# 3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

| 44 CFR Part 201 Requirement: |
| --- |
| *[The State plan must include] Risk assessments that provide the factual basis for activities proposed in the strategy portion of the mitigation Plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments.* |

The Hazard Identification and Risk Assessment (HIRA) lays the foundation for the South Dakota Multi-Hazard Mitigation Plan. It sets the stage for identifying mitigation goals and activities to help the State become disaster resilient and keep South Dakota residents safe. The major components of this HIRA include a hazard identification/analysis and a vulnerability analysis that answer the following questions: What are the hazards that could affect South Dakota? What can happen as a result of those hazards? How likely is each of the possible outcomes? When the possible outcomes occur, what are the likely consequences and losses, and how does this vary across the state? This section attempts to answer these questions on a hazard-by-hazard basis, based on best available data.

The Federal Emergency Management Agency (FEMA) defines risk assessment terminology as follows:

- **Hazard** - A hazard is an act or phenomenon that has the potential to produce harm or other undesirable consequences to a person or thing.
- **Vulnerability** - Vulnerability is susceptibility to physical injury, harm, damage, or economic loss. It depends on an asset's construction, contents, and economic value of its functions.
- **Exposure** - Exposure describes the people, property, systems, or functions that could be lost to a hazard. Generally, exposure includes what lies in the area the hazard could affect.
- **Risk** - Risk depends on hazards, vulnerability, and exposure. It is the estimated impact that a hazard would have on people, services, facilities, and structures in a community. It refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage.
- **Risk Assessment** - Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from hazards.

## 3.1 Identifying Hazards

| 44 CFR Part 201 Requirement: |
| --- |
| *[The State risk assessment shall include an] overview of the type…of all natural hazards that can affect the State…* |

The hazards evaluated in the HIRA include those that have occurred historically or have the potential to cause significant human and/or monetary losses in the future. The following resources were used to identify hazards that may affect the State of South Dakota:

- Federal disaster/emergency declarations (see Table 3-3)
- State South Dakota Hazard Mitigation Team (SHMT) and South Dakota Silver Jackets members
- Local hazard mitigation plans covering all 66 counties and six tribal governments
- National Risk Index Data
- Survey of Rural Electric Cooperatives (2021)
- Public input via an online survey (2013)

Based on past disaster history and population and property potentially at risk (numbers and dollars), the following hazards have emerged as the greatest concern statewide and are profiled in detail in this plan:

- Agricultural Pests and Diseases
- Drought
- Floods (flash, long-rain, snowmelt, and dam failure or levee failure floods)
- Geological Hazards (Landslides, Mudflows, Expansive Soils, Subsidence, and Earthquakes)
- Summer Storm (Hail and Lighting)
- Tornadoes
- Wildfire
- Windstorm
- Winter Storm
- Hazardous Materials

The South Dakota Hazard Mitigation Plan has matured over several update cycles, and each time the SHMT has reexamined the hazards that threaten the State. Since 2016 OEM has followed a sequenced update process to its State Plan, with a comprehensive update of the HIRA in 2021 in anticipation of the next overall Plan update in 2024. The SHMT met three times at Silver Jackets quarterly meetings between June and December 2021 to discuss the HIRA update. Wood Environment & Infrastructure Solutions, Inc. was the consultant utilized to prepare the update. During the 2021 update, all hazard profiles were updated with recent hazard events occurring since the last time the HIRA was updated during 2016-2018.

During the 2021 HIRA update the overall significance of the hazards were assessed using the methodology summarized in the table below. A hazard ranking survey was conducted with the SHMT during a meeting to assess any significant changes in perceived hazard significance since the 2016 HIRA update. The hazards of greatest significance were identified to be flooding, winter storms, wildfires, and drought.

**Table 3-1 South Dakota Hazard Significance Summary Table**

| Hazard | Geographic Extent | Potential Magnitude/Severity | Probability of Future Occurrence | Overall Significance |
|---|---|---|---|---|
| Agricultural Pests and Diseases | Limited | Limited | Likely | Medium |
| Drought | Extensive | Critical | Likely | High |
| Floods | Significant | Critical | Highly Likely | High |
| Geological Hazards | Negligible | Negligible | Occasional | Low |
| Tornadoes | Extensive | Limited | Highly Likely | Medium |
| Summer Storms | Extensive | Limited | Highly Likely | Medium |
| Wildfire | Limited | Critical | Highly Likely | High |
| Windstorm | Extensive | Limited | Highly Likely | Medium |
| Winter Storm | Extensive | Critical | Highly Likely | High |
| Hazardous Materials | Negligible | Limited | Highly Likely | Medium |

| Geographic Extent | Probability of Future Occurrences |
|---|---|
| Negligible: Less than 10 percent of planning area or isolated single-point occurrences<br>Limited: 10 to 25 percent of the planning area or limited single-point occurrences<br>Significant: 25 to 75 percent of planning area or frequent single-point occurrences | Unlikely: Less than 1 percent probability of occurrence in the next year or has a recurrence interval of greater than every 100 years.<br>Occasional: Between a 1 and 10 percent probability of occurrence in the next year or has a recurrence interval of 11 to 100 years. |

| | |
|---|---|
| Extensive: 75 to 100 percent of planning area or consistent single-point occurrences<br><br>Potential Magnitude/Severity<br>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.<br>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.<br>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.<br>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. | Likely: Between 10 and 90 percent probability of occurrence in the next year, or has a recurrence interval of 1 to 10 years<br>Highly Likely: Between 90 and 100 percent probability of occurrence in the next year or has a recurrence interval of less than 1 year.<br><br>Overall Significance<br>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.<br>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.<br>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. |

### 3.1.1 Hazards Considered but Not Included

The following natural hazards were not included in this analysis because they do not threaten South Dakota: avalanches, coastal erosion, coastal storms, hurricanes, tsunamis, and volcanoes. Other hazards considered during the 2021 HIRA update included human disease/pandemic due to the COVID-19 pandemic affecting the world from late 2019 and continuing into 2022 as of the time of this HIRA update. It was ultimately determined that other public health planning mechanisms address pandemics, and to keep the focus of the HIRA on natural hazards more commonly addressed with mitigation efforts, and funding, by OEM and other agencies.

### 3.1.2 Local Hazard Mitigation Plan Roll-up

As part of the plan update process for this HIRA, the hazard mitigation plans for each county and tribe in the State were reviewed for their content and analysis of hazard significance. A total of 58 local plans have undergone updates since the last state HIRA update in 2016, providing new risk assessment information at the local level to be incorporated into this update. The majority of the local plans in South Dakota identified and prioritized hazards in a largely consistent manner with those prioritized by the State HMP. Amongst the local plans flood was the most commonly profiled hazard, with all 70 county or tribal plans profiling the hazard. This aligns with the State Plan's identification of flood as the highest significance hazard. The next most commonly profiled hazards were wildfire, drought, tornado, and winter storms, each of which are also profiled in this plan.

Many of the local plans also identified hazards individually which are contained under the wider umbrella of a specific hazard profile that is included in this plan. For example, 24 counties profiled earthquake and 14 profiled landslides separately while both of these are included in the geological hazards profile. Similarly, many counties profiled individual hazards such as ice storms, heavy snow, and extreme cold which are all address under winter storm in this plan. Several additional hazards were identified by the local plans, but not profiled by the State Plan. While these are not explicitly profiled in this plan, the SHMT and the State Hazard Mitigation Officer (SHMO) will use this information to continue working with the local communities to understand the concerns these hazards pose, how they are in part already addressed by the State Plan, and ways they can be mitigated.

A summary of all hazards profiled by each local plan is included in Table 3-2 below, showing how many plans ranked each hazard and they priority the hazards were given. Additionally, Appendix 5 has additional details of the plan roll-up.

**Table 3-2 Summary of Local Hazard Mitigation Plan Roll-Up**

| | Ranked High | Ranked Medium | Ranked Low | Profiled, but not Ranked | Total |
|---|---|---|---|---|---|
| **Floods** | 20 | 19 | 7 | 24 | 70 |
| **Wildfires** | 9 | 21 | 14 | 23 | 67 |
| **Drought** | 20 | 21 | 3 | 20 | 64 |
| **Tornadoes** | 9 | 26 | 2 | 20 | 57 |
| **Severe Winter Storms** | 21 | 7 | 0 | 25 | 53 |
| **Windstorm** | 20 | 9 | 1 | 20 | 50 |
| **Hail** | 9 | 14 | 5 | 16 | 44 |
| **Ice Storm or Freezing Rain/Sleet** | 12 | 7 | 0 | 10 | 29 |
| **Severe Thunderstorms** | 7 | 6 | 3 | 13 | 29 |
| **Summer Storm (Hail, Lightning, High Winds, Tornadoes)** | 6 | 9 | 2 | 11 | 28 |
| **Heavy Snow** | 10 | 8 | 1 | 8 | 27 |
| **Lightning Strikes** | 4 | 9 | 6 | 8 | 27 |
| **Urban Fire** | 2 | 7 | 7 | 10 | 26 |
| **Hazardous Materials Incidents** | 1 | 5 | 4 | 16 | 26 |
| **Earthquake** | 0 | 2 | 17 | 5 | 24 |
| **Extreme Heat** | 8 | 8 | 4 | 2 | 22 |
| **Extreme Cold** | 12 | 6 | 2 | 0 | 20 |
| **Heavy Rain** | 7 | 11 | 1 | 0 | 19 |
| **Dam Failure** | 0 | 3 | 10 | 4 | 17 |
| **Ice Jam** | 0 | 7 | 10 | 0 | 17 |
| **Terrorism** | 0 | 0 | 3 | 12 | 15 |
| **Landslide and Mudflow** | 0 | 4 | 8 | 2 | 14 |
| **Spring Snow Melt** | 5 | 8 | 1 | 0 | 14 |
| **Transportation Incidents** | 0 | 4 | 0 | 7 | 11 |
| **Utility Interruption** | 5 | 2 | 3 | 1 | 11 |
| **Geologic Hazards** | 0 | 1 | 6 | 3 | 10 |

| | Ranked High | Ranked Medium | Ranked Low | Profiled, but not Ranked | Total |
|---|---|---|---|---|---|
| **Infectious Diseases/ Epidemic** | 0 | 2 | 0 | 5 | 7 |
| **Civil Disturbances** | 0 | 2 | 1 | 4 | 7 |
| **Agriculture Contamination/Illness in Livestock** | 1 | 4 | 1 | 0 | 6 |
| **Wildland/Interface Fire** | 0 | 0 | 1 | 4 | 5 |
| **Nuclear Incident** | 0 | 0 | 2 | 3 | 5 |
| **Epidemic** | 0 | 1 | 2 | 0 | 3 |
| **Aviation Incident** | 0 | 1 | 1 | 1 | 3 |
| **Communication Failure** | 2 | 1 | 0 | 0 | 3 |
| **Active Shooter** | 0 | 2 | 1 | 0 | 3 |
| **National Security Emergency** | 0 | 0 | 0 | 3 | 3 |
| **Subsidence** | 0 | 0 | 2 | 0 | 2 |
| **Motor Vehicle Transportation Incidents** | 0 | 0 | 0 | 2 | 2 |
| **Mass Casualty Incident** | 0 | 0 | 1 | 1 | 2 |
| **Avalanche** | 0 | 0 | 1 | 0 | 1 |
| **Volcano** | 0 | 0 | 1 | 0 | 1 |
| **Manmade Hazards** | 0 | 0 | 0 | 1 | 1 |
| **Railway Incident** | 0 | 0 | 0 | 1 | 1 |
| **Structural Fires** | 0 | 0 | 0 | 1 | 1 |
| **Bioterrorism** | 0 | 0 | 0 | 1 | 1 |
| **Shortage of Critical Materials** | 0 | 0 | 0 | 1 | 1 |

### 3.1.3 Non-Natural Hazards

Beyond hazardous materials, the SHMT determined not to include human-caused and technological hazards in this plan. Certain human-caused hazards are addressed in the State's Threat and Hazard Identification and Risk Analysis (THIRA), originally developed in 2012 and updated periodically. The THIRA analyzes the State's capabilities toward addressing certain natural, human-caused, and technological hazards that are anticipated to have significant impacts. The THIRA was developed in compliance with the U.S. Department of Homeland Security Comprehensive Preparedness Guide 201 by a committee led by the State's Office of Homeland Security. The THIRA was scheduled for an update in 2022.

### 3.1.4 Disaster Declaration History

Table 3-3 summarizes presidential disaster declarations, fire management assistance declarations, and emergency declarations for South Dakota since 1954 through the end of 2021. 85 presidential declarations in this 67-year period indicate that a disaster is declared in the State on average at least once a year. However, the frequency of disasters has increased in recent decades; since the early 1990's the State has had a presidential declaration on an annual basis, with many years seeing multiple declarations. These declared disasters have resulted in a total federal funding obligation of $775,920,379 to the State, which results in an average annual loss of $11,580,901.

**Table 3-3 Federal Declaration History in South Dakota 2021-1954**

| Declaration Number | Declaration Date | Counties/ Reservations (#) | Disaster Type | FEMA Disaster Relief Costs[1] (Federal Share) |
|---|---|---|---|---|
| FEMA-5418-SD | 10/4/2021 | 1 | Auburn Fire | n/a |
| FEMA-5348-FM | 3/29/2021 | 1 | Schroeder Fire | n/a |
| FEMA-4527-DR | 4/5/2020 | Statewide | COVID-19 Pandemic | $6,865,434 |
| FEMA-3536-EM | 3/13/2020 | 1 reservation | Covid-19 Pandemic | n/a |
| FEMA-3526-EM | 3/13/2020 | 1 reservation | Covid-19 Pandemic | $1,232,767* |
| FEMA-3513-EM | 3/13/2020 | 1 reservation | Covid-19 Pandemic | n/a |
| FEMA-3475-EM | 3/13/2020 | Statewide | Covid-19 Pandemic | n/a |
| FEMA-4469-DR | 11/18/2019 | 23 | Severe Storms, Tornadoes, and Flooding | $24,358,888 |
| FEMA-4467-DR | 10/7/2019 | 6 | Severe Storms, Tornadoes, and Flooding | $2,459,331 |
| FEMA-4463-DR | 9/23/2019 | 25 | Severe Storms and Flooding | $7,949,600 |
| FEMA-4448-DR | 6/20/2019 | 1 | Severe Winter Storm, Snowstorm, and Flooding | $1,179,421* |
| FEMA-4440-DR | 6/7/2019 | 58 | Severe Winter Storm, Snowstorm, and Flooding | $58,681,798 |
| FEMA-5272-FM | 8/11/2018 | 1 | Vineyard Fire | $665,425* |
| FEMA-5229-FM | 12/12/2017 | 1 | Legion Lake Fire | $3,055,336 |
| FEMA-4298-DR | 2/1/2017 | 24 | Severe Winter Storm | $11,339,993 |
| FEMA-4237-DR | 8/7/2015 | 1 reservation | Severe Storms, Straight-line Winds, and Flooding | $439,284 |
| FEMA-4233-DR | 7/30/2015 | 11 | Severe Storms, Tornadoes, Straight-line Winds, and Flooding | $3,071,933* |
| FEMA-4186-DR | 7/28/2014 | 11 | Severe Storms, Tornadoes, and Flooding | $11,144,676* |
| FEMA-4155-DR | 11/8/2013 | 11 | Severe Winter Storm, Snowstorm, and Flooding | $43,113,023* |
| FEMA-4137-DR | 8/2/2013 | 8 | Severe Storms, Tornado, and Flooding | $1,159,221* |
| FEMA-4125-DR | 6/28/2013 | 4 | Severe Storms, Tornado, and Flooding | $1,215,685* |
| FEMA-4115-DR | 5/10/2013 | 7 | Severe Winter Storm and Snowstorm | $8,231,035* |
| FEMA-5010-FM | 9/1/2012 | 1 | Wellnitz Fire | $6,664* |
| FEMA-2996-FM | 7/20/2012 | 1 | Myrtle Fire | $622,321* |
| FEMA-1984-DR | 5/13/2011 | 28 | Severe Storms and Flooding | $56,890,071 |
| FEMA-1947-DR | 11/2/2010 | 4 (1 Reservation) | Severe Storms and Flooding | $1,079,973* |
| FEMA-1938-DR | 9/23/2010 | 12 | Severe Storms and Flooding | $4,429,890* |
| FEMA-1929-DR | 7/29/2010 | 3 (1 Reservation) | Severe Storms, Tornadoes, and Flooding | $666,649* |
| FEMA-1915-DR | 5/13/2010 | 31 | Flooding | $21,498,620* |

