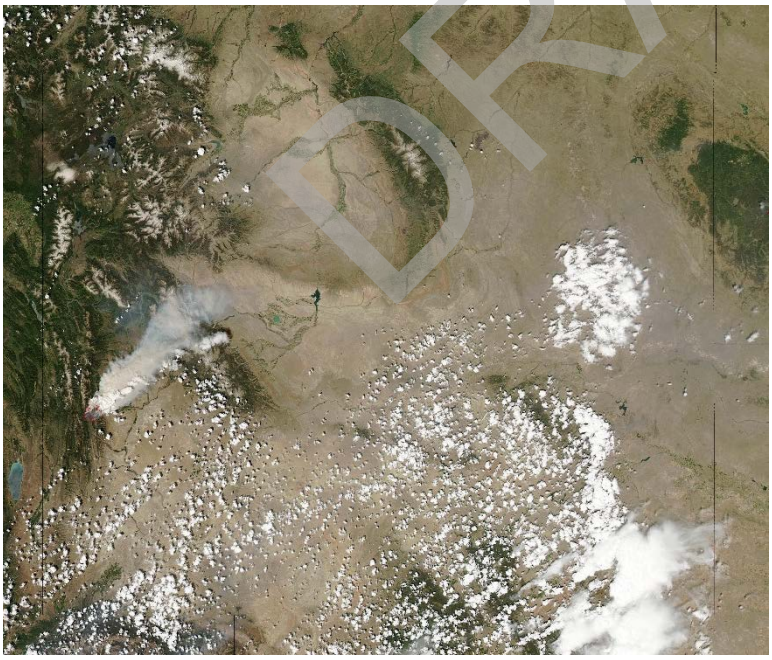
Wildfire Name	Year	Acres Burned
Sheep Trail 2	2007	1,745
Sheep Trail	2006	1,120
Rock Creek	2005	10,500
East Table	2003	3,599
Commissary	2002	3,561
Fontenelle	2000	14,750
Blind Trail	2000	9,800
Bridger Basin	1999	10,500
Aspen Hollow	1996	2,780
Corral Creek	1988	2,700
Seismic	1988	2,400
Truman	1987	1,593
North Lake	1981	12,000

The Fontenelle Fire began on June 24, 2012 about 33 miles northwest of LaBarge Wyoming. NASA's Aqua satellite captured an image of the fire on June 28, 2012. The red outlines indicate the extent of the fire that the satellite's Moderate Resolution Imaging Spectroradiometer picked up. The fire was likely started by a downed power line, affecting gas, oil, and helium production in the area.

Figure 4.43. Fontanelle Fire - Aerial View



Source: NASA Earth Observatory – Fontanelle Fire in Wyoming

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Sweetwater

Historically, most significant fires in Sweetwater County have occurred in the southern region, in and around the foothills and higher elevations of the Ashley National Forest. According to the Federal Wildland Fire Occurrence data, a total of 470 fires burned 119,230 acres between 1980 and 2015. Many of these fires were relatively small, burning only a few acres. In 2000, two of the worst wildfires in Sweetwater County occurred. The Wild Horse Fire and the Sheep Mountain Fire added up to 73,345 acres.

Table 4.61. Wildfires over 1,000 acres in Sweetwater County: 1956 - 2016

Wildfire Name	Year	Acres Burned
Bitter Creek	2015	2,487
Elk Butte	2012	1,002
Pepper	2002	13,200
Monument	2002	2,000
Vengeance	2002	1,350
Red Creek	2002	1,000
Wild Horse	2000	36,700
Sheep Mountain	2000	36,645
Black Butte	2000	2,550
Sage Creek 3	2000	1,377
Red Creek	1999	1,300
Substation	1994	1,784
Sugarloaf	1988	1,000

Uinta

When referring to the Federal Wildlands Fire Occurrence data, Uinta County has less occurrences on record than Lincoln and Sweetwater. A total of 63 wildfires burned 17,362 acres.

Table 4.62. Wildfires over 1,000 acres in Uinta County: 1956 - 2016

Name	Year	Acres Burned
Tokewanna	2016	1,300
Windmill	2010	5,261
Pond	1996	1,000
Littlebrynn	1988	5,000

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Likelihood of Future Occurrence

Wildfires are highly likely to occur in each county in the Region each year, meaning that there is nearly a 100% chance of a fire happening in any given year. There have been 758 wildfires in the Region from 1980 to 2010 for an average of roughly 25 per year. 54 of those fires were 500 acres or more. It is important to note that the likelihood of wildfires occurring may increase during times of drought; this is noted by droughts and wildfires in the region in 1988, 1998, 2002 and 2012.