| Declaration Number | Declaration Date | Counties/ Reservations (#) | Disaster Type | FEMA Disaster Relief Costs[1] (Federal Share) |
|---|---|---|---|---|
| FEMA-1914-DR | 5/13/2010 | 3 | Severe Winter Storm | $1,862,943* |
| FEMA-1887-DR | 3/10/2010 | 29 (3 Reservations) | Severe Winter Storm | $49,059,868* |
| FEMA-1886-DR | 3/9/2010 | 12 (2 Reservations) | Severe Winter Storm and Snowstorm | $874,503* |
| FEMA-1844-DR | 6/16/2009 | 14 (2 Reservations) | Severe Storms and Flooding | $5,301,081* |
| FEMA-1811-DR | 12/12/2008 | 13 (4 Reservations) | Severe winter storm and record and near record snow | $5,825,275* |
| FEMA-1774-DR | 7/2/2008 | 26 (3 Reservations) | Severe storms and flooding | $4,716,310* |
| FEMA-1759-DR | 5/22/2008 | 6 | Severe winter storm and record and near record snow | $7,826,996* |
| FEMA-2716-FSA | 7/21/2007 | 1 | Boxelder Fire | $387,967* |
| FEMA-2710-FSA | 7/8/2007 | 1 | Alabaugh Canyon Fire | $1,953,897* |
| FEMA-1702-DR | 5/22/2007 | 24 (3 Reservations) | Severe Storms, Tornadoes, and Flooding | $13,159,478 |
| FEMA-2658-FSA | 7/27/2006 | 1 | East Ridge Fire | $1,543,489* |
| FEMA-1647-DR | 6/5/2006 | 6 | Severe Winter Storm | $3,177,446* |
| FEMA-1620-DR | 12/20/2005 | 26 | Severe Winter Storm | $24,647,040* |
| FEMA-3234-EM | 9/10/2005 | Statewide | Hurricane Katrina Evacuation | $219,506* |
| FEMA-1596-DR | 7/22/2005 | 7 | Severe Storm (wind) | $677,995* |
| FEMA-2569-FSA | 7/16/2005 | 1 | Skyline #2 Fire | $14,231* |
| FEMA-2565-FSA | 7/10/2005 | 1 | Ricco Fire | $428,064* |
| FEMA-2557-FSA | 4/19/2005 | 1 | Camp Five Fire | n/a |
| FEMA-1531-DR | 7/20/2004 | 10 (1 Reservation) | Severe Storms and Flooding | $1,058,537* |
| FEMA-2513-FSA | 11/20/2003 | 1 | Mill Road Fire | $45,685* |
| FEMA- 2458-FSA | 8/18/2002 | 1 | Battle Creek Fire | $1,313,879* |
| FEMA-2434-FSA | 6/29/2002 | 1 | Grizzly Gulch Fire | $759,650* |
| FEMA-2369-FSA | 7/31/2001 | 1 | Elk Mountain Fire | $293,179* |
| FEMA-1375-DR | 5/17/2001 | 24 | Severe Storms (flooding) | $5,097,819* |
| FEMA-2324-FSA | 8/25/2000 | 1 | Jasper Fire | $2,496,379* |
| FEMA-2319-FSA | 8/13/2000 | 1 | Flagpole Fire | $1,050,618* |
| FEMA-1330-DR | 5/19/2000 | 7 | Winter Storm | $1,779,886* |
| FEMA-1280-DR | 6/9/1999 | 2 | Severe Storms, Flooding, and Tornadoes | $801,100* |
| FEMA-1218-DR | 6/1/1998 | 9 | Flooding, Severe Storms, and Tornadoes | $15,953,312 |
| FEMA-1173-DR | 4/7/1997 | 66 | Severe Storms, Flooding (high winds) | $82,490,180 |
| FEMA-1161-DR | 2/28/1997 | 10 | Severe Winter Storms | $2,526,209 |
| FEMA-1156-DR | 1/10/1997 | Statewide | Severe Winter Storms/Blizzards | $18,431,301 |
| FEMA-1075-DR | 1/5/1996 | 26 | Ice Storms | $12,431,366 |
| FEMA-1052-DR | 5/26/1995 | 52 | Severe Storms, Flooding | $33,866,882 |
| FEMA-1045-DR | 3/14/1995 | 21 | Severe Winter Storms | $3,627,131 |
| FEMA-2109-FSA | 8/16/1994 | 1 | Stagebarn Canyon Fire | $49,833* |

| Declaration Number | Declaration Date | Counties/ Reservations (#) | Disaster Type | FEMA Disaster Relief Costs[1] (Federal Share) |
|---|---|---|---|---|
| FEMA-1031-DR | 6/21/1994 | 21 | Severe Storm, Flooding | $7,789,915 |
| FEMA-999-DR | 7/19/1993 | 39 | Flooding, Severe Storms, Tornadoes | $50,202,256 |
| FEMA-948-DR | 7/2/1992 | 9 | Flooding, Severe Storms, Tornadoes (high winds) | $1,669,825 |
| FEMA-2076-FSA | 9/14/1990 | 1 | Swedlund Fire | $715,276* |
| FEMA-2068-FSA | 7/26/1988 | 1 | West Berry Trail Fire | n/a |
| FEMA-2061-FSA | 7/22/1987 | 1 | Battle Mountain Fire | n/a |
| FEMA-764-DR | 5/3/1986 | 25 | Severe Storms, Flooding | $4,893,611 |
| FEMA-2057-FSA | 7/15/1985 | 1 | Flint Hill Fire | n/a |
| FEMA-2056-FSA | 7/15/1985 | 1 | Seven Sisters Fire | n/a |
| FEMA-717-DR | 7/19/1984 | 9 | Severe Storms, Flooding | $4,216,001 |
| FEMA-511-DR | 6/25/1976 | 4 | Flash Flooding, Mudslides | $4,439,769 |
| FEMA-3015-EM | 6/17/1976 | 61 | Drought | n/a |
| FEMA-2017-FSA | 7/29/1975 | 1 | Custer State Park | n/a |
| FEMA-2016-FSA | 7/8/1974 | 1 | Argle & Booms Canyon | n/a |
| FEMA-336-DR | 6/10/1972 | 4 | Heavy Rains, Flooding | $111,907,010 |
| FEMA-257-DR | 4/18/1969 | 26 | Flooding | $4,369,737 |
| FEMA-197-DR | 5/26/1965 | 4 | Flooding | $3,771,780 |
| FEMA-132-DR | 7/27/1962 | 23 | Floods, Tornadoes | $3,652,937 |
| FEMA-99-DR | 4/8/1960 | 16 | Floods | $933,934 |
| FEMA-20-DR | 7/31/1954 | 2 | Floods | $252,255 |

Sources: FEMA, South Dakota Office of Emergency Management, Public Entity Risk Institute
1Costs include Public Assistance, Individual Assistance, and mitigation and are in constant 2006 dollars (with the exception disasters post-2006, which are year of event dollars). Fire costs are from the State, represent total outlays, and are not adjusted for inflation (with the exception of FEMA-2710-FSA, which is from InciWeb).
*Includes Public Assistance only

Another way to assess the significance of South Dakota's hazards is to review the patterns of past disaster declarations and the costs incurred by them. FEMA's Public Assistance Program provides supplemental grants to State, tribal, territorial, and local governments to enable communities to quickly respond to and recover from major disasters. Under the program, facilities which can be funded by public assistance must be a building, public works, system, equipment, or natural feature and work must be required as a result of the declared incident, located within the designated disaster area, and be the legal responsibility of the applicant. The federal share of assistance provided is not less than 75 percent of the eligible cost, with a 25 percent local match.

Different hazards have historically impacted South Dakota to differing levels and can reasonably be expected to continue to do so in a similar pattern. Table 3-4 The table below summarizes the public assistance funding provided to South Dakota since 1999, detailing the number of projects which received funding, the federal amount obligated, and the amount required by the State agency, as well as the incident type which triggered the federal disaster declaration. There have been 419 projects funded by public assistance since 1999, at a cost to the federal government of $36 million and state government $12 million. By far the greatest number of projects and the highest costs have been incurred by flooding, followed by severe storms. Given this trend coupled with the State's past history of disaster declarations and the future probability for these two hazards to continue as the most pressing hazards, it can be expected that they will cause the most risk to jurisdictions and state assets in the future. While disaster losses continue, the maps in Figure 3-1 and Figure 3-2 below illustrates the location of various mitigation

projects in South Dakota funded with FEMA HMA. Nearly every county has at least one project that will mitigate losses from future events.

**Table 3-4 Public Assistance by Hazard, 1999-2020**

| Incident Type | Number of Projects | Federal Amount Obligated | State Obligation |
|---|---|---|---|
| Biological | 1 | $811,668 | $270,556 |
| Coastal Storm | 6 | $208,997 | $69,666 |
| Flood | 242 | $27,262,234 | $9,087,411 |
| Severe Storm | 156 | $7,642,965 | $2,547,655 |
| Snow | 9 | $243,856 | $81,285 |
| Tornado | 5 | $191,783 | $63,928 |
| **Total** | **419** | **$36,361,503** | **$12,120,501** |

Source: OpenFEMA Data

**Figure 3-1 Hazard Mitigation Projects Funded by FEMA**

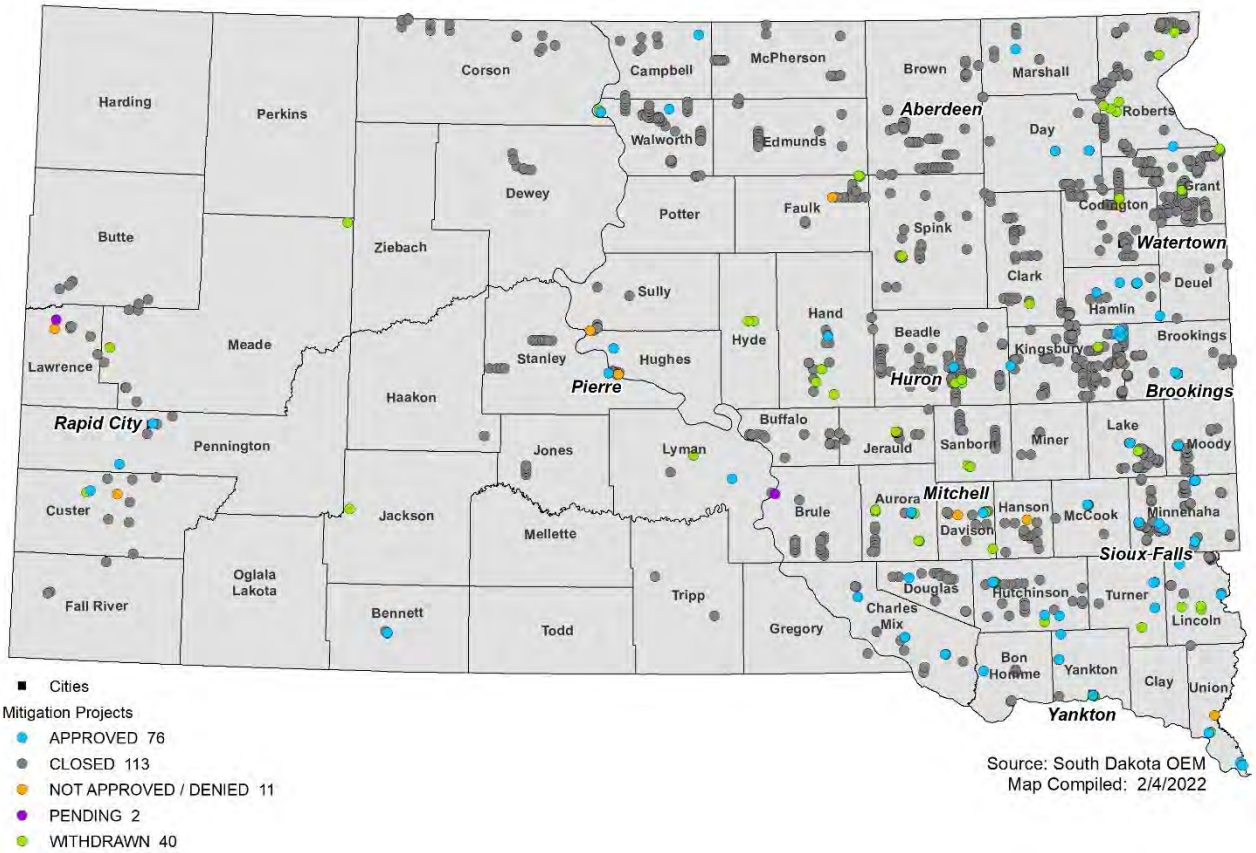
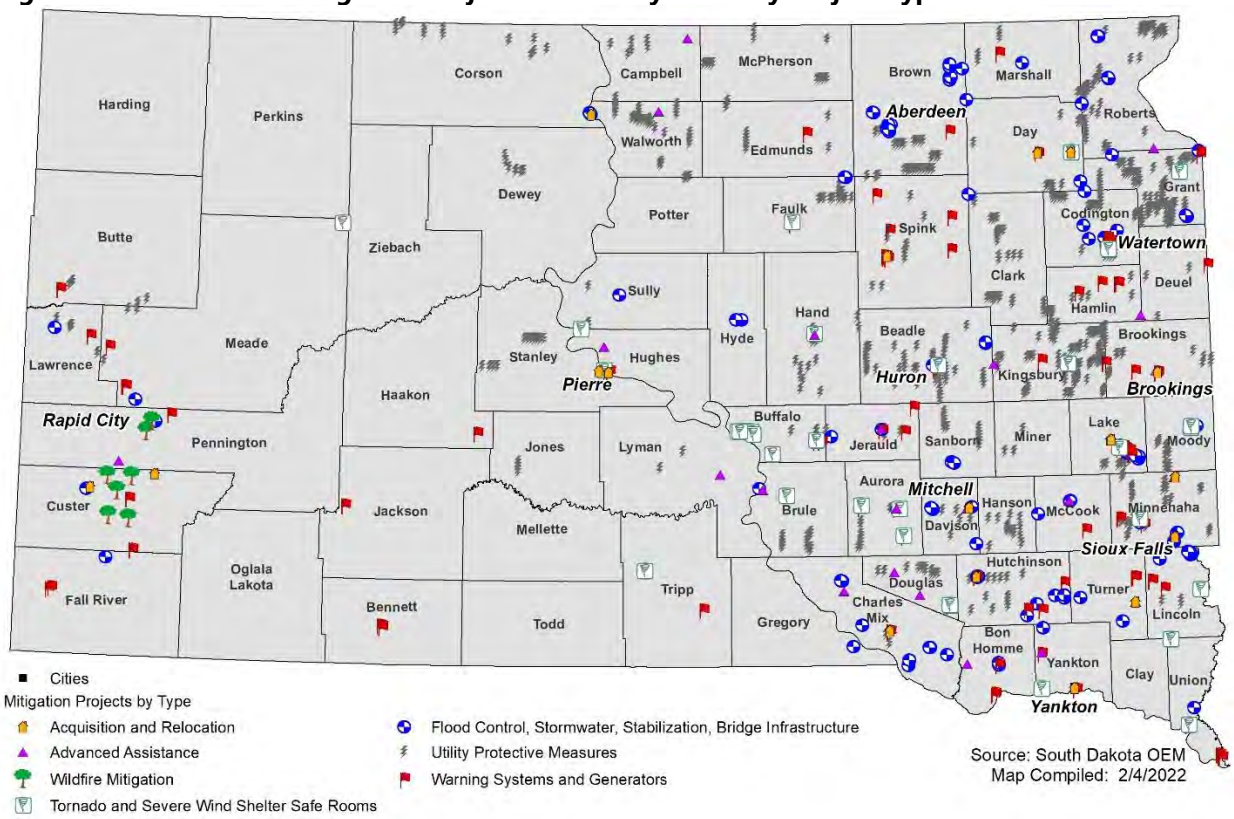


**Figure 3-2 Hazard Mitigation Projects Funded by FEMA by Project Type**




## 3.1.5 Overview of Hazard Identification and Risk Assessment

The HIRA was re-organized during the 2021 update to consolidate information by hazard that had previously been split into profiles and vulnerability sections. State Assets have been consolidated into the next section in the document to discuss the overall exposure of state property, critical facilities, and infrastructure. The Hazard Profiles section of the HIRA includes detailed information for the identified hazards. Each hazard profile includes the following subsections:

**Hazard Description** —This section gives a description of the hazard and associated issues

**Location** – This section gives a spatial description of the potential location or areas of South Dakota where the hazard expected to impact.

**Magnitude/Severity (Extent)** – This section gives a description of the potential strength or magnitude of the hazard.

**Past Events** —This section contains information on historical incidents, including impacts where known.

**Probability of Future Occurrence**—The frequency of past events is used in this section to gauge the likelihood of future occurrences.

**Climate Change Considerations -** This describes the potential for climate change to affect the frequency and intensity of the hazard in the future.

**Vulnerability -** Following the hazard profiles is a vulnerability assessment for each identified hazard. The assessment was conducted through the study of potential impacts to the following specific sectors:

- People

- Property
- State Assets, Critical Facilities, and Infrastructure
- Economy
- Environment and Cultural Resources
- Development Trends and Consequence Summary

Following the hazard profiles is a section on Rural Electric Cooperative Considerations, which summarizes vulnerability specifics to the electric providers in the State. At the end of the HIRA is a Risk Summary that captures the key issues/problems identified for each hazard, as an easy reference and for basing the update or development of mitigation strategies.

### Information Sources

Data used to support the HIRA and updates to have included the following:

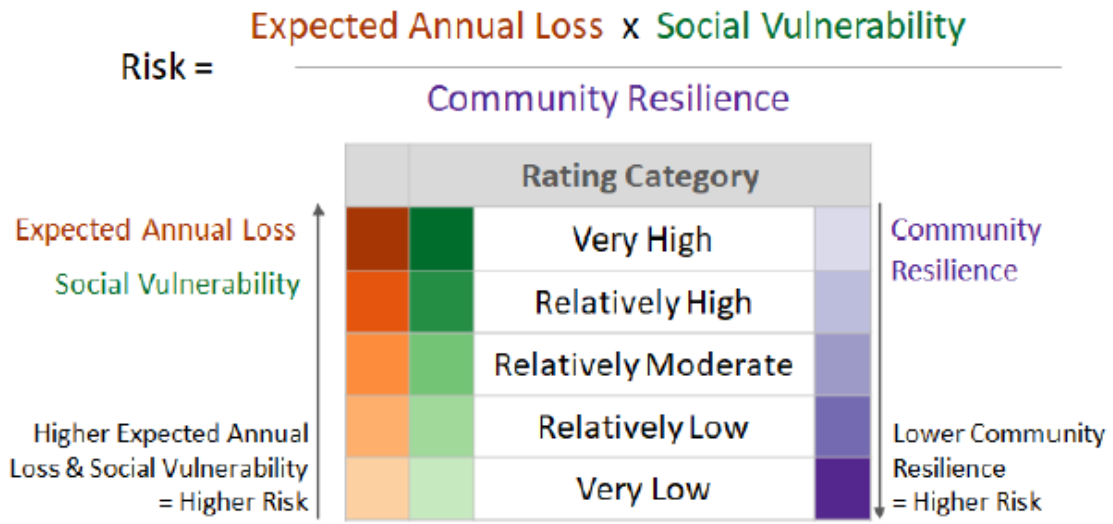
- South Dakota Agencies and Departments
- FEMA
  - National Risk Index
  - FEMA Region VIII
  - Hazus-MH
- Public Entity Risk Institute
- University of South Carolina Hazards and Vulnerability Research Institute
  - Spatial Hazard Events and Losses Database for the United States (SHELDUS)
  - Social Vulnerability Index for the United States
- National Oceanic and Atmospheric Administration
  - National Centers for Environmental Information
  - National Weather Service
- U.S. Department of Agriculture Risk Management Agency
- Federal Wildland Fire Occurrence Database
- U.S. Army Corps of Engineers
- U.S. Geological Survey
- Input given at stakeholder meetings during the 2021 update process
- Literature and written and oral communications from state and national hazard experts

## 3.1.6 National Risk Index Overview

During the 2021 HIRA update a new online risk assessment tool became available from FEMA. The National Risk Index (NRI) is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards. It was designed and built by FEMA in close collaboration with various stakeholders and partners in academia; local, state and federal government; and private industry. The Risk Index leverages available source data for natural hazard and community risk factors to develop a baseline relative risk measurement for each United States county and census tract. The NRI's interactive mapping and data-based interface enables users to visually explore individual datasets to better understand what is driving a community's natural hazard risk. Users may also create reports to capture risk details on a

community or conduct community-based risk comparisons, as well as export data for analysis using other software. Intended users of the NRI include planners and emergency managers at the local, regional, state, and federal levels, as well as other decision makers and interested members of the general public. The NRI provides relative Risk Index scores and ratings based on data for Expected Annual Loss (EAL) due to natural hazards, social vulnerability, and community resilience. Separate scores and ratings are also provided for each component: Expected Annual Loss, Social Vulnerability, and Community Resilience.

**Figure 3-3 Generalized National Risk Index Risk Equation and Components**




Source: FEMA NRI Technical documentation 2021

For the Risk Index and EAL, scores and ratings can be viewed as a composite score for all hazards or individually for each of the 18 hazard types.

**NATIONAL RISK INDEX HAZARD TYPES**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. | Avalanche | 6. | Hail | 11. | Lightning | 16. | Volcanic Activity |
| 2. | Coastal Flooding | 7. | Heat Wave | 12. | Riverine Flooding | 17. | Wildfire |
| 3. | Cold Wave | 8. | Hurricane | 13. | Strong Wind | 18. | Winter Weather |
| 4. | Drought | 9. | Ice Storm | 14. | Tornado | | |
| 5. | Earthquake | 10. | Landslide | 15. | Tsunami | | |

The NRI was evaluated by the SHMT and OEM's planning consultant to determine its applicability to South Dakota's HIRA update. Prior to 2021, the planning consultant had used similar methods to generate composite vulnerability indices for each county in South Dakota for wind, winter storm, and tornado hazards based on available census data and National Centers for Environmental Information (NCEI) incident data. Comparing these to the NRI, the SHMT and consultant found similar trends in risk rankings. An added benefit of leveraging NRI data for the update included standardized methods for assess risk on a county-by-county scale for all of the hazards in the HIRA, with the exception of agricultural pest and disease. This included composite risk indicators for hazards previously lacking necessary data, including lightning, hail, landslides, and subsets of winter storms including cold wave and ice storms. The other benefit is that moving forward, FEMA will be periodically updating and improving the NRI, which should provide a valuable and standardized resource for future HIRA updates.

Each hazard profile in the HRIA contains the following aggregate risk products, mapped by Wood using NRI products:

- Annualized Frequency
- Composite Risk Index Rating
- Expected Annual Loss

Sources of hazards and exposure data includes SHELDUS, NOAA, USGS, National Weather Service (NWS), United States Department of Agriculture (USDA). Consequences of hazard occurrences are categorized into three different types: buildings, population, and agriculture. Additional details can be referenced in the FEMA NRI Technical documentation 2021, available at https://hazards.fema.gov/nri/.

## 3.2 State Assets

| 44 CFR Part 201 Requirement: |
|---|
| *[The State risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. …State owned or operated critical facilities located in the identified hazard areas shall also be addressed….*<br><br>*The State shall update the overview and analysis of vulnerable State owned or operated buildings, critical facilities, and infrastructure, based on available data. The update should reflect acquisition or development of new properties and infrastructure.* |
| **44 CFR Part 201 Requirement:** |
| *[The State risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to state-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.* |
| **44 CFR Part 201 Enhanced Plan Requirement:** |
| *Enhanced State Mitigation Plans must include…*<br><br>*A comprehensive, multi-year plan to mitigate the risks posed to existing buildings that have been identified as necessary for post-disaster response and recovery operations.* |

State Assets which are evaluated for the purpose of determining vulnerability can include many categories, such as people, structures, critical facilities, and natural, historic, or cultural resources. The following is a discussion of the assets that can potentially be affected by hazard in South Dakota.

### 3.2.1 State Owned or Leased Property

In order to help assess the overall exposure of the State's assets, the State of South Dakota provided information pertaining to the number and value of buildings owned by various state agencies. Table 3-5 The table below summarizes the number of buildings, total square footage, insured building value, content value, and total value of facilities owned and maintained by the state. This information helps to provide an overall picture of the exposure of state assets tot hazards in South Dakota. Discussions on how vulnerability to state assets differs by hazard can be found in the State Assets, Critical Facilities, and Infrastructure subsection of each hazard profile, with more specific analysis aided by GIS where data is available.

**Table 3-5 Summary of Insured State Owned Buildings by State Agency**

| State Agency | Building Count | Total Square Footage | Building Value (Insured) | Content Value | Total Value |
|---|---|---|---|---|---|
| Office of the Attorney General | 1 | 1200 | $264,000 | $47,054 | $311,054 |
| SD Board of Regents BHSU | 28 | 872,809 | $250,097,989 | $13,590,804 | $263,688,793 |
| Board of Administration | 20 | 799,219 | $88,670,641 | $29,633,047 | $118,303,688 |
| Dakota State University | 23 | 693,755 | $193,267,859 | $18,926,332 | $212,194,191 |
| Northern State University | 27 | 1,002,954 | 283,512,137 | $23,067,591 | $306,579,728 |
| SD School for the Deaf | 1 | 43,021 | $5,469,898 | $104,565 | $5,574,463 |
| SD Board of Regents SD School for the Visually Handicapped | 1 | 44,956 | $13,740,808 | $1,025,150 | $14,765,958 |
| SD Board of Regents SD School of Mines & Technology | 22 | 886,204 | $268,142,734 | $35,148,513 | $303,291,247 |
| SDSU | 183 | 4,923,890 | $1,369,988,933 | $145,460,023 | $1,515,448,956 |
| University of South Dakota | 51 | 2,824,034 | $794,314,610 | $61,085,626 | $855,400,236 |
| South Dakota Department of Corrections | 49 | 1,263,311 | $348,627,585 | $10,541,548 | $359,169,133 |
| South Dakota Department of Game, Fish, & Parks | 88 | 466,002 | $121,134,217 | $19,111,205 | $140,245,422 |
| South Dakota Department of Human Services | 21 | 356,231 | $96,577,847 | $8,903,883 | $105,481,730 |
| South Dakota Department of Military Affairs (State share in parentheses) | 57 | 909,123 | $234,689,475 ($112,083759) | $13,079,561 ($6,594,705) | $247,769,036 ($118,678,464) |
| South Dakota Department of Social Services | 12 | 355,845 | $106,267,968 | $7,317,797 | $113,585,765 |
| South Dakota Department of Transportation | 240 | 1,602,581 | $277,800,640 | $43,588,395 | $321,389,035 |
| South Dakota Department of Agriculture/Natural Resources | 70 | 618,730 | $61,793,718 | $5,159,116 | $66,952,834 |
| South Dakota Department of Public Safety/Highway Patrol | 20 | 53,362 | $10,034,122 | $2,659,193 | $12,693,315 |
| South Dakota Federal Surplus Property | 5 | 41,280 | $3,637,239 | $238,977 | $3,876,216 |
| South Dakota Governor's Mansion | 1 | 14,550 | $6,804,000 | $526,665 | $7,330,665 |
| South Dakota Veteran's Home | 18 | 214,458 | $56,693,033 | $7,713,851 | $64,406,884 |
| South Dakota Public Broadcasting | 10 | 11,112 | $4,598,983 | $7,424,138 | $12,023,121 |
| South Dakota Department of Education | 1 | 900 | $256,597 | $39,755 | $296,352 |
| **Grand Total** | **949** | **17,999,527** | **$4,596,385,033** | **$454,392,789** | **$5,050,777,822** |

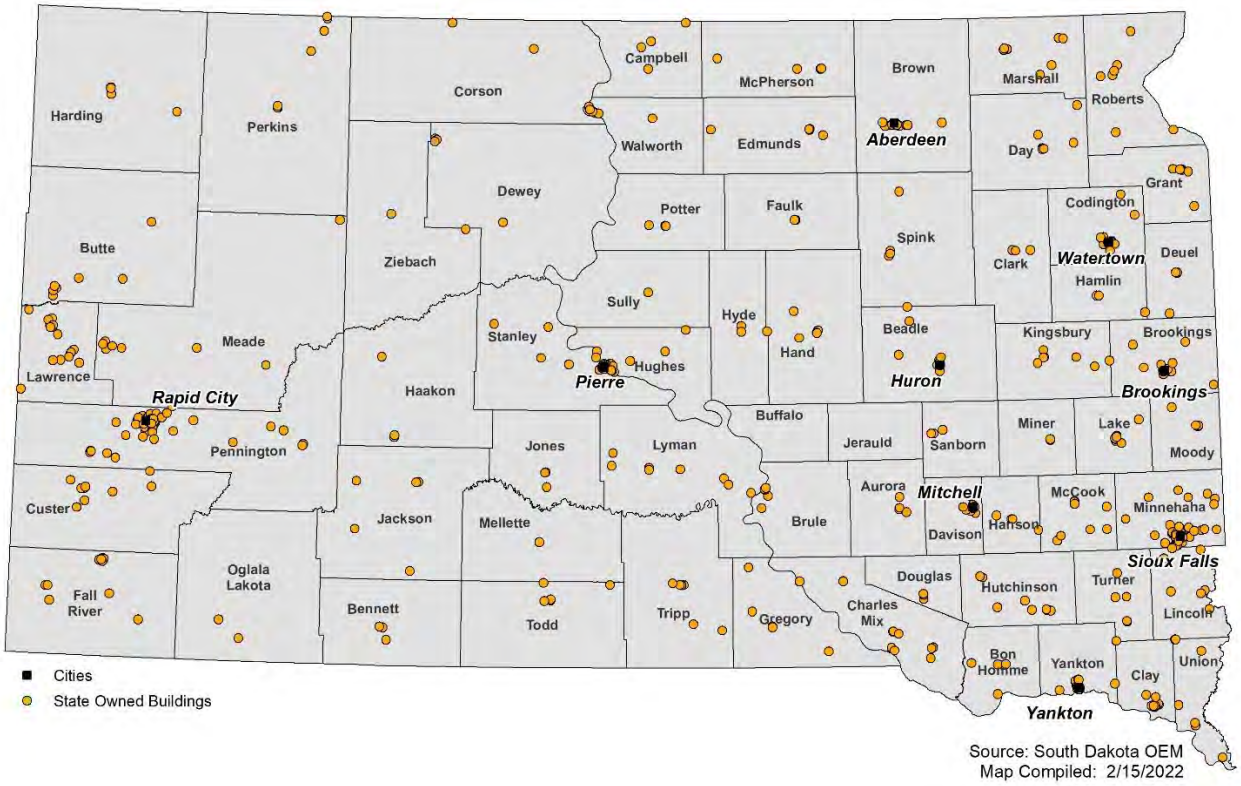
Source: Compiled by Wood from data provided by SD Office of Risk Management Feb 2022

The method used to determine vulnerability to state facilities was to overlay facilities data on digital hazard maps, where available, and identify those facilities potentially at risk. This method was used to determine vulnerability to floods and wildfire. For severe weather hazards including winter weather,

tornadoes, and wind it is generally accepted that these hazards could strike anywhere in the State at various levels of severity. Instead, an exposure analysis was used for these hazards. Exposure analyses are different from loss estimates in that they present facilities that may be exposed to these hazards, but do not attempt to estimate the amount of damages to be incurred during an event.

Some state properties were made available in a GIS database as depicted in the figure below. Building valuations are not included in the State's GIS-based facility data, thus an estimate of potential losses to state facilities is difficult to quantify. The State's facility data was used for location information to overlay the facilities with the hazard maps, where applicable.

**Figure 3-4 State Owned Buildings**




## 3.2.2 Lifelines (Critical Facilities and Infrastructure)

A significant aspect of the 2021 HIRA update was the update of critical facilities and an alignment/classification with the FEMA Lifelines framework. For the purposes of this plan, a critical facility is defined as one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. FEMA sorts critical facilities into seven lifeline categories as shown in the figure below.

**Figure 3-5 Lifeline Categories**

These lifeline categories standardize the classification of critical facilities and infrastructure that provide indispensable service, operation, or function to a community, and ultimately the State. A lifeline is defined as providing indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety, or economic security. These categorizations are particularly useful as they:

- Enable effort consolidations between government and other organizations (e.g., infrastructure owners and operators).
- Enable integration of preparedness efforts among plans, easier identification of unmet critical facility needs.
- Refine sources and products to enhance awareness, capability gaps, and progress towards stabilization.
- Enhance communication amongst critical entities, while enabling complex interdependencies between government assets.
- Highlight lifeline related priority areas regarding general operations as well as response efforts.

During the 2021 HIRA update the local critical facilities/infrastructure GIS layers were sourced from the Homeland Infrastructure Foundation Level Database (HIFLD). This generally aligns the data with layers associated with FEMA's Resilience Analysis and Planning Tool (RAPT). The categories of facilities and infrastructure include:

- Public Schools (state source)
- Private Schools
- Colleges/Universities
- Courthouses
- EMS
- Fire stations
- Electric power plants
- Hospitals
- Hazardous Materials: Risk Management Plan and Toxic Resource Inventory facilities
- Local Law Enforcement
  Local Emergency Operations Center
- Prisons
- Wastewater Treatment Facilities
- Water Facilities (source SD OEM)
- Weather Radar Stations

**Table 3-6 Summary of Critical Facilities by FEMA Lifeline**

| FEMA Lifeline | Critical Facility | Count |
|---|---|---|
| Energy | Power Plant | 56 |
| | **Total** | **56** |
| Food, Water, Shelter | Wastewater Facility | 341 |
| | Water Facility | 7 |
| | **Total** | **348** |
| Hazardous Material | Risk Management Plans (RMP) Facility | 162 |
| | Toxics Release Inventory (TRI) Facility | 259 |
| | EMS Station | 262 |
| | Hospital | 76 |
| | **Total** | **759** |
| Safety and Security | College/University | 30 |
| | Courthouse | 65 |
| | Fire Station | 383 |
| | Local EOC | 86 |
| | Local Law Enforcement | 169 |
| | Prison | 55 |
| | Private School | 66 |
| | Public School | 649 |
| | State EOC | 1 |
| | Weather Radar Station | 3 |
| | **Total** | **1,507** |
| Transportation | Aviation | 183 |
| | Bridge | 5,640 |
| | Bridge Scour | 248 |
| | **Total** | **6,071** |
| | **Grand Total** | **8,741** |

Source: State of South Dakota OEM, HIFLD, South Dakota OpenData, Wood GIS analysis

Other linear infrastructure that is considered a lifeline is the State's transportation network including highways and bridges. Impacts to these assets are noted by hazard where applicable, e.g. flood, and winter storm in particular. The majority of the State's electric power infrastructure is owned by rural