Potential Magnitude

Local assessments rated wildfire to have a limited magnitude, meaning that an event would likely result in some injuries, complete shutdown of critical facilities for more than one week, and more than 10 percent of property being severely damaged. It is important to note that the magnitude of a wildfire can be intensified by drought.

Vulnerability Assessment

Lincoln County

The 2006 Lincoln Community Wildfire Protection Plan identified the following communities as areas of concern. See that document for additional descriptions of these communities and mitigation recommendations.

Alpine
Star Valley
Pomeroy Subdivision
Cokeville
Fontenelle
Pine Creek Ski
Canyon Club
Nugget
Hobble Creek
Sage Jct.
Twin Creek

Sweetwater County

Sweetwater County does not have a previous Community Wildfire Protection Plan available for reference.

Uinta County

The 2010 Uinta Community Wildfire Protection Plan identified the following communities as areas of concern. See that document for additional descriptions of these communities and mitigation recommendations.

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Meeks Cabin
Wild River
Gilbert Creek
Bear River Divide
Evanston North
Piedmont
Robertson
Table Mountain

Population

The most exposed population are those living in the wildland-urban interface (WUI) zones, where residential properties are directly intruding into traditional wildland areas. The exposure of the population in these zones increases with the exposure of the corresponding general property, examined in the section below. Other exposed groups include children, the elderly, or those with breathing conditions who may be exposed to high levels of smoke.

Population at-risk estimates were developed by multiplying the average household size from the U.S. Census for each county in the region by the number of residential structures within the Redzone. These results are shown in the tables in the next section. It is important to note that many of these structures may include seasonal homes that could be vacant, although the likelihood of them being occupied during fire season is higher.

General Property

The statewide Wildland Urban Interface Hazard Assessment was used as the best available data for assessing general property exposed within the Region. The mapping analysis evaluates areas of varying wildfire vulnerability, based on a Risk, Hazard, and Value (RHV) map displaying areas of concern (Redzones) for catastrophic wildland fires.

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.

Risk – Probability of Ignition

a. Lightning Strike density
b. Road density
c. Historic fire density

Hazard – Vegetative and topological features affecting intensity and rate of spread

d. Slope

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e. Aspect
f. Fuels – Interpreted from GAP Vegetation information.

Values – Natural or man-made components of the ecosystem on which a value can be placed

g. Housing Density – Life and property

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."

Another method of estimating vulnerability 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. The total building exposure value is $729,737,204 according to this analysis. The Redzone analysis also includes a buffer zone to exhibit potential areas at risk within 2 miles of the Redzone. Since wildfires can spread rapidly, it is important to consider areas close to the Redzone boundary. According to the Redzone Buffer analysis, the total building exposure value is $7,003,102,068. The table below summarizes exposure by jurisdiction. Table 4.58 illustrates the exposure values within the Redzones and Redzone buffers in the Region. County maps can be referenced in the county annexes.

Any flammable materials are vulnerable during a wildfire, including structures and personal property. The vulnerability of general property increases as the distance of the property to wildfire-prone areas decreases, and is particularly high for structures located in the WUI. These structures receive an even higher level of vulnerability if the properties surrounding them are not properly mitigated for fire. Appropriate mitigation techniques include using non-flammable materials such as concrete for construction, leaving appropriate spaces between buildings and vegetation areas filled with non-flammable materials (such as decorative rock or stone), and clearing of underbrush and trees.

Table 4.63. Buildings and Population Exposed to Redzone Areas by Jurisdiction

County	Building Count	Improved Value	Est. Content Value	Total Exposure	Population
Lincoln	1,113	$206,542,834	$120,746,140	$327,288,974	2,096
Sweetwater	980	$221,035,807	$137,854,223	$358,890,030	668
Uinta	196	$27,708,544	$15,849,656	$43,558,200	476
Total	2,289	$455,287,185	$274,450,019	$729,737,204	3,239

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Table 4.64. Buildings and Population Exposed to a 2-Mile Buffer of Redzone Areas

County	Building Count	Improved Value	Est. Content Value	Total Exposure	Population
Lincoln	6,814	$1,084,008,865	$652,231,932	$1,736,240,797	16,533
Sweet-water	13,017	$2,459,453,681	$1,563,600,175	$4,023,053,856	30,663
Uinta	5,126	$770,824,283	$472,983,133	$1,243,807,416	12,477
Total	24,957	$4,314,286,829	$2,688,815,239	$7,003,102,068	59,673

Essential Infrastructure, Facilities, and Other Important Community Assets

These aspects of the region may be exposed directly or indirectly to wildfire. Direct exposures are similar to those of General Property and increase as the infrastructure or facilities and capabilities moves into the WUI zone. Communications lines passing through susceptible areas such as forests are more exposed than those located in cities and other more urban areas. The indirect exposure of response capability increases seasonally and with the number of occurrences. Though the populations making up the response capability are not directly exposed to all fire events, the response of some of the personnel to an event lessens the capabilities overall for response to other emergency situations. If there is a large increase in the number of simultaneous wildland fires, even small ones, the response capability of the Region could easily be compromised.