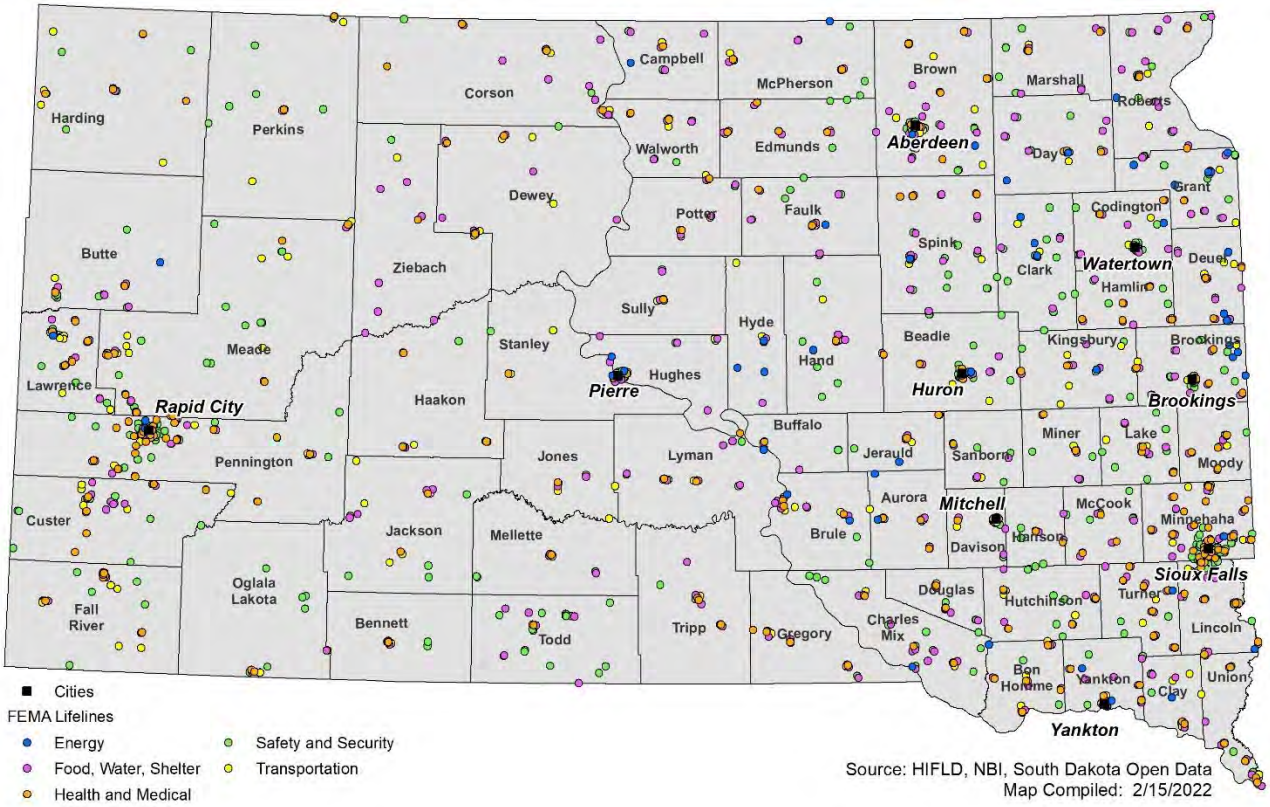
electric cooperatives. While these assets are not included here with state-owned assets, the SHMT recognizes they are critical resources. See the section on Rural Electric Cooperative Considerations for a detailed discussion of rural electric infrastructure, including the vulnerability of those assets and potential mitigation activities.

Linear and Transportation networks

- Highways
- National Bridge Inventory
- Aviation Facilities
- Transmission lines

Maps of the lifelines and infrastructure are shown below.

**Figure 3-6 Critical Facilities / Lifelines**




## *Critical Facility and Lifeline Exposure Summary*

Hazus-MH version 5.1 inventory data was used as the basis for overall exposure of buildings and lifelines. The Essential Facilities inventory for the State includes schools, police departments, fire departments and emergency operations centers. Hazus-based total count and value of buildings in these categories include 1,586 buildings and $6.2 billion in exposure. Essential facilities in Hazus include 857 schools representing $3.9 billion in value, 86 hospitals with 3,281 beds representing $697 million, 169 police stations representing $405 million, 387 fire stations representing $929 million, and 87 emergency operations facilities representing $208 million in value respectively. In Hazus-MH there are utility and infrastructure data sets that are considered 'lifeline' inventory. There are seven transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The total value of

the lifeline inventory is over $196 billion. This inventory includes over 7,417 miles of highways, 5,815 bridges, and 293,608 miles of pipes.

### 3.2.3 Population

The U.S. Census Bureau's 2020 Census results show South Dakota's 2020 population at 886,667. This reflects an increase of 8.9% between 2010 and 2020, which has placed South Dakota ahead of the national average for state population growth. South Dakota ranked 45th among the 50 states in population in 2020, 17th in rate of growth from 2010 to 2020, 16th in land area, and is the 5th least densely populated state. Decennial census data in Table 3-7 from the last several decades illustrate South Dakota's growth.

**Table 3-7 South Dakota Decennial Census 1970-2020**

| Year | Population | % Change |
|---|---|---|
| 1970 | 665,507 | -2.2 |
| 1980 | 690,768 | +3.8 |
| 1990 | 696,004 | +.8 |
| 2000 | 754,844 | +8.5 |
| 2010 | 814,180 | +7.9 |
| 2020 | 886,667 | +8.9 |

Source: U.S. Census Bureau

Between 2014 and 2020, 31 South Dakota counties gained population. Lincoln County was the 9th fastest growing county in the United States (of counties with 10,000 or more in population) between 2010 and 2020, with a 45.4% increase in population since a 2010 and an 85.8% increase in population during the previous decade from 2000 to 2010. No counties in South Dakota were ranked among the top 100 largest (by population) in the U.S. The three largest counties in the State (Minnehaha, Pennington, and Lincoln) were in the Top 10 Counties that experienced the largest population growth by number and by percent gained.

**Table 3-8 Ten Largest Counties Ranked by Population**

| County | 2020 Population |
|---|---|
| Minnehaha | 197,214 |
| Pennington | 109,222 |
| Lincoln | 65,161 |
| Brown | 38,301 |
| Brookings | 34,375 |
| Meade | 29,852 |
| Codington | 28,325 |
| Lawrence | 25,768 |
| Yankton | 23,310 |

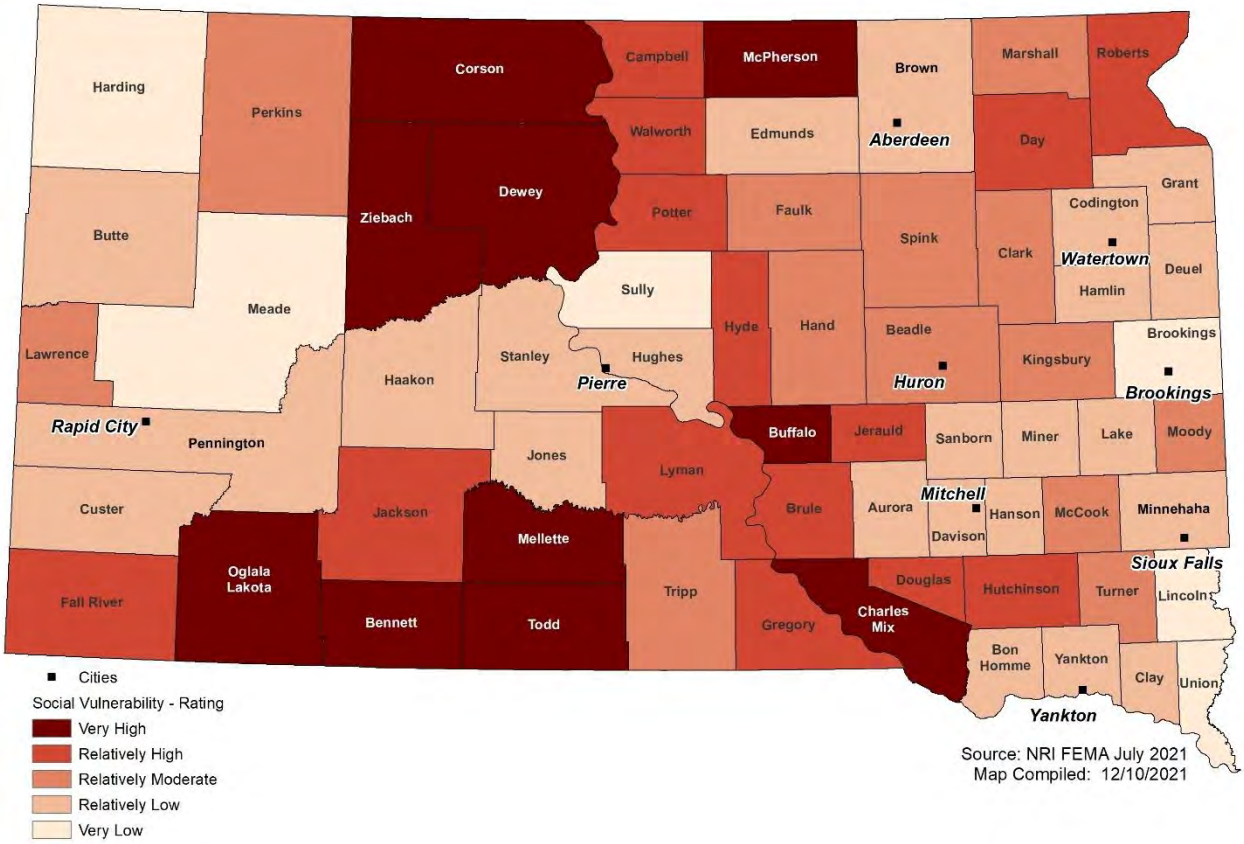
#### Social Vulnerability and Community Resilience

Social vulnerability is broadly defined as the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood. Social Vulnerability considers the social, economic, demographic, and housing characteristics of a community that influence its ability to prepare for, respond to, cope with, recover from, and adapt to environmental hazards.

The NRI has incorporated a social vulnerability index (SoVI) rating as a "consequence enhancing risk component" using the SoVI compiled by the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina. This SoVI is a location-specific assessment and measures the social vulnerability of U.S. counties to environmental hazards utilizing 29 socioeconomic

variables which have been deemed to influence a community's vulnerability. The comparison of SoVI values between counties within the State allows for a more detailed depiction of variances in risk and vulnerability. Figure 3-7 below shows this social vulnerability rating by county in South Dakota, with those counties shaded in darker red having the highest levels of social vulnerability.

**Figure 3-7 Social Vulnerability Rating by County in South Dakota**



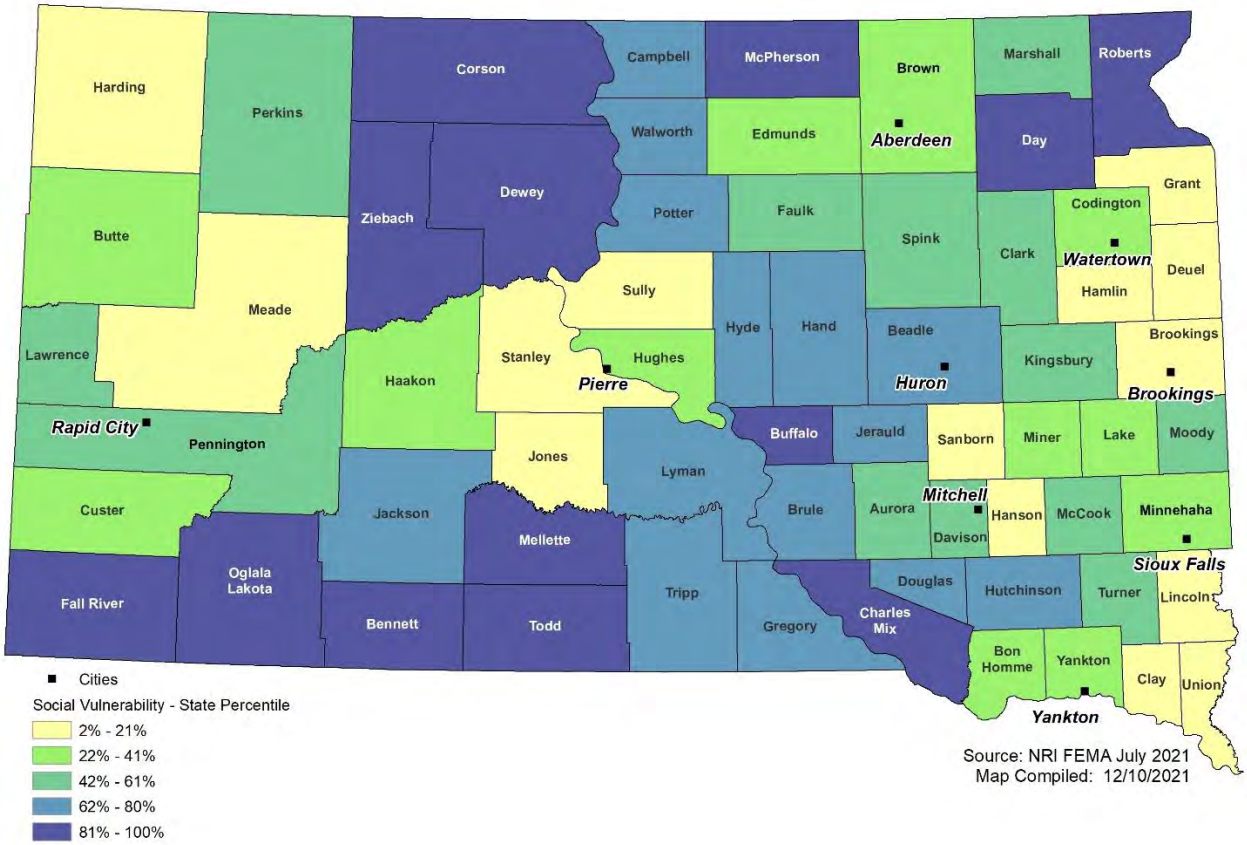

The index can be used by the State to help determine where social vulnerability and exposure to hazards overlaps and how and where mitigation resources might best be used. The SoVI provides a score between 0.01 and 100, with higher scores indicative of higher levels of social vulnerability. According to the index, the following, listed in order, are South Dakota's ten most socially vulnerable counties:

1. Todd County (Score 88.73)
2. Oglala Lakota County (Score 87.82)
3. Buffalo County (Score 77.53)
4. Bennett County (Score 71.66)
5. Dewey County (Score 70.52)
6. Ziebach County (Score 64.41)
7. Mellette County (Score 61.41)
8. Charles Mix County (Score 60.62)
9. Corson County (Score 59.68)

10. McPherson County (Score 59.09)

Each of the above counties are also in the top 20 percent in the nation in terms of social vulnerability. The average national social vulnerability score is 38.35 and the average for South Dakota is 41.26. Todd County for instance has a higher social vulnerability score than 99.8% of U.S. counties. In addition to the ten counties listed above, Day, Roberts, and Fall River also rank in the top 20% most socially vulnerable counties nationwide. Figure 3-8 below shows the percentile of each county's social vulnerability ranking on a national scale.

**Figure 3-8 Social Vulnerability State Percentile**



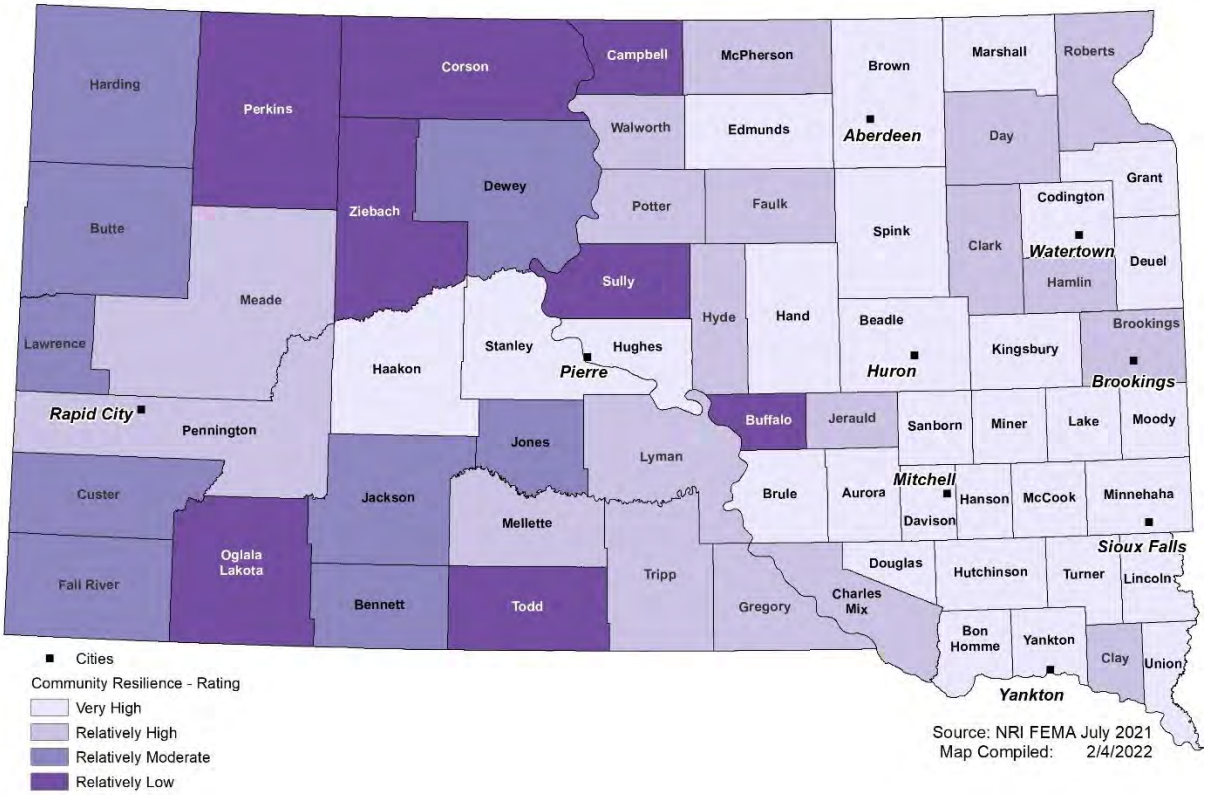

Related to social vulnerability, the NRI utilizes community resilience as a "consequence reduction component". Community Resilience can essentially be thought of as an inverse to social vulnerability. The NRI defines community resilience as the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. There are multiple, well-established ways to define community resilience at the local level, and key drivers of resilience vary between locations. Because there are no nationally available, bottom-up community resilience indices available, the Social Vulnerability and Community Resilience Working Group chose to utilize a top-down approach. The NRI relies on using broad factors to define resilience at a national level and create a comparative metric to use as a risk factor.

The Community Resilience score is a consequence reduction risk factor and represents the relative level of community resilience in comparison to all other communities at the same level. A higher Community Resilience score results in a lower Risk Index score. Because Community Resilience is unique to a geographic location—specifically, a county—it is a geographic risk factor. Community resilience data are supported by the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI)

Baseline Resilience Indicators for Communities (BRIC). HVRI BRIC provides a sound methodology for quantifying community resilience by identifying the ability of a community to prepare and plan for, absorb, recover from, and more successfully adapt to the impacts of natural hazards. The HVRI BRIC dataset includes a set of 49 indicators that represent six types of resilience: social, economic, community capital, institutional capacity, housing/infrastructure, and environmental. It uses a local scale within a nationwide scope, and the national dataset serves as a baseline for measuring relative resilience. The data can be used to compare one place to another and determine specific drivers of resilience, and a higher HVRI BRIC score indicates a stronger and more resilient community.

Figure 3-9 below shows the community resilience rating for each county in South Dakota.

**Figure 3-9 Community Resilience Rating by County in South Dakota**



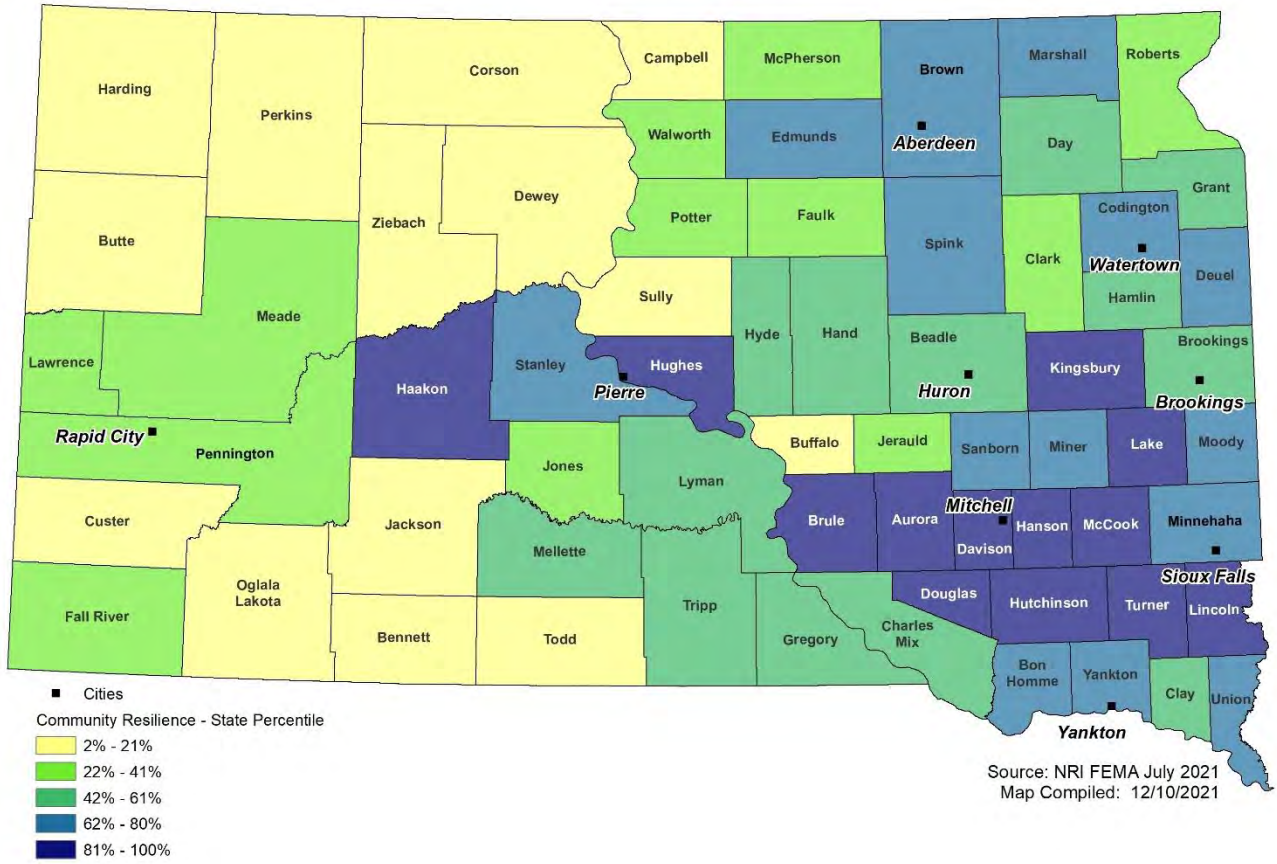

The community resilience rating can be useful in determining counties which have higher levels of ability to cope with hazards and identify success stories for building resilience. According to the index, the following, listed in order, are South Dakota's ten most resilient counties:

1. Turner County (61.56)
2. McCook County (61.47)
3. Hanson County (61.42)
4. Hutchinson County (61.12)
5. Lincoln County (61.03)
6. Brule County (60.62)
7. Lake County (60.51)

8. Aurora County (60.28)
9. Haakon County (60.16)
10. Kingsbury County (60.11)

Each of the above counties are also in the top 20 percent in the nation in terms of community resilience. The average community resilience score for the State of South Dakota is 57.10, which is higher than the national average score of 54.59. Only 0.4% of counties in the country have a higher level of community resilience than South Dakota's highest rated county, Turner County. In addition to the ten counties listed above, Davison, Hughes, and Douglas County each are identified as having very high levels of community resilience and also rank in the top 20% of resilient counties nationwide. Figure 3-10 below shows the percentile of each county's community resilience ranking on a national scale.

**Figure 3-10 Community Resilience State Percentile**

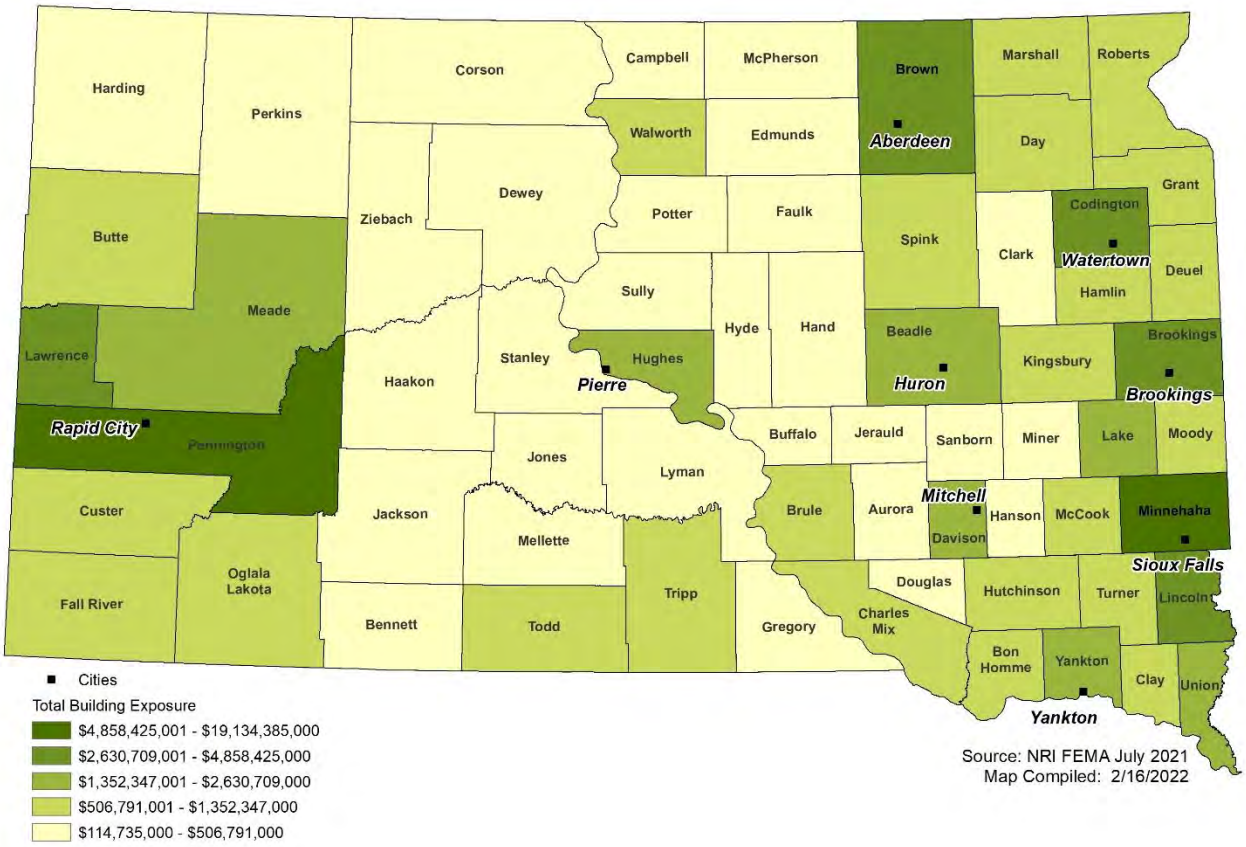



## 3.2.4 Building Exposure

Exposure is a term borrowed from the insurance industry as a measure of property "exposed" to a particular hazard. FEMA NRI-based building values were used to estimate South Dakota's total building replacement value (excluding contents) of $89,645,685,000. 2020 Census estimates that there are 393,375 total buildings in the planning area. Figure 3-11**Error! Reference source not found.** shows a thematic map at how building exposure varies by county across the State.

An event that would destroy or damage the entire inventory in a given county is unlikely, but it is possible that a tornado or wind-driven wildfire impacting the heart of a rural community could result in considerable building losses.

Figure 3-11 Building Exposure 2021




## 3.2.5 Land Use, Growth, and Development Trends

Land use and development trends exert a significant impact on the vulnerability assessments for South Dakota relative to specific hazards. In some cases, a dominant land use may increase the vulnerability to a specific hazard, such as agricultural diseases or wildfire. Land use trends may also indicate areas where vulnerability and risk may be more sustained than in other areas of the State and help identify areas where vulnerability and risk levels vary. This is particularly important to examine in a statewide hazard mitigation plan, to ensure the document reflects accurate variability of these elements.

One characteristic of local land use in South Dakota that must be considered in both state and local hazard mitigation planning is how the land use patterns are changing at the community level. Identifying both the type and rate of change from existing land uses to future land uses, whether they are planned or unplanned, can help to identify the local jurisdictions most subject to development pressures and consequently help to focus the mitigation planning to minimize the vulnerability to future disasters of the newly constructed neighborhoods, facilities, and infrastructure. Data from local plans can be used to identify the jurisdictions where planned land uses are significantly different from existing land uses.

Figure 3-15 in the agricultural pests and diseases section shows land cover data from the USGS National Map. Land cover in South Dakota is predominantly cropland and rangeland. The significant forested areas

in the State are concentrated in the Black Hills Region, located in the southwest corner of the State. Large bands of cultivated cropland and pastureland or haymaking areas run from north to south across eastern South Dakota. Areas in the western half of the State are marked with cropland and pastureland and pockets of barren land but are primarily characterized by grasslands. Highly concentrated areas of development, including residential and commercial/industrial/transportation classifications of land, are limited geographically and centralized around the major population centers of Rapid City, Pierre, and Sioux Falls. Other areas of concentrated urbanization include Aberdeen, Watertown, and Huron, which correspond to the population and demographic information outlined in the population section above.

As part of the plan update process, the State looked at changes in growth and development at the county level and examined these changes in the context of the State's hazard-prone areas and how the changes in growth and development affect loss estimates and vulnerability. Increases in population growth and development can result in greater exposure to hazards, particularly atmospheric hazards such as tornadoes, windstorms, and winter storms.

Table 3-9 and Table 3-10 summarize some trends in population growth in South Dakota since 2010. The decreases and increases in population by county are depicted on the map below.

**Table 3-9 Top Ten Counties with Numerical Population Increase, 2010-2020**

| County | 2010 Population | 2020 Population | Numerical Change |
|---|---|---|---|
| Minnehaha County | 169,468 | 197,214 | 27,746 |
| Lincoln County | 44,828 | 65,161 | 20,333 |
| Pennington County | 100,948 | 109,222 | 8,274 |
| Meade County | 25,434 | 29,852 | 4,418 |
| Union County | 14,399 | 16,811 | 2,412 |
| Brookings County | 31,965 | 34,375 | 2,410 |
| Brown County | 36,531 | 38,301 | 1,770 |
| Beadle County | 17,398 | 19,149 | 1,751 |
| Lawrence County | 24,097 | 25,768 | 1,671 |
| Clay County | 13,864 | 14,967 | 1,103 |

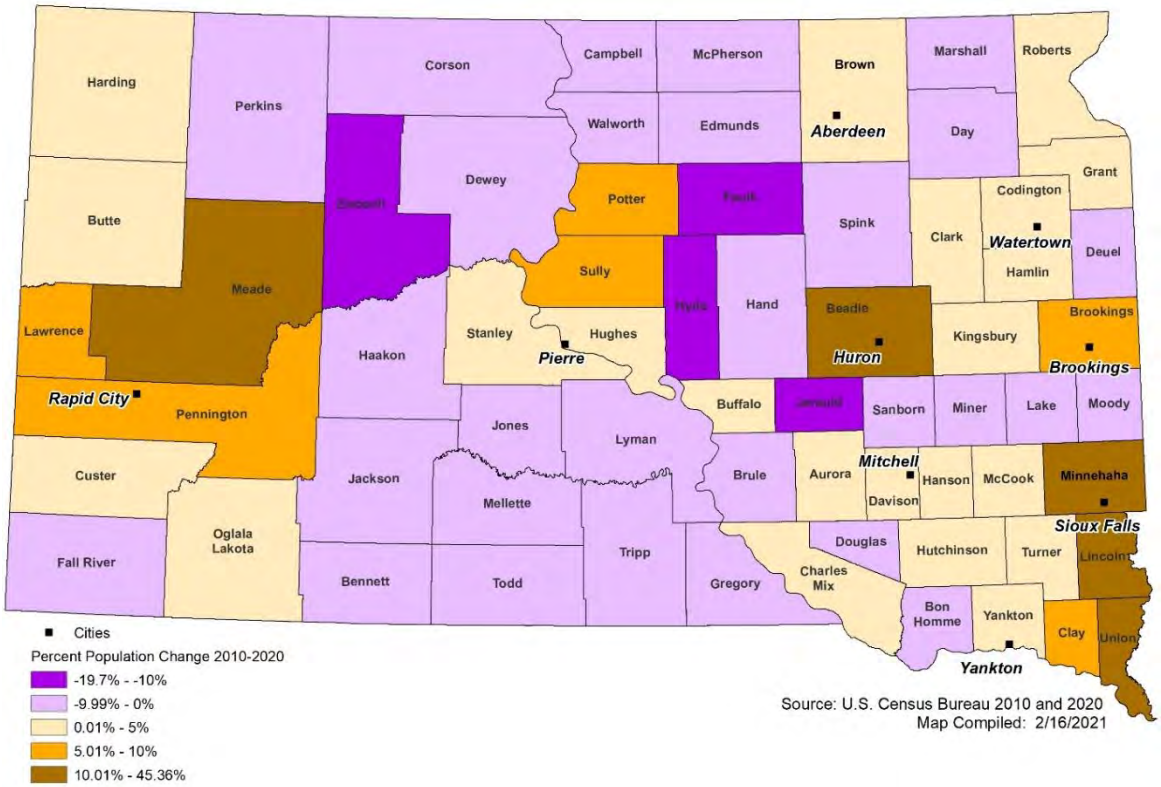
Source: U.S. Census Bureau, 2010 and 2020 Census Results

**Table 3-10 Top Ten Counties by Percent Growth, 2010-2020**

| County | Percent Change |
|---|---|
| Lincoln County | 45.36% |
| Meade County | 17.37% |
| Union County | 16.75% |
| Minnehaha County | 16.37% |
| Beadle County | 10.06% |
| Pennington County | 8.20% |
| Clay County | 7.96% |
| Brookings County | 7.54% |
| Lawrence County | 6.93% |
| Potter County | 6.14% |

Source: U.S. Census Bureau, 2010 and 2020 Census Results

**Figure 3-12 Population Change 2010-2020**




Between 2010 and 2020, 33 South Dakota counties lost population. Of the counties with the greatest losses in population, five of them (Mellette, Jones, Faulk, Hyde, and Jerauld) also rank among South Dakota's 10 least populous counties. This trend of population loss amongst half of all counties in South Dakota, coupled with the fact that the State as a whole saw an 8.9% population increase over the same period, outpacing the national average growth rate, indicates that South Dakota's future growth is urbanizing. More and more of the population growth is directed towards the existing urban centers in the State.