Table 4.65. Critical Facilities within Redzone

County	Facility Type	Facility Count
Lincoln	Air Facility	1
	Bridge	1
	Communications	13
	Day Care Center	1
	EMS	3
	Fire Station	2
	HAZMAT	2
	Law Enforcement	2
	Public School	1
	Total	**26**
Sweetwater	Air Facility	2
	Bridge	20
	College/University	1
	Communications	59
	Day Care Center	2
	EMS	2
	Fire Station	2
	HAZMAT	2
	Hospital	1

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County	Facility Type	Facility Count
	Law Enforcement	2
	Public School	4
	Total	**97**
Uinta	Bridge	4
	Communications	7
	Total	**11**
	Grand Total	**134**

Table 4.66. Critical Facilities within Redzone Buffer

County	Facility Type	Facility Count
Lincoln	Air Facility	6
	Bridge	29
	Communications	118
	Day Care Center	3
	EMS	3
	Fire Station	3
	HAZMAT	8
	Hospital	2
	Law Enforcement	8
	Local EOC	1
	Natural Gas Market Hub	1
	Nursing Home	2
	Power Plant	2
	Public Health Department	2
	Public School	11
	Total	**199**
Sweetwater	HAZMAT	1
	Bridge	95
	Communications	203
	Day Care Center	14
	EMS	8
	Fire Station	7
	HAZMAT	23
	Law Enforcement	7
	Local EOC	1
	National Shelter System Facility	2
	Nursing Home	2
	Private School	2
	Public Health Department	2

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County	Facility Type	Facility Count
	Public School	18
	Total	**385**
Uinta	Air Facility	2
	Bridge	56
	Communications	73
	Day Care Center	4
	EMS	2
	Fire Station	7
	HAZMAT	8
	Hospital	2
	Law Enforcement	2
	Local EOC	1
	Natural Gas Market Hub	1
	Nursing Home	3
	Public Health Department	1
	Public School	10
	Urgent Care Facility	1
	Total	**173**
	Grand Total	**757**

Natural, Historic and Cultural Resources

According to GIS mapping, Pine Creek Ski Resort and Fossil Butte Monument are vulnerable to wildfires. These areas provide recreational opportunities for locals and visitors in Lincoln County. Fossil Butte Monument contains some of the world's best preserved fossils in the flat-topped ridges. Fossilized fish, insects, plants, and other animals provide insight into the ancient subtropical landscape of Wyoming.

Sweetwater County also has multiple preserved sites that are vulnerable to wildfires. These areas include Flaming Gorge, White Mountain Petroglphys, WWCC College, and Seedskadee National Wildlife Refuge. Wildfires in this region would put many natural and cultural resources potentially at risk. Damage to these areas would also have a regional impact on summer tourism.

Fort Bridger State Historic Site and Bear River State Park are two sites with cultural significance that are near historic fire locations. Wildfires in this region would have an impact on tourism and would put resources at risk in Uinta County.

Other natural resources and natural areas may actually benefit from wildland fire, as at some level they must also be exposed to wildfire for a healthy ecological development of the area. Historic and cultural resources exhibit a vulnerability rating similar to those in general property, where vulnerability ratings increase the further into the WUI the property is, and the less mitigated the

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landscaping surrounding the property is. In addition, older buildings may be exempt from internal fire mitigation such as sprinklers and fire suppression technology, which may increase the vulnerability of the resource.

Future Development

The wildland/urban interface (WUI) is a very popular building location, as shown by national and statewide trends. More and more homes are being built in the interface. Overall, Wyoming has less developed wildland urban interface than most western states. According to the 2016 Wyoming Hazard Mitigation Plan the areas of highest existing risk from wildfire (number of square miles of the wildland urban interface with homes now) mainly occur within Park, Teton and northern Lincoln Counties. Throughout Wyoming there remains potential for future home construction in undeveloped, forested private lands adjacent to fire-prone public lands. Building homes in these high-risk areas would put lives and property in the path of wildfires. Regulating growth in these areas will be a delicate balance between protecting private property rights and promoting public safety. Should the region begin to experience this type of growth, local government may wish to consider regulation of subdivision entrance/exit roads and bridges for the safety of property owners and fire personnel, building considerations pertaining to land on slopes greater than 25% (in consideration of access for fire protection of structures), and water supply requirements set forth to include ponds, access by apparatus, pumps, and backup generators. Such standards serve to protect residents and property, as well as emergency services personnel.

Summary

Wildfires occur within the region on generally an annual basis. Based on GIS analysis, the Region has over $729 million in building value potentially at risk to wildland fires in the Redzone. This estimate is not including the extended buffer, which would reach over $7 billion in building value potentially at risk. 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.

Overall, wildfire is a high hazard to the Region. County ratings are noted in the table below.

Table 4.67. Wildfire Hazard Risk Summary

County	Likelihood	Spatial Extent	Potential Magnitude	Significance
Lincoln	Likely	Significant	Limited	High
Sweetwater	Likely	Significant	Limited	High
Uinta	Likely	Significant	Limited	High

Municipalities Impacted:

- Alpine

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- Star Valley
- Pomeroy Subdivision
- Cokeville
- Fontenelle
- Pine Creek Ski
- Canyon Club
- Nugget
- Hobble Creek
- Sage Jct.
- Rock Springs
- Granger
- Green River
- Twin Creek
- Meeks Cabin
- Wild River
- Gilbert Creek
- Bear River Divide
- Evanston North
- Piedmont
- Robertson
- Table Mountain

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5 MITIGATION STRATEGY

Requirement §201.6(c)(3): [The plan shall include] a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.

5.1 Mitigation Strategy: Overview

This section describes the mitigation strategy process and mitigation action plan for the Region 4 Hazard Mitigation Plan. It describes how the counties in the Region met the following requirements from the 10-step planning process:

- Planning Step 6: Set Goals
- Planning Step 7: Review Possible Activities
- Planning Step 8: Draft an Action Plan

The results of the planning process, the risk assessment, the goal setting, the identification of mitigation actions, and the hard work of each county's HMPC led to this mitigation strategy and action plan. Section 5.2 below identifies the goals of this plan and Section 5.4 describes the mitigation action plan.

5.2 Goals and Objectives

Requirement §201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

Up to this point in the planning process, each county's HMPC had organized resources, assessed hazards and risks, and documented mitigation capabilities; the resulting goals and mitigation actions were developed and updated based on these tasks. During the development of this plan, each county held a series of meetings designed to achieve a collaborative mitigation strategy as described further throughout this section.

During the first set of planning workshops held in May 2016, the counties reviewed the results of the hazard identification, vulnerability assessment, capability assessment and goals from previous county-level hazard mitigation plans as well as the State of Wyoming Multi-Hazard Mitigation Plan. This analysis of the risk assessment identified areas where improvements could be made and provided the framework for the counties to update (or formulate, in Sweetwater County's case) planning goals and to base the development of new or updated mitigation strategies for the counties in the Region.

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Goals were defined for the purpose of this mitigation plan as broad-based public policy statements that:

- Represent basic desires of the community;
- Encompass all aspects of community, public and private;
- Are nonspecific, in that they refer to the quality (not the quantity) of the outcome;
- Are future-oriented, in that they are achievable in the future; and
- Are time-independent, in that they are not scheduled events.

Goals are stated without regard to implementation. Implementation cost, schedule, and means are not considered. Goals are defined before considering how to accomplish them so that they are not dependent on the means of achievement. Goal statements form the basis for objectives and actions that will be used as means to achieve the goals. Objectives define strategies to attain the goals and are more specific and measurable and are sometimes developed in mitigation planning as an intermediate step between goals and mitigation actions or projects.

The update/development of goals for each county in the region was initiated through a facilitated discussion at the first planning workshops held in 2016 (Risk Assessment and Goals workshop). The HMPC members were provided a PowerPoint presentation that explained goals, objectives and actions and listed examples of each. Existing plan goals and related plan goals were noted in the PowerPoint, including the State of Wyoming Multi-Hazard Mitigation Plan (2016). This review was to ensure that the Regional plan's mitigation goals were aligned and integrated with existing plans and policies. Based on discussion at the HMPC meetings the groups decided that the mission statement from the Wyoming Multi-Hazard Mitigation Plan was applicable as an overall mission statement for the Region as well.

The mission statement of the Region 4 Mitigation Plan is to "*reduce or eliminate risk to human life and property from hazards.*"

Based on this mission statement, the risk assessment review and the goals development/update process, each county identified or updated county-specific goals which provide the direction for reducing future hazard-related losses within the county and regional planning area. During the 2016 Regional Plan development process, the counties all felt that the State of Wyoming Multi-Hazard Mitigation Plan goals provided a good baseline, with some modifications. Therefore, all counties adopted the same goals for the planning process. The updated goal statements for each county in the Region are noted below.