Table 3-11 and Table 3-12 summarizes these trends in development growth in South Dakota, in terms of housing unit development, since 2010. The counties with the greatest increases in housing units have an increased building and population exposure hazards compared to counties that have experienced a decrease in units.

**Table 3-11 Top Ten Counties with Percentage Increase in Housing Units, 2010-2020**

| County | 2010 Units | 2020 Units | Change (+/-) | Percent change |
|---|---|---|---|---|
| Lincoln County | 17,875 | 26,227 | 8,352 | 47% |
| Minnehaha County | 71,557 | 83,717 | 12,160 | 17% |
| Union County | 6,280 | 7,215 | 935 | 15% |
| Brookings County | 13,137 | 14,849 | 1,712 | 13% |
| Meade County | 11,000 | 12,357 | 1,357 | 12% |
| Lawrence County | 12,756 | 14,163 | 1,407 | 11% |
| Clay County | 5,639 | 6,180 | 541 | 10% |
| Pennington County | 44,949 | 49,153 | 4,204 | 9% |
| Hanson County | 1,177 | 1,279 | 102 | 9% |
| Yankton County | 9,652 | 10,372 | 720 | 7% |

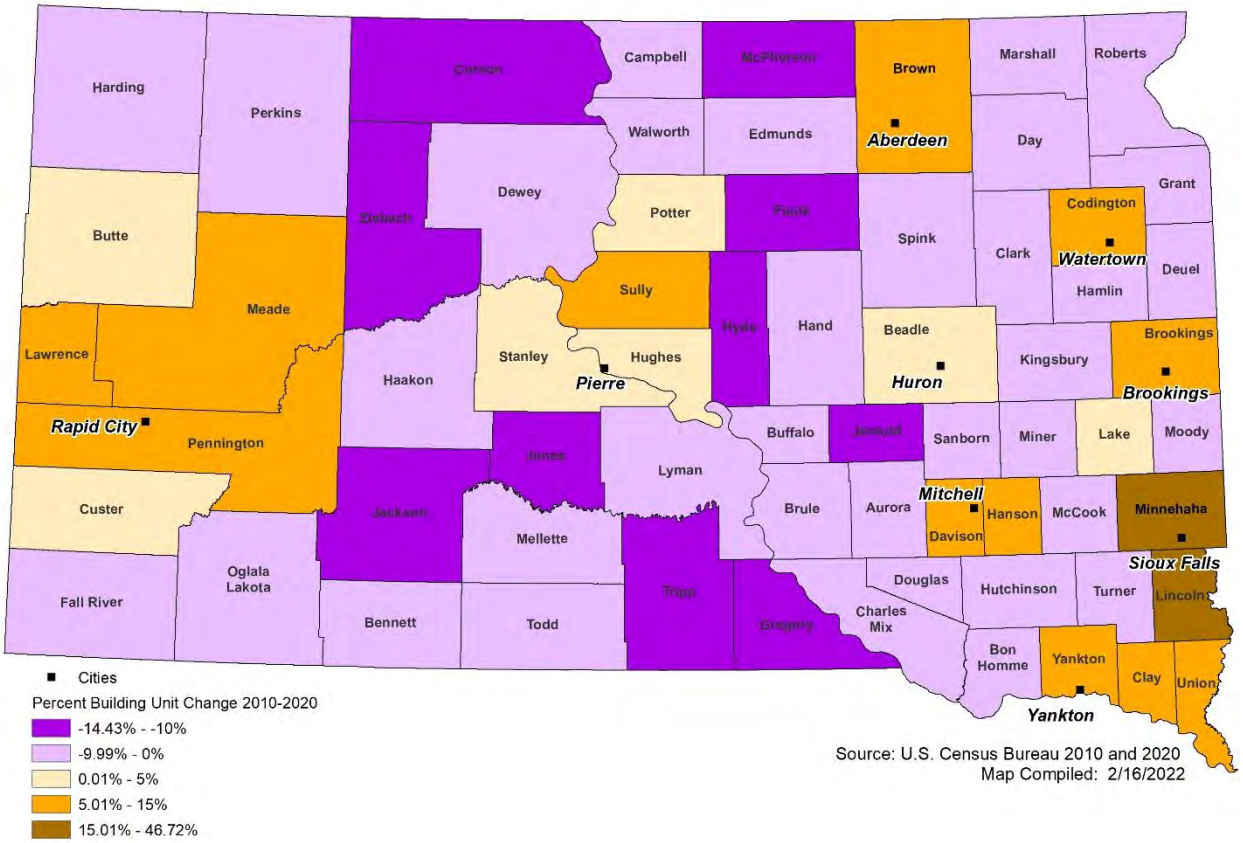
Source: U.S. Census Bureau, 2010 and 2020 Census Results

**Table 3-12 Top Ten Counties with Percentage Decrease in Housing Units, 2010-2020**

| County | 2010 Units | 2020 Units | Change (+/-) | Percent change |
|---|---|---|---|---|
| Jones County | 589 | 504 | -85 | -14% |
| Gregory County | 2,503 | 2,186 | -317 | -13% |
| Hyde County | 708 | 626 | -82 | -12% |
| Corson County | 1,540 | 1,362 | -178 | -12% |
| McPherson County | 1,418 | 1,258 | -160 | -11% |
| Jerauld County | 1,070 | 952 | -118 | -11% |
| Jackson County | 1,193 | 1,064 | -129 | -11% |
| Ziebach County | 987 | 882 | -105 | -11% |
| Tripp County | 3,072 | 2,762 | -310 | -10% |
| Faulk County | 1,136 | 1,022 | -114 | -10% |

Source: U.S. Census Bureau, 2010 and 2020 Census Results

**Figure 3-13 Housing Unit Change 2010-2020**




In general, counties with growing populations and number of housing units have an increased exposure to hazards not defined by specific geographic areas. These hazards may include winter storms, summer storms, tornadoes, wind, drought, wildfire, and earthquake. The counties experiencing the most development pressures all participate in the National Flood Insurance Program.

Rapid City, in Pennington County, is in the Community Rating System at Class 7. This suggests that flood risk should not be increasing, assuming that county floodplain ordinances are being effectively implemented and wise use of floodplains encouraged. New data suggests that repetitive loss is increasing in the State. Union County is one of the fastest growing counties and has potential for high flood losses as

described in the flood vulnerability section. New homes being built in Meade and other counties increase the exposure to damage from tornadoes.

## 3.3 Hazard Profiles

| 44 CFR Part 201 Requirement: |
| --- |
| *[The State risk assessment shall include an overview of the] location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate…* |

South Dakota identified the 10 hazards for analysis in the HIRA which are discussed in the following order:

1. Agricultural Pests and Diseases
2. Flood (including Dam and Levee Failure)
3. Summer Storm (including Lightning and Hail)
4. Winter Storm
5. Wildfire
6. Drought (including Extreme Heat)
7. Tornado
8. Windstorm
9. Hazardous Materials
10. Geologic Hazards (Landslides, Mudflows, Expansive Soils, Subsidence, and Earthquakes)

### 3.3.1 Agricultural Pests and Diseases

#### Hazard Description

Agricultural hazards are divided into two categories: pests and diseases. For this plan, such events are defined as the naturally occurring infection of crops or livestock with insects, vermin, or diseases that render the crops or livestock unfit for consumption, sale, or other use. South Dakota has a substantial agricultural industry and a significant infrastructure composed of related facilities and locations, so the potential for infestation of crops or livestock poses a significant risk to the economy of the State. In order to profile each element adequately, this hazard profile focuses on events that primarily affect livestock (primarily disease) and crops (disease and pests). In some cases, pests may also serve as the vector of disease for livestock.

Agriculture is a vital industry in South Dakota. According to the most recent (2017) Census of Agriculture conducted by the USDA, the State had 29,968 farms, with over 43,243,742 acres of farmland, for an average farm size of 1,443 acres. The agriculture industry nets over $2.4 billion per year in farm income. The State boasts 48,813 producers, ninety-five percent of which operate family-owned farms. South Dakota's agricultural history dates back to the nineteenth century, when homesteaders used a mule and moldboard plow to break the thick prairie sod. Currently, in the twenty-first century, crop production has increased as farmers embrace new technologies, better hybrids, and more efficient land use practices, which has resulted in a 6% decrease in the total number of farms since the 2012 (USDA) Census of Agriculture. More than 19.8 million acres of the State is cropland and approximately 22 million acres are devoted to pastureland. Figure 3-14 below shows where South Dakota ranks amongst other states in the production of various crops, including the amount produced and what percentage of the total U.S. production comes from South Dakota.

**Figure 3-14 South Dakota Rank in U.S. by Commodity**

| U.S. Rank | Commodity and Date | Number | Unit | Percent of U.S. Total |
|---|---|---|---|---|
| 1 | **Bison,** inventory, Census of Agriculture, 2017 | 30,035 | head | 16.3 |
| 1 | **Oats,** production, 2020 | 10,780,000 | bushels | 16.5 |
| 2 | **Honey,** production, 2020 | 14,945,000 | pounds | 10.1 |
| 2 | **Sunflower, All,** production, 2020 | 1,167,020,000 | pounds | 39.1 |
| 2 | **Sunflower, Oil,** production, 2020 | 1,064,000,000 | pounds | 40.7 |
| 2 | **Sunflower, Non-oil,** production, 2020 | 103,020,000 | pounds | 28.2 |
| 3 | **Millet, Proso,** production, 2020 | 1,715,000 | bushels | 18.6 |
| 3 | **Sorghum for Silage,** production, 2020 | 350,000 | tons | 11.2 |
| 4 | **Sorghum for Grain,** production, 2020 | 11,360,000 | bushels | 3.0 |
| 5 | **Beef Cows, All**, inventory, January 1, 2021 | 1,799,000 | head | 5.8 |
| 5 | **Calf Crop,** January-December, 2020 | 1,780,000 | head | 5.1 |
| 5 | **Hay, Alfalfa,** production, 2020 | 3,240,000 | tons | 6.1 |
| 5 | **Lamb Crop,** inventory, 2020 | 200,000 | head | 6.2 |
| 5 | **Land in Farms,** 2020 | 43,200,000 | acres | 4.8 |
| 5 | **Safflower,** production, 2020 | 16,875,000 | pounds | 11.4 |
| 5 | **Wheat, Spring**, production, 2020 | 35,720,000 | bushels | 6.1 |
| 5 | **Wool,** production, 2020 | 1,650,000 | pounds | 7.1 |
| 6 | **Peas, Dry Edible**, production, 2020 | 448,000 | cwt | 2.1 |
| 6 | **Sheep and Lambs, All**, inventory, January 1, 2021 | 245,000 | head | 4.7 |
| 6 | **Sheep and Lambs, Market,** inventory, January 1, 2021 | 56,000 | head | 4.0 |
| 7 | **Cattle and Calves, All**, inventory, January 1, 2021 | 4,000,000 | head | 4.3 |
| 7 | **Cattle on Feed,** inventory, January 1, 2021 | 460,000 | head | 3.1 |
| 7 | **Corn for Grain**, production, 2020 | 729,000,000 | bushels | 5.1 |
| 7 | **Corn for Silage,** production, 2020 | 6,480,000 | tons | 4.7 |
| 7 | **Grain Storage Capacity, On Farm**, December 1, 2020 | 730,000,000 | bushels | 5.4 |
| 7 | **Hay, All,** production, 2020 | 5,365,000 | tons | 4.2 |
| 7 | **Principal Crops Harvested,** 2020 | 15,189,000 | acres | 5.2 |
| 8 | **Cropland,** total, acres, Census of Agriculture, 2017 | 19,813,517 | acres | 5.0 |
| 8 | **Pig Crop,** December 2019-November 2020 | 6,857,000 | head | 4.9 |
| 8 | **Principal Crops Planted,** 2020 | 15,581,000 | acres | 5.0 |
| 8 | **Soybeans,** production, 2020 | 223,860,000 | bushels | 5.4 |
| 8 | **Wheat, All,** production, 2020 | 70,520,000 | bushels | 3.9 |
| 10 | **Grain Storage Capacity, Off Farm,** December 1, 2020 | 440,000,000 | bushels | 3.7 |
| 10 | **Wheat, Winter**, production, 2020 | 34,800,000 | bushels | 3.0 |
| 11 | **Hay, Other,** production, 2020 | 2,125,000 | tons | 2.9 |
| 11 | **Hogs and Pigs, All,** inventory, December 1, 2020 | 2,020,000 | head | 2.6 |
| 13 | **Cash Receipts from Farm Marketings,** 2019 | 8,894,483,000 | dollars | 2.4 |
| 13 | **Red Meat Production, Commercial,** 2020 | 1,473,800,000 | pounds | 2.6 |
| 16 | **Barley**, production, 2020 | 616,000 | bushels | 0.4 |

Source: USDA National Agricultural Statistics Service

Small losses caused by agricultural pests and diseases are normal for South Dakota farmers and ranchers. Concerns arise when the level of an infestation escalates suddenly and overwhelms normal control efforts,

a new type of infestation occurs, diseases decimate animal populations, or when diseases pose a risk to humans. The levels and types of such events vary based on many factors, including cycles of heavy rains and drought, feeding practices, cross contamination or exposure, or inadequate infection control measures.

While zoonotic diseases (those transmissible to humans from animals or via an animal vector) are a concern, those events are best addressed in a pandemic or contagious disease plan, in order to address the variability and magnitude those events entail. The control of insects and rodents partially addresses the mitigation of zoonotic disease, but for the purposes of this plan, that is an extra factor, rather than a primary focus. This hazard profile focuses on the diseases which impact the population of domesticated livestock or crops, which in turn damages the economic return on these valuable assets.

The following evaluation of crop hazards is reproduced from the South Dakota State University website:

> Farmers endure a number of problems during the growing season which can curtail yield. Some of these problems occur because best management practices are not applied. The lack of a good stand, crop-nutrient deficiencies, insect infestations, weed population increases, poor field drainage, and salinity problems can to some degree be managed. However, there are some weather-related natural events that are beyond the farmer's control. High humidity and strong southerly breezes can carry windborne pathogens from Mexico and the southern states to infect crops. Violent storms from May to August can bring hail can reduce crop yield potential or damage crops beyond recovery. Lack of timely precipitation can wither crops and reduce yields. Late frost in the spring can kill crops and early frost in the fall can curtail the grain filling period of fall harvested crops.

Weeds that infest fields may cause problems during harvest. The weeds may clog small to medium size combines, so alternative harvesting techniques are required. The cut-and-swathing technique is not preferable as it may encourage grain loss and requires a greater investment of time and/or manpower.

Rodent infestations, such as mice, rabbits, and other pests, also threaten to damage crops in all stages of the production process. Young plants are vulnerable to the rodents who feed on them. Harvested and stored crops may be contaminated by rodents burrowing into storage units, either to feed on the materials or create nests during winter months or become contaminated by fecal matter. The nature of such infestations makes tracking statistical data nearly impossible. Variables include the geographic distribution of the rodents and the crops, the number of rodents in the area, the presence and proliferation of natural predators, and the reproduction rates relative to the amount of natural food resources available. As such, while this is an acknowledged element of the agricultural hazards, it is not a primary focus in this profile.

Insect plagues also cause significant damage to crops in South Dakota. The last major grasshopper infestation in the United States occurred in the 1930s. Following this disaster, it was decided that local control of grasshopper outbreaks was insufficient, and that regional coordination was required. The 1934 Congress charged the U.S. Department of Agriculture (USDA) with controlling grasshoppers on federal rangeland. In 1987, the Animal and Plant Health Inspection Service (APHIS), which is part of the USDA, created the Grasshopper Integrated Pest Management (GHIPM) Project to develop new technologies for managing grasshopper populations. Grasshopper infestations in the 1950s, 1980s, and 2000s further underscore the importance of mitigating this insect-driven hazard.