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Region 4 Goals

Goal 1: Strengthen public infrastructure

Goal 2: Improve local mitigation capabilities

Goal 3: Reduce economic losses due to hazard events

Goal 4: Reduce local costs of response and recovery

Goal 5: Increase public awareness and participation in hazard mitigation

5.3 Identification and Analysis of Mitigation Actions

Requirement §201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

The next step in the mitigation strategy is to identify and analyze a comprehensive range of specific mitigation actions and projects to reduce the effects of each hazard on new and existing buildings and infrastructure. During the 2016 Regional Plan development each county's HMPC analyzed viable mitigation options by hazard that supported the identified goals. The HMPC was provided with the following list of categories of mitigation actions, which originate from the Community Rating System:

- **Prevention**: Administrative or regulatory actions or processes that influence the way land and buildings are developed and built.
- **Property protection**: Actions that involve the modification of existing buildings or structures to protect them from a hazard or remove them from the hazard area.
- **Structural**: Actions that involve the construction of structures to reduce the impact of a hazard.
- **Natural resource protection**: Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural systems.
- **Emergency services**: Actions that protect people and property during and immediately after a disaster or hazard event.
- **Public information/education and awareness:** Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigate them.

In order to identify and select mitigation actions to support the mitigation goals, each hazard identified and profiled in Chapter 4 was evaluated. At the mitigation strategy workshops the counties were also provided a matrix showing examples of potential mitigation action alternatives for each of the above categories, for each of the identified hazards. The counties were also provided a handout that explains the categories and provided further examples. Finally, another reference document titled "Mitigation Ideas" developed by FEMA was distributed. This document lists the

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common alternatives for mitigation by hazard. The counties were asked to consider both future and existing buildings in considering possible mitigation actions. A facilitated discussion then took place to examine and analyze the options. Appendix C provides the matrix of alternatives considered. Each proposed action was written on a large sticky note and posted on flip charts in the meeting rooms underneath the hazard it addressed. The result was a number of new project ideas with the intent of reducing the impacts of the identified hazards.

The mitigation strategy is based on existing local authorities, policies, programs, and resources, as well as the ability to expand on and improve these existing tools. As part of the Regional Plan development the county planning teams reviewed existing capabilities for reducing long-term vulnerability to hazards. Those capabilities are noted by jurisdiction in the county annexes and can be assessed to identify gaps to be addressed and strengths to enhance through new mitigation actions. For instance, gaps in design or enforcement of existing regulations be addressed through additional personnel or a change in procedure or policy.

Based upon the key issues identified in the risk assessment, including the capability assessment, the counties came to consensus on proposed mitigation actions for each hazard for their jurisdictions. Certain hazards' impacts were best reduced through multi-hazard actions. A lead for each new action was identified to provide additional details on the project so they could be captured in the plan. Final action strategies are discussed in Section 5.4.

5.3.1 Prioritization Process

Once the mitigation actions were identified, the county planning teams were provided FEMA's recommended prioritization criteria STAPLEE to assist in deciding why one recommended action might be more important, more effective, or more likely to be implemented than another. STAPLEE is an acronym for the following:

- Social: Does the measure treat people fairly? (e.g., different groups, different generations)
- Technical: Is the action technically feasible? Does it solve the problem?
- Administrative: Are there adequate staffing, funding, and other capabilities to implement the project?
- Political: Who are the stakeholders? Will there be adequate political and public support for the project?
- Legal: Does the jurisdiction have the legal authority to implement the action? Is it legal?
- Economic: Is the action cost-beneficial? Is there funding available? Will the action contribute to the local economy?
- Environmental: Does the action comply with environmental regulations? Will there be negative environmental consequences from the action?

Other criteria used to assist in evaluating the priority of a mitigation action includes:

- Does the action address hazards or areas with the highest risk?

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- Does the action protect lives?
- Does the action protect infrastructure, community assets or critical facilities?
- Does the action meet multiple objectives (Multiple Objective Management)?

At the mitigation strategy workshops, the counties used STAPLEE to determine which of the new identified actions were most likely to be implemented and effective. Keeping the STAPLEE criteria in mind, each member 'voted' for the new mitigation actions by sticking a colored dot on the sticky note on which the action was written. The number of dots next to each action was totaled as an indication of relative priority and translated into 'high,' 'medium' and 'low.' The results of the STAPLEE evaluation process produced prioritized mitigation actions for implementation within the planning area.

The process of identification and analysis of mitigation alternatives allowed the county planning teams to come to consensus and to prioritize recommended mitigation actions for their jurisdictions. During the voting process, emphasis was placed on the importance of a benefit-cost review in determining project priority as this is a requirement of the Disaster Mitigation Act regulations; however, this was a planning level analysis as opposed to a quantitative analysis. Quantitative cost-benefit analysis will be considered in additional detail when seeking FEMA mitigation grant funding for eligible projects identified in this plan.

Each mitigation action developed for this plan contains a description of the problem and proposed project, the entity with primary responsibility for implementation, any other alternatives considered, a cost estimate, expected project benefits, potential funding sources, and a schedule for implementation. Development of these project details for each action led to the determination of a high, medium, or low priority for each.

5.4 Mitigation Action Plan

Requirement §201.6(c)(3)(iii): [The mitigation strategy section shall include] an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

This section outlines the development of the mitigation action plan. The action plan consists of the specific projects, or actions, designed to meet the plan's goals. Over time the implementation of these projects will be tracked as a measure of demonstrated progress on meeting the plan's goals.

5.4.1 Progress on Previous Mitigation Actions

This Regional Plan represents a plan update for Lincoln and Uinta counties. The mitigation actions in these county's plans provided the basis for the updates of mitigation action strategies. As part of the update process these two counties reviewed the previously identified actions to assess

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progress on implementation. These reviews were completed using worksheets to capture information on each action including if the action was completed or deferred to the future. Actions that were not completed were discussed for continued relevance and were either continued in the Plan or in some cases recommended for deletion.

The counties and the majority of their participating jurisdictions have been very successful in implementing actions identified in their respective plans' Mitigation Strategy, thus, working steadily towards meeting each plan's goals. Progress on mitigation actions previously identified in these planning mechanisms are detailed in the mitigation action strategy in the Lincoln and Uinta county annexes. These action plans were also shared amongst the regional plan participants to showcase progress and stimulate ideas amongst the respective planning committees in each county. Reasons that some actions have not been completed include low priority, lack of funding, or lack of administrative resources. See the county annexes for more details on progress on implementation.

5.4.2 Continued Compliance with NFIP

Given the significance of the flood hazard in the planning area and as required by DMA, an emphasis will be placed on continued compliance with the National Flood Insurance Program (NFIP). Counties and jurisdictions that participate in the NFIP will continue to make every effort to remain in good standing with the program. This includes continuing to comply with the NFIP's standards for updating and adopting floodplain maps and maintaining and updating the floodplain zoning ordinance. Actions related to continued compliance include:

- Continued designation of a local floodplain manager whose responsibilities include reviewing floodplain development permits to ensure compliance with the local floodplain management ordinances and rules;
- Suggest changes to improve enforcement of and compliance with regulations and programs;
- Participate in Flood Insurance Rate Map updates by adopting new maps or amendments to maps;
- Utilize Digital Flood Insurance Rate maps in conjunction with GIS to improve floodplain management, such as improved risk assessment and tracking of floodplain permits;
- Promote and disperse information on the benefits of flood insurance.

Also to be considered are the flood mitigation actions contained in this Regional Plan that support the ongoing efforts by participating counties to minimize the risk and vulnerability of the community to the flood hazard, and to enhance their overall floodplain management program. It is also important to note that a defined mitigation action for Sweetwater County is to educate the public about the NFIP since multiple jurisdictions have opted out of the program.

5.4.3 Mitigation Action Plan

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The action plan presents the recommendations developed by the county planning teams, outlining how each county and the Region can reduce the risk and vulnerability of people, property, infrastructure, and natural and cultural resources to future disaster losses. The mitigation actions developed by the counties are detailed in the county annexes. These details include the action description, hazard(s) mitigated, lead and partner agencies responsible for initiating implementation, costs, and timeline. Many of the action items included in this plan are a collaborative effort among local, state, and federal agencies and stakeholders in the planning area.

Further, it should be clarified that the actions included in this mitigation strategy are subject to further review and refinement; alternatives analyses; and reprioritization due to funding availability and/or other criteria. The counties are not obligated by this document to implement any or all of these projects. Rather, this mitigation strategy represents the desires of the community to mitigate the risks and vulnerabilities from identified hazards. The counties also realize that new needs and priorities may arise as a result of a disaster or other circumstances and reserves the right to support new actions, as necessary, as long as they conform to their overall goals, as listed in this plan.

Where feasible it is recommended that mitigation be integrated and implemented through existing planning mechanisms. Specific related mechanisms such as Community Wildfire Protection Plans, are noted in the county annexes.

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6 PLAN ADOPTION, IMPLEMENTATION AND MAINTENANCE

Requirement §201.6(c)(4): [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

Implementation and maintenance of the plan is critical to the overall success of hazard mitigation planning. This is Planning Step 10 of the 10-step planning process. This chapter provides an overview of the overall strategy for plan implementation and maintenance and outlines the method and schedule for monitoring, updating, and evaluating the plan. The chapter also discusses incorporating the plan into existing planning mechanisms and how to address continued public involvement.