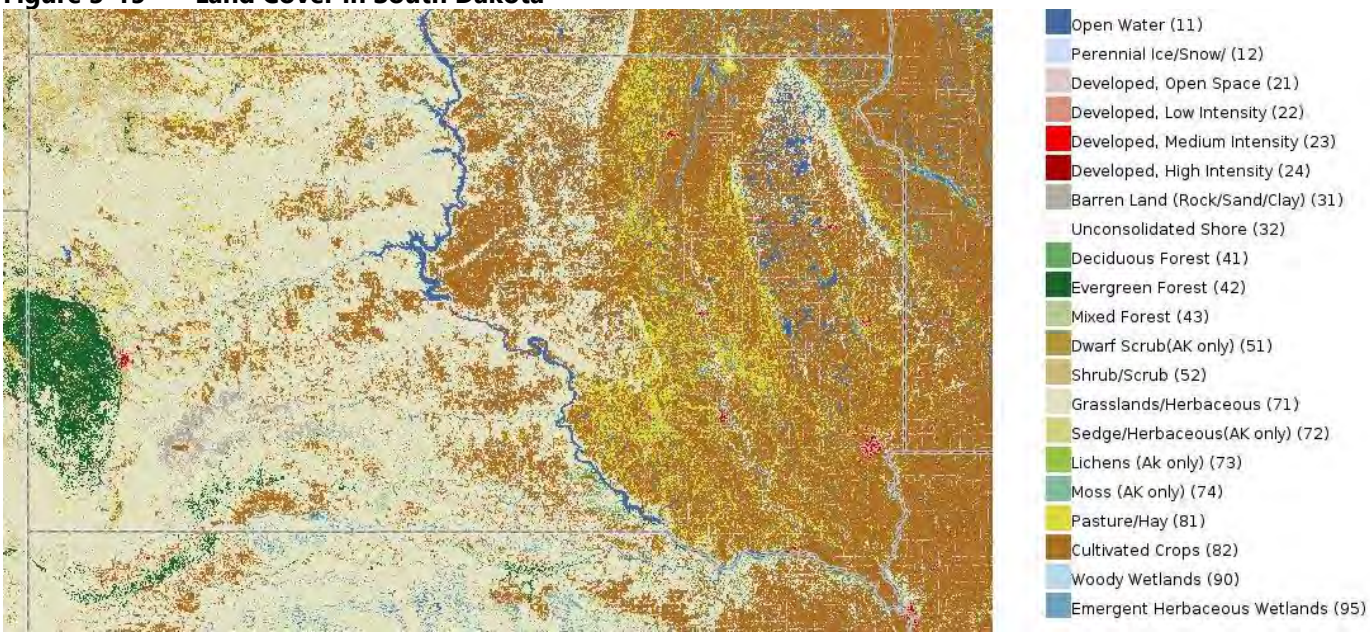
Similar insect hazards include locusts, aphids, and bark beetle plagues. In 2012, Campbell, Corson, Harding, and Perkins counties all received USDA disaster designations involving insects and disease (S3467). In early March 2010, USDA designated Ziebach County as a primary natural disaster area due to weather and grasshopper problems in 2009.

## Location

Livestock diseases are possible anywhere that livestock are present. In addition, humans who come into contact with contaminated livestock or byproducts may also be exposed to livestock diseases. 21,997,620 acres in South Dakota are devoted to pastureland, which accounts for 44.6% of the total land area of the State. Pastureland is primarily located in bands that stretch from north to south in the eastern half of the State, and in the grasslands that dominate the western area of the State. In Figure 3-15, pastureland areas are indicated in yellow, while grasslands are indicated in beige and cultivated crops are indicated with darker brown.

Similarly, crop diseases are possible in any cultivated cropland environment. While some crop varieties are engineered for resistance to specific diseases or pests, the overall location of any pest or disease hazard corresponds to the cropland extent in the State. 19,813,517 acres in South Dakota are designated as cropland, which accounts for 40.1% of the total land area of the State. Cultivated crops are more prevalent in the eastern half of the State, though significant areas of cropland interspersed with grasslands also exist in the west.

**Figure 3-15 Land Cover in South Dakota**

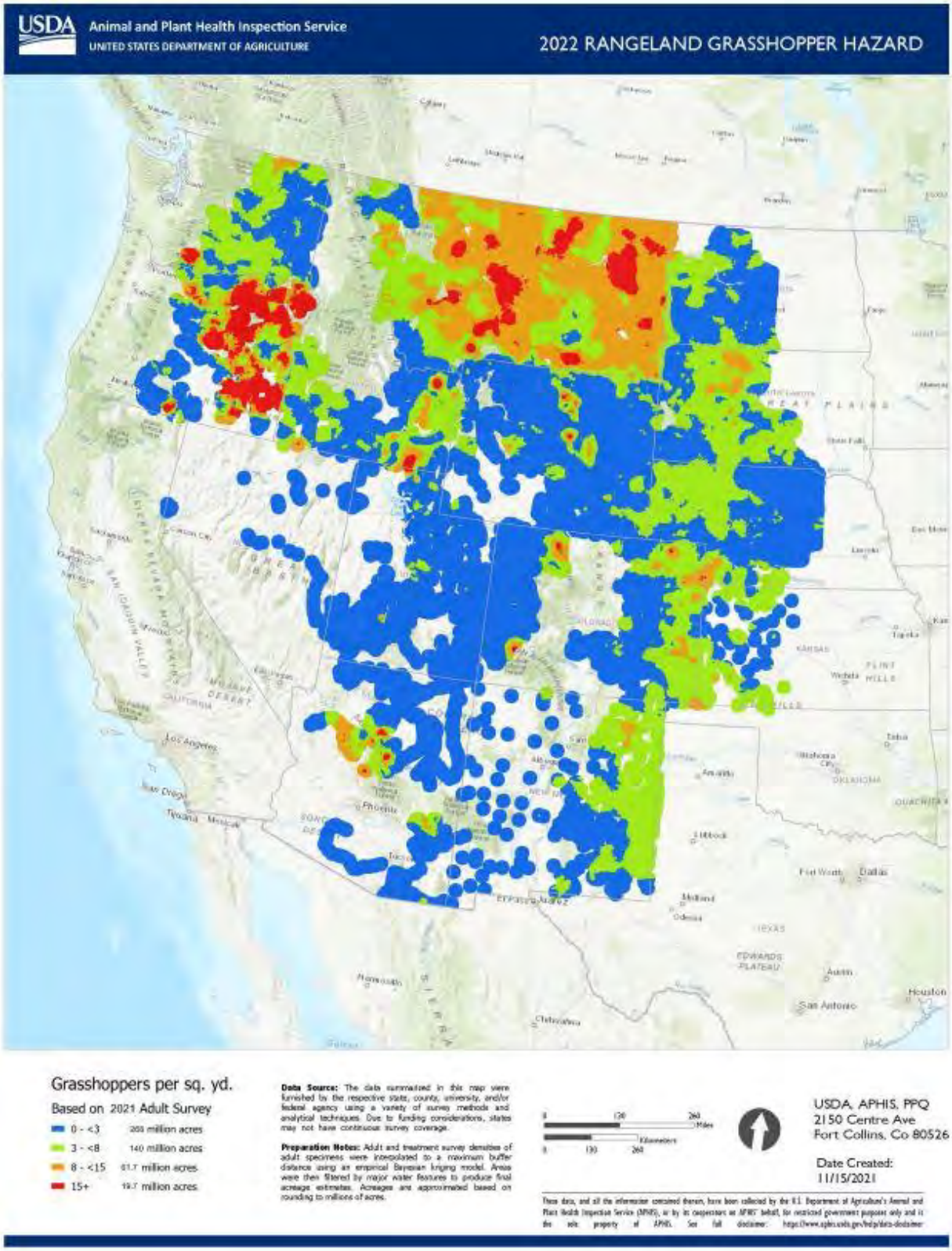



Source: The National Map Seamless Server hosted by the USGS, using NLCD 2016 Land Cover data.

Rodents such as mice, rats, and rabbits, are found across the entire planning region, as are insects. The presence of the rodents and insects is a consistent feature, with normal population density flows following the seasonal patterns. However, when density of these populations exceeds the capacity of the ecosystem, agricultural industries such as crops, and the health of livestock are threatened. As discussed above, the ability to model these trends is difficult and inconsistent.

Grasshoppers are a historical insect hazard impacting agricultural production of crops. Figure 3-16 below shows the projected grasshopper density in the Western U.S. for 2021. While the map indicates that the majority of the density ratings are in western South Dakota, outside of the majority of cultivated cropland, this is due to the fact that the USDA does not survey in the eastern part of the State.

**Figure 3-16 South Dakota Grasshopper Hazard**



## Past Events

Past events are detailed differently in this section compared to other hazard profiles. While previous occurrences are listed, where applicable, it is also important to recognize the potential devastating diseases or pests for which the State constantly monitors. The use of vaccines in livestock and fungicides, pesticides or resistant seeds have mitigated some previously severe hazards. Other potentially devastating hazards have not yet appeared in South Dakota and appropriate preventative measures are in place to help inhibit their introduction. As such, monitored diseases or infestations are as equally important as known events.

Table 3-13 is a summary of the information presented on the South Dakota Animal Industry Board Disease Control Website with additional information provided from the USDA and other resources. Only diseases for cattle, pigs, poultry, and wildlife are profiled here due to their importance to South Dakota's economy. However, additional information on sheep and horses is also available on the website. In addition, diseases with minimal impact on humans and a low incidence rating in animals are not included in this profile.

Table 3-14 and Table 3-15 also summarize some of the many common crop diseases that impact the production, yield, and overall quality of harvests. Some crops are sold as a commodity, while others are used to support the livestock industry. As with livestock disease, tracking every occurrence is unwieldy because, to some level, crop disease is omnipresent. This section shows the occurrence rate of common crop hazards for the top commodities groups grown in South Dakota - that is, small grains, oilseeds, dry beans and dry peas (ranked 9th in the nation for value of sales), corn for grain (ranked 7th in the nation for production in 2020), soybeans (ranked 8th in the nation for production in 2020), sunflowers (ranked 2nd in the nation for production in 2020), and forage (ranked 3rd in the nation for production). Note that commodities are grouped by disease vulnerability, rather than by commodities group. The information is drawn from an issue of "Extension Extra" published by the College of Agricultural and Biological Sciences at the South Dakota State University, which discusses the recognition and management of common crop diseases in South Dakota.[1] Additional information was obtained from news sources and the USDA for events post-2009.

The 2021 HIRA update did not identify significant events post-2012. Some highlights of past events listed below, or events of particular significance, include:

- Campbell, Corson, Harding, and Perkins counties received USDA disaster designations for losses related to insects and disease (S3467) in 2012. In that same year, 30 counties received a total of $702,633 in indemnities for crop loss related to insects. 22 counties received $184,810 in insect-related indemnities in 2011, and 27 counties received $927,938 in insect-related indemnities in 2010. The crop losses in all three years included forage used to feed livestock.
- In 2013, the majority of counties in the State were declared by the USDA for drought (S3591; S3620; S3505; S3522; S3549); secondary impacts of this drought included insect infestation and disease spread.
- Several counties also received indemnities for crop losses related to plant disease between 2010 and 2012. 12 counties received $62,183 in 2012, 38 counties received $3,303,117 in 2011, and 16 counties received $572,831 in 2010. Impacted crops included wheat, corn, soybeans, oats, dry peas, sunflowers, forage, and "other" not specified. The specific plant diseases that caused these losses were not identified in the Risk Management Agency data.
- The USDA produced a "Cattle Death Loss" report in 2011 which detailed the number of cattle and calves lost to various causes (predator and non-predator) in each State in 2010. A total of 68,000

1 https://openprairie.sdstate.edu/extension_extra/

head of cattle and 90,000 calves died in South Dakota in 2010. 12.6% (8,568 head) of cattle losses were attributed to digestive problems, 31.1% (21,148 head) to respiratory problems, and 5.2% (3,536 head) to other unspecified diseases. 12.8% (11,520 head) of calf losses were related to digestive problems, 29.2% (26,280 head) to respiratory problems, and 0.9% (810) to other unspecified diseases. Additional details were not available on the specific nature of the digestive and respiratory problems. At a value of $1,133 per head for cattle and $381 per head for calves, South Dakota's cattle industry losses in 2010 totaled $52,384,926 due to respiratory, digestive, and other diseases. (Weather-related cattle and calf losses are discussed in the Winter Storm hazard profile.)

- The USDA "Cattle Death Loss" report comes out approximately every five years, but previous reports for 2005 and 2000 organized data by region rather than state. The 1995 and 1991 reports are organized by state and can be compared to the 2011 report. The 1995 report indicates that a total of 59,600 cattle and 162,600 calves were lost in 1995. Of the 59,600 total cattle deaths, 6,800 were lost to digestive problems and 14,300 to respiratory problems. Of the 162,600 total calf deaths, 37,000 died from digestive problems and 30,000 were lost to respiratory problems. In 1991, cattle and calf losses totaled 55,000 head and 110,000 head respectively. Digestive problems killed 8,100 cattle and 33,400 calves. Respiratory problems killed 16,500 cattle and 31,300 calves. "Other diseases" was not listed as a category in 1995 or 1991. Total dollar value per head was not provided in the 1995 and 1991 reports.
- In January 2011, the USDA designated Jackson and Todd Counties as natural disaster areas due to the ongoing grasshopper infestation that began in June 2010. Designated contiguous counties included Bennett, Jones, Pennington, Tripp, Haakon, Mellette, and Oglala Lakota (previously Shannon County).
- In April 2010, the State was approved for pasture grazing loss assistance under the Emergency Livestock Assistance Program (ELAP) due to the 2009 grasshopper infestation.
- In 2009, the State experienced combined effects of severe storms with hail, high wind, flooding, and grasshopper infestation in 35 counties. This led to the release of USDA Secretarial Disaster S2916.
- In 2005, the State experienced an unusually high outbreak of anthrax, with 56 positively confirmed cases in 18 counties.
- Trichomoniasis (trich) cases have been steadily increasing in recent years. The highest number of cases also occurred in FY 2005, with 45 positive cases in 11 counties.
- Asian soybean rust is still not documented and confirmed in the State, but extensive scouting efforts are underway, particularly in the southeast counties.
- Palmer amaranth, a vigorous weed that has developed herbicide resistance in other states, was confirmed in central South Dakota in 2014. It has since been found in other locations in the State and in North Dakota, but it is not widespread and is currently being monitored.

**Table 3-13 South Dakota Livestock Diseases**

| Disease Name | Incidents, History, and Other Reporting Measures | Human Vulnerability |
|---|---|---|
| **Cattle** | | |
| Brucellosis, also known as Bangs Disease or Bangs | U.S. states are free from brucellosis in domestic cattle herds due to extensive vaccination and testing requirements. Buffalo and Elk in the Greater Yellowstone Area remain natural carriers of the disease and present the largest risk to domestic cattle herds. Documented cases include far reaching impacts and tremendous costs for movement restrictions, testing requirements, indemnities, and epidemiology. | Yes, if ingested or directly exposed to the bacteria. Human-to-human transmission is possible, but rare. |
| Tuberculosis, also known as TB | South Dakota has maintained a "TB Free" status by the USDA since 1982; however, all intact dairy cattle imported to the State must reflect a 'negative' result in official TB testing within 60 days prior to entering South Dakota. The bovine strain of bacteria is distinct from the most common forms that impact humans. However, the strain may be passed between cattle, from humans to cattle, and from cattle to humans. In both human and cattle patients, TB may be fatal if untreated or neglected. | Yes, if ingested (particularly from untreated milk). Sustained animal-to-human transmission is possible but rare. |
| Bovine Spongiform Encephalopathy (BSE), also called 'Mad Cow Disease' | First surfacing in Great Britain in 1986, BSE is a chronic degenerative disease of the central nervous system. There is no method for testing for the disease in live cattle, so suspected cases pose an extreme cost impact on ranchers. There have been sporadic cases in Canada and the United States. Strict regulations prohibit the feeding of ruminant derived proteins to ruminants. The disease is not passed between cows except via consumption. According to the Center for Disease Control, the first confirmed domestic case of BSE disease was reported in Washington State in 2003. Two subsequent diagnoses were confirmed for a 2004 case in Texas (confirmed in 2005) and in 2006 in Alabama. Luckily, these cases have resulted in minimal impact on domestic cattle herds, but monitoring remains a key component. | Suspected yes, if ingested. The link is suspected between VSE and certain cases of CJD, which is a chronic degenerative central nervous disease in humans. |
| Anthrax | Anthrax is a spore-forming bacterium that causes acute infections. In 2005, South Dakota experienced a serious anthrax outbreak, with 55 herds with confirmed losses to the disease in the space of four months. Mitigation and response measures helped contain the outbreak, with efforts to vaccinate over 1 million cattle during the summer months. The State Veterinarian reported that the effects of drought, contributed to the severity of the 2005 outbreak. Since South Dakota is located in the 'anthrax belt', potential losses and vulnerability remain high and vigilance remains critical. Previous cases include 1infected herd in 2009, 3 in 2008, 2 in 2007, and 2 in 2006. | Yes, if spores are inhaled, ingested, or infected materials are improperly handled. The disease is not known to be peer-to-peer transmissible. |