6.1 Formal Adoption

The purpose of formally adopting this plan is to secure buy-in from participating jurisdictions, raise awareness of the plan, and formalize the plan's implementation. The adoption of this plan completes Planning Step 9 of the 10-step planning process: Adopt the Plan. The governing board for each participating jurisdiction has adopted this local hazard mitigation plan by passing a resolution. A copy of the generic resolution and the executed copies are included in Appendix E, Plan Adoption. This plan will be updated and re-adopted every five years in concurrence with the required DMA local plan update requirements.

6.2 Implementation

Once adopted, the plan faces the truest test of its worth: implementation. While this plan contains many worthwhile actions, each County and jurisdiction will need to decide which action(s) to undertake first. Two factors will help with making that decision: the priority assigned the actions in the planning process and funding availability. Low or no-cost actions most easily demonstrate progress toward successful plan implementation.

Mitigation is most successful when it is incorporated into the day-to-day functions and priorities of government and development. Implementation will be accomplished by adhering to the schedules identified for each action and through constant, pervasive, and energetic efforts to network and highlight the benefits to the counties, communities and stakeholders. This effort is achieved through the routine actions of monitoring meeting agendas for hazard mitigation related initiatives, coordinating on the topic at meetings, and promoting a safe, sustainable community. Additional mitigation strategies could include consistent and ongoing enforcement

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of existing policies and vigilant review of programs for coordination and multi-objective opportunities.

Simultaneous to these efforts, it is important to maintain a constant monitoring of funding opportunities that can be leveraged to implement some of the more costly recommended actions. This will include creating and maintaining a bank of ideas on how to meet local match or participation requirements. When funding does become available, the Region and its counties will be in a position to capitalize on the opportunity. Funding opportunities to be monitored include special pre- and post-disaster funds, state and federal earmarked funds, benefit assessments, and other grant programs, including those that can serve or support multi-objective applications.

6.2.1 Role of Hazard Mitigation Planning Committee in Implementation and Maintenance

With adoption of this plan, the Region and its counties will be responsible for the plan implementation and maintenance. Each county, led by their emergency management agency, will reconvene their HMPC for plan implementation and maintenance. This HMPC will be the same committee (in form and function, if not actual individuals) that developed this HMP and will also be responsible for the next formal update to the plan in five years.

Each county's HMPC will:

- Act as a forum for hazard mitigation issues;
- Disseminate hazard mitigation ideas and activities to all participants;
- Pursue the implementation of high-priority, low/no-cost recommended actions;
- Ensure hazard mitigation remains a consideration for community decision makers;
- Maintain a vigilant monitoring of multi-objective cost-share opportunities to help the community implement the plan's recommended actions for which no current funding exists;
- Monitor and assist in implementation and update of this plan;
- Report on plan progress and recommended changes to county and municipal officials; and
- Inform and solicit input from the public.

Each HMPC will not have any powers over respective county staff; it will be purely an advisory body. The primary duty is to see the plan successfully carried out and to report to the county commissioners, municipal boards, and the public on the status of plan implementation and mitigation opportunities. Other duties include reviewing and promoting mitigation proposals, considering stakeholder concerns about hazard mitigation, passing concerns on to appropriate entities, and posting relevant information on county websites (and others as appropriate).

6.3 Maintenance

Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as progress, roadblocks, or changing circumstances are recognized.

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6.3.1 Maintenance Schedule

The emergency management coordinators are responsible for initiating plan reviews and consulting with the heads of participating departments in their own counties. In order to monitor progress and update the mitigation strategies identified in the action plan, each county and their standing HMPC will conduct an annual review of this plan and/or following a hazard event. An annual mitigation action progress report will be prepared by the HMPC and kept on file to assist with for future updates. The annual review will be conducted by re-convening each HMPC in November of each year.

This plan will be updated, approved and adopted within a five-year cycle as per Requirement §201.6(c)(4)(i) of the Disaster Mitigation Act of 2000 unless disaster or other circumstances (e.g., changing regulations) require a change to this schedule. The Region and its counties will inquire with WOHS and FEMA for funds to assist with the update. It is recommended to begin seeking funds in 2019 as most applicable grants have multiple years to expend the funds. Funding sources may include the Emergency Management Performance Grants, Pre- Disaster Mitigation, Hazard Mitigation Grant Program (if a presidential disaster has been declared), and Flood Mitigation Assistance grant funds. The next plan update should be completed and reapproved by WOHS and FEMA Region VIII within five years of the FEMA final approval date. The planning process to prepare the update should begin no later than 12 months prior to that date.

6.3.2 Maintenance Evaluation Process

Evaluation of progress can be achieved by monitoring changes in vulnerabilities identified in the plan. Changes in vulnerability can be identified by noting:

- Decreased vulnerability as a result of implementing recommended actions;
- Increased vulnerability as a result of new or altered hazards
- Increased vulnerability as a result of new development.

Updates to this plan will:

- Consider changes in vulnerability due to action implementation;
- Document success stories where mitigation efforts have proven effective;
- Document areas where mitigation actions were not effective;
- Document any new hazards that may arise or were previously overlooked;
- Incorporate new data or studies on hazards and risks;
- Incorporate new capabilities or changes in capabilities;
- Incorporate growth and development-related changes to infrastructure inventories; and
- Incorporate new action recommendations or changes in action prioritization.

In order to best evaluate any changes in vulnerability as a result of plan implementation, each County will adhere to the following process:

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- A representative from the responsible office identified in each mitigation measure will be responsible for tracking and reporting on an annual basis to the department lead on action status and provide input on whether the action as implemented meets the defined objectives and is likely to be successful in reducing vulnerabilities.
- If the action does not meet identified objectives, the lead will determine what additional measures may be implemented, and an assigned individual will be responsible for defining action scope, implementing the action, monitoring success of the action, and making any required modifications to the plan.

Changes will be made to the plan to accommodate for actions that have failed or are not considered feasible after a review of their consistency with established criteria, time frame, community priorities, and/or funding resources. Actions that were not ranked high but were identified as potential mitigation activities will be reviewed as well during the monitoring and update of this plan to determine feasibility of future implementation. Updating of the plan will be by written changes and submissions, as each HMPC deems appropriate and necessary, and as approved by the respective participating agencies. In keeping with the five-year update process, the HMPC will convene public meetings to solicit public input on the plan and its routine maintenance and the final product will be adopted by the governing council.

6.3.3 Incorporation into Existing Planning Mechanisms

Another important implementation mechanism that is highly effective and low-cost is incorporation of the hazard mitigation plan recommendations and their underlying principles into other County plans and mechanisms. Where possible, plan participants will use existing plans and/or programs to implement hazard mitigation actions. As described in each county annex capability assessment, the Counties already implement policies and programs to reduce losses to life and property from hazards. This plan builds upon the momentum developed through previous and related planning efforts and mitigation programs and recommends implementing actions, where possible, through these other program mechanisms. Where applicable, these existing mechanisms could include:

- County or community comprehensive plans
- County or community land development codes
- County or community emergency operations plans
- Threat and Hazard Identification and Risk Assessments (THIRA)
- Community Wildfire Protection Plans (CWPP)
- Transportation plans
- Capital improvement plans and budgets
- Recovery planning efforts
- Watershed planning efforts
- Wildfire planning efforts on adjacent public lands
- Master planning efforts

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- Greenway or river corridor planning efforts
- Other plans, regulations, and practices with a mitigation aspect

HMPC members involved in these other planning mechanisms will be responsible for integrating the findings and recommendations of this plan with these other plans, programs, etc, as appropriate. As described in Section 7.1 Implementation, incorporation into existing planning mechanisms will be done through the process of:

- Monitoring other planning/program agendas;
- Attending other planning/program meetings;
- Participating in other planning processes;
- Ensuring that the related planning process cross-references the hazard mitigation plan, where appropriate, and
- Monitoring community budget meetings for other community program opportunities.

The successful implementation of this mitigation strategy will require constant and vigilant review of existing plans and programs for coordination and multi-objective opportunities that promote a safe, sustainable community.

Efforts should continuously be made to monitor the progress of mitigation actions implemented through these other planning mechanisms and, where appropriate, their priority actions should be incorporated into updates of this hazard mitigation plan.

6.3.4 Continued Public Involvement

Continued public involvement is imperative to the overall success of the plan's implementation. The update process provides an opportunity to solicit participation from new and existing stakeholders and to publicize success stories from the plan implementation and seek additional public comment. The plan maintenance and update process will include continued public and stakeholder involvement and input through attendance at designated committee meetings, web postings, press releases to local media, and through public hearings.

When each HMPC reconvenes for the update, they will coordinate with all stakeholders participating in the planning process—including those that joined the committee since the planning process began—to update and revise the plan. Public notice will be posted and public participation will be invited, at a minimum, through available website postings and press releases to the local media outlets, primarily newspapers, or through public surveys. As part of this effort, at least one public meeting will be held and public comments will be solicited on the plan update draft.

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