| Disease Name | Incidents, History, and Other Reporting Measures | Human Vulnerability |
|---|---|---|
| Johne's Disease (pronounced Yo-nees), also called Paratuberculosis | Johne's disease is a chronic infection that causes diarrhea and wasting, which primarily impacts cattle over the age of 2 years and is also found in other ruminant animals such as goats and sheep. The disease is closely related to tuberculosis but grows very slowly. The disease causes wasting of the inflicted animals and may be spread via fecal matter, nursing from infected dams or contamination of the udder with manure, or en vitro. The disease may cause early death or culling losses, decreased milk production, decreased slaughter weights, loss of show, sale and breeding animals, and incurred veterinary costs. There is no effective vaccine. Johne's disease cases are reported at a rate of approximately 4.4% and appear to be increasing. Dairy cows seem to demonstrate a higher occurrence rate than beef cows. | There does not appear to be a transmission of this disease to people. Crohn's disease is a similar infliction in human populations. |
| Foot and Mouth Disease (FMD) | FMD is a fast-spreading virus which impacts all cloven-footed animals and causes blisters on feet, in mouths, and on mammary glands, resulting in lameness, the inability to eat or drink, and mastitis in dairy animals. In all cases, animals rapidly lose weight and may die. Transmission rates are nearly 100% of exposure, and young animals may die. FMD poses huge economic risks to livestock owners and consumers. In February 2001, the UK was forced to destroy over 9% of the national food animal production industry, and over 11 months to eradicate the disease. | FMD is distinct from Hand, foot, and mouth disease that impacts humans though the symptoms are similar. People cannot contract FMD. |
| Vesicular Stomatitis (VS) | VS is a virus that causes similar symptoms as FMD and is highly contagious, though it demonstrates a lower mortality rate. The disease may lead to serious restrictions on the movement, marketing, and exportation of animals from affected areas, which has a significant economic impact on livestock-driven economies. While no cases have been diagnosed recently in South Dakota, cases in nearby states underscore the need for vigilance and close reporting requirements. | Humans may contract the disease from sand flies or improper handling of infected animals and animal byproducts. Symptoms are flulike. |
| Trichomoniasis, also called 'trich' | Trich is a venereal disease that causes infertility and occasional abortions in cows. Bulls, once infected, carry the disease for life but cows seem to spontaneously recover after a period of infection, in some cases. During the FY 2005 breeding season, South Dakota experienced an unexpected resurgence of the disease in 45 confirmed cases, all west of the Missouri River. The known endemic qualities of the disease and the presence of the disease in states west and south of South Dakota, increased cases and magnified losses. Regulations for controlling and reporting Trichomoniasis were affected on June 1, 2005. Additional cases include 13 in FY 2009, 7 in FY 2008, 10 in FY 2007, and nine in FY 2006. | Humans may contract the disease and spread it from person to person via sexual contact. The disease may be contracted from livestock through improper hygiene when handling infected animals. |

| Disease Name | Incidents, History, and Other Reporting Measures | Human Vulnerability |
|---|---|---|
| **Swine** | | |
| Pseudorabies (PRV), also known as Aujesky's Disease or mad itch in cattle | PRV is a viral disease that causes abortion, high mortality of piglets, and may cause other symptoms in adult pigs. In addition, cattle, dogs, bears, cats, sheep, rabbits, and raccoons may contract the disease, which often proves fatal in these secondary hosts. The disease is spread via nasal secretions and saliva. On April 16, 2003, South Dakota was granted Stage V-Free status. Though domestic swine herds have been PRV-free since 2003, the disease remains in feral herds, which pose the greatest risk to domesticated animals. Positive animals must be destroyed to limit the spread, and, in some cases, the entire herd must be destroyed. The disease is considered one of the most economically devastating diseases of swine herds and the potential for a reintroduction of the virus from feral pig exposures remains a concern. | Humans are not potential hosts. |
| Porcine Reproductive and Respiratory Syndrome (PRRS) | PRRS is a virus that attacks the respiratory system and leads to an overall weakened immune system. The disease is highly contagious and spreads rapidly but seems to impact different herds with varying degrees of severity for unknown reasons. First identified in the U.S. in North Carolina in the 1980s, the disease spread rapidly across the continent. All breeds and ages of pigs are susceptible, though there is some indication that some breeds demonstrate less vulnerability than others. The impacts of this disease are still under evaluation, but losses to pig herds have economic ramifications for sale for slaughter and breeding. | There is no known human susceptibility to the disease. Humans may serve as mechanical vectors of the disease without proper infection control practices. |
| **Poultry** | | |
| Avian Influenza | While Avian Influenza is not currently documented in the State, the concern remains that exposure could result in the infection of domestic avian flocks, including turkeys, geese, chicken, and other fowls, that may contribute to the crossover between birds and people. A detailed response and containment plan has been developed and is a factor in mitigation should quarantine and/or subsequent destruction of flocks be required. A surveillance project went into effect in FY 2007. | Currently humans may contract the disease through extensive exposure to avian carriers. The concern is that the influenza serotype could genetically alter to sustain peer-to-peer transmission. |
| West Nile Virus | The first identified domesticated cases of WNV occurred in FY 2006, identified in geese at a production site in northeastern South Dakota. | Though mosquitoes remain the primary vector for human transmission, close contact with birds also increases the risk of exposure and may contribute to an alteration of the virus for sustained peer-to-peer transmission. |

| Disease Name | Incidents, History, and Other Reporting Measures | Human Vulnerability |
|---|---|---|
| **Wildlife** | | |
| Chronic Wasting Disease | The first case of CWD in farmed elk or deer in the U.S. was identified in a private South Dakota herd in late 1997. On February 5, 1998, a mandatory Cervid Chronic Wasting Disease Surveillance Identification (CCWDSI) Program was enacted. This monitoring program has become the model program for numerous other state CWD monitoring programs as well as the federal interim CWD monitoring plan. | No known human transmissions exist at this time. The disease is a variant of the same family that houses BSE, however, so appropriate precautions are appropriate. |
| Rabies | Rabies in the wildlife population remains at a high level. Skunks are the reservoir of the disease and they represent the largest number of positive diagnoses at the laboratory. Bats have also been recognized as a significant reservoir of rabies. For FY 2009, thirty-two (32) animals were reported infected with rabies, compared to twenty-nine (29) in FY 2008, twenty-five (25) in FY 2007; fifty-three (53) in FY 2006; eighty (80) in FY 2005; one hundred five (105) in FY 2004. | Yes, if exposed through bites or handling of infected animals. |

Sources: South Dakota Animal Industry Board Disease Control Website, Centers for Disease Control, U.S. APHIS

**Table 3-14 Small Grains**

| Disease | Winter Wheat | Spring Wheat | Barley | Oats | Rye | Occurrence |
|---|---|---|---|---|---|---|
| Barley Yellow Dwarf (Red Leaf of Oats) | X | X | X | X | | Common |
| Common Root Rot | X | X | X | X | X | Widespread |
| Covered Smut & Common Bunt | X | X | X | X | X | Fairly Common |
| Dryland Root & Crown Rot | X | X | X | X | X | Widespread, most serious on winter wheat |
| Leaf Rust | X | X | X | X | | Widespread |
| Loose Smut | X | X | X | X | | Common (>2% In Given Field) |
| Scab (Fusarium Head Blight) | X | X | X | X | X | East River Counties: Common<br>West River Counties: Rare |
| Stem Rust | X | X | X | X | X | Rare |
| Stripe Rust | X | X | | | | Frequent, Severity Varies by Year |
| Take All | X | | | | | Rare |
| Tan Spot, Septoria Leaf Blotch & Other Leaf Spot Diseases | X | X | X | X | | Widespread |
| Vomitoxin | X | X | X | X | X | Fairly Common |
| Wheat Streak Mosaic | X | X | | | | Frequent |

**Table 3-15 Sunflowers, Oilseeds, Dry Beans, Dry Peas and Soybeans, Corn, Alfalfa and Flax**

| Disease | Sunflowers | Canola | Safflower | Field Pea | Chick-pea | Lentil | Dry Bean | Soybeans | Corn | Alfalfa | Flax | Occurrence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alternaria Leaf &Stem Spot, Leaf Blight | X | | X* | | | | | | | | | Annually in late summer *common |
| Anthracnose | | | | | | X | X | | X* | X | X* | Rare *Occasional |
| Apical Chlorosis | X | | | | | | | | | | | Infrequent |
| Ascochyta Blight | | | | | X | X | | | | | | Common |
| Asian Soybean Rust | | | | | | | | X | | | | Not yet reported in the State |
| Aster Yellows | | X | | | | | | | | | X | Infrequent, no control |
| Bacterial Blight & Wilt$ | | | | X | | | X* | X | | X$ | | Widespread, *Occasional |

| Disease | Sunflowers | Canola | Safflower | Field Pea | Chick-pea | Lentil | Dry Bean | Soybeans | Corn | Alfalfa | Flax | Occurrence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | $Rare |
| Bean Pod Mottle | | | | | | | | X | | | | Widespread |
| Black Leg | | X | | | | | | | | | | Common |
| Blackspot | | X | | | | | | | | | | Common, no control |
| Brown Spot | | | | | | | | X | | | | Widespread |
| Brown Stem Rot (BSR) | | | | | | | | X | | | | Occasional |
| Charcoal Rot | | | | | | | | X | | | | Occasional, extreme southeast counties |
| Common Leaf Spot | | | | | | | | | | X | | Common |
| Damping Off | | | X | | | | | | X | X | | Common |
| Downy Mildew | X | | | | | | | X | | | | Common |
| Eyespot | | | | | | | | | X | | | Occasional |
| Frogeye Leaf Spot | | | | | | | | X | | | | Rare in state, observed in extreme southeast counties |
| Fusarium Root Rot and Wilt$ | | | | X | X | X | X | X | | X$* | X$* | Occasional *Common |
| Goss's Bacterial Wilt & Blight | | | | | | | | | X | | | Rare |
| Gray Leaf Spot | | | | | | | | | X | | | Fairly common |
| Holcus Spot | | | | | | | | | X | | | Annual in early summer |
| Maize Dwarf Mosaic | | | | | | | | | X | | | Common, typically low incidence |
| Northern Stem Canker | | | | | | | | X | | | | Frequent |
| Northern Corn Leaf Blight | | | | | | | | | X | | | Occasional |
| Pasmo | | | | | | | | | | | X | Occasional |
| Phoma Black Stem | X | | | | | | | | | | | Annually in late summer |

| Disease | Sunflowers | Canola | Safflower | Field Pea | Chick-pea | Lentil | Dry Bean | Soybeans | Corn | Alfalfa | Flax | Occurrence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Phomopsis Stem Canker | X | | | | | | | | | | | Annually in late summer |
| Pod & Stem Blight | | | | | | | | X | | | | Widespread |
| Pythium Damping Off & Seed Decay | | | | X | X | X | X | X | | X | | Widespread |
| Pytophthora Root & Stem Rot | | | | | | | | X | | X* | | Widespread *Fairly Common |
| Rhizoctonia Seedling Blight$ & Root Rot | | | | | | | | X | | | X$* | Widespread *Common |
| Root & Crown Rot Complex | | | | | | | | | | X | | Common |
| Sclerotinia Wilt, Stalk Rot & Head Rot | X | | | | | | | | | | | Annually in late summer |
| Soybean Cyst Nematode | | | | | | | | X | | | | Widespread in southeastern counties, scattered in other areas |
| Soybean Mosaic | | | | | | | | X | | | | Rare |
| Spring Black Stem & Leaf Spot | | | | | | | | | | X | | Widespread |
| Stalk Rot Complex | | | | | | | | | X | | | Annual in fall |
| Stem Nematode | | | | | | | | | | X | | Rare, restricted to western counties |
| Sudden Death Syndrome (SDS) | | | | | | | | X | | | | Rare: only in Clay County |
| Summer Black Stem & Leaf Spot | | | | | | | | | | X | | Common |
| Verticillium Wilt | | | | | | | | | | X | | Common |
| White Mold | | X | X | X | X | X | X | | | | | Common |

## Probability of Future Occurrence

To some extent, these events are guaranteed to occur on an annual basis, particularly when evaluated on a statewide scale. The determination of probability becomes most valuable when areas of particular occurrence rates, or when events of unusual severity, are recorded. Many times, extreme events are documented concurrently with other hazard event occurrences, such as the outbreak of high anthrax levels in 2005, which was attributed to drought; the grasshopper plagues of the 1930s, also attributed to drought; or the recurrence of certain crop molds, which correspond to unusually wet growing periods.

Overall, if the general annual probability of occurrence statewide is near 100%, some general probabilities for regions or specific counties may also be drawn.

In general, the western portion of the State (counties lying to the west of the Missouri River) have a higher documented occurrence rate of trich and stem nematode afflictions of alfalfa crops. Counties along the river basins bore the brunt of the anthrax outbreaks in 2005. Eastern counties have higher documented rates of the soybean cyst nematode, frogeye leaf spot, scab, and West Nile Virus in domestic fowl flocks. Areas with a primarily cultivated crop land use are more susceptible to crop diseases, and thus have a predicted higher probability rating than areas devoted to rangeland. Areas where wildlife interaction is more common among livestock have higher exposure probabilities to diseases like rabies and brucellosis.

A South Dakota State University Extension entomologist said that "based on the high grasshopper count late last summer (2009), there is potential for another year of grasshopper infestation in counties in western South Dakota". This prediction was accurate; grasshopper infestations continued to plague South Dakota in 2010. Dangerously high levels of grasshopper populations seem to follow a cycle of 7 to 10 years, meaning the State can reasonably expect another between 2017 and 2020. Drought or periods of higher-than-average temperatures, particularly in the winter, increase the severity of grasshopper population numbers, because more eggs survive to hatch. Based on historical data, South Dakota has experienced four grasshopper plagues in the 123-year time period from 1887 to 2010, resulting in an annual chance of 3.2%. Smaller infestations, which still exert significant economic impact, may be predicted at the cycle of ten years, or a 10% annual chance.

## Magnitude/Severity (Extent)

Different pests can impact different crops in different ways; while there is no scale to define the extent of an infestation, a pest could have a major economic impact on the value of infested crops.

Another large factor that may influence crop yield is the spread of invasive plants, which may compete with crops for resources and in some cases also introduce pests. Based on the USDA's Risk Management Agency (RMA) Crop Indemnity Reports, between 2007 and 2020, there were 269,937 acres lost due to plant disease, mycotoxins, and insects and $22,878,707 in indemnity payments were made. Statewide there was approximately $5.7 million in crop indemnity payments issued in the time period since the last plan update, from 2016-2020, for damages caused by mycotoxins, insects, or plant diseases.

As mentioned above in the Location section, the impacts of grasshoppers on cattle have also been significant, with several past events causing significant Campbell, Corson, Harding, and Perkins counties received USDA disaster designations for losses related to insects and disease (S3467) in 2012. In that same year, 30 counties received a total of $702,633 in indemnities for crop loss related to insects. 22 counties received $184,810 in insect-related indemnities in 2011, and 27 counties received $927,938 in insect-related indemnities in 2010. The crop losses in all three years included forage used to feed livestock. The prediction for 2009, based on the grasshopper density ratings mentioned above, indicated that food supplies for cattle in the western portion of the State would be severely impacted by the grasshoppers. This proved accurate in August of 2009, when the Associated Press reported that grasshopper infestations

forced ranchers to sell livestock because food supplies were unavailable.[2] South Dakota, specifically Ziebach County, was named in USDA Secretarial Disaster Declaration S2916 for damages done by grasshoppers.

## Climate Change Considerations

With agriculture as one of South Dakota's primary industries, climate change has the potential to have a direct impact on the economy. UC Davis published research on the effects climate change has on agricultural pests, crop diseases and weed species. Climate change can alter and increase the range or "damage niche" of many weed species. With these geographic range shifts, new weed species can enter communities further north than in the past. The effects of climate change on vary by region and crop type, so it is important to understand the different environmental factors and the underlying physiological mechanisms' responses. If the invasion of new species can be detected in advance, efforts can be made to control the growth.

Crop diseases can be animal, fungal, bacterial, or viral. An increase in severe weather events such as tornadoes, high wind, or storms may increase crop damage, crop losses and/or catalyze the spread of crop disease such as soybean rust. Local increases in precipitation also have the potential to aid in the dispersal of plant and crop disease.

Various frost-sensitive insects have been shown to increase in population with the rise of milder winters. Warmer winters may foster an environment that allow for pests and invasive weeds to survive through the cold season. Increasing annual average temperatures also aid in the growth and reproduction in certain insects. Studies on aphids and moths have shown that increasing temperatures can allow insects to reach their minimum flight temperature sooner, aiding in increased dispersal capabilities. Multiple studies have shown the northward expansion or shift of insect ranges, such as Edith's checkerspot butterfly or the mountain pine beetle, to be correlated with increasing temperatures.

According to the Fourth National Climate Assessment, the Northern Great Plains region is projected to become warmer and generally wetter through the middle of the 21$^{st}$ century, along with elevated levels of atmospheric $CO_2$. The assessment includes a detailed overview of agriculture in the Northern Great Plains states and the impacts that a changing climate may have on the economy and food security in the U.S., including how these changes may influence the prevalence and impact of agricultural pests and diseases. For example, an increase in the abundance and competitive ability of weeds and invasive species, an increase in the range and fecundity of crop pests, and overall warmer conditions which may make more favorable conditions for certain pests and diseases to establish.

The rising minimum (overnight) temperatures and relative humidity, particularly in the summer season, also have impacts on livestock health. Warm, humid nights can prevent proper body cooling and reduce cattle comfort and performance.

## Vulnerability Assessment

The impacts of agricultural pests and diseases will vary from year-to-year and county to county, but it is anticipated that the agricultural industry will continue to suffer losses from the various pests and diseases. Economically, these impacts can total up to a billion dollars in the State. Outside of the economic impacts, some of these have the potential to affect human health as well. Average annual crop loss can be estimated based on indemnity data from the RMA.

2 Carson Walker, Associated Press. "Grasshopper Infestation forces livestock sales in 15 states including Oklahoma"

### *People*

A widespread infestation of animals/livestock and crops could impact the economic base of the county and its communities. According to the USDA 2017 Census of Agriculture, South Dakota has 29,968 farms, a -6% change from the previous census in 2012. Table 3-13 above describes several livestock diseases which could occur in South Dakota, as well as whether they may have impacts on humans. Many animal diseases can cause illness or injury in humans in the event humans ingest or come into contact with infected animals.

Disease can exacerbate the impacts from other hazards, and an example of this is adverse weather; dead branches weakened by Emerald Ash Borer can be broken by high winds, and there are reports of these branches falling and causing harm to people.

### *Property*

An infestation of agriculture pests could impact crop yields, potential destroying whole fields. Between 2007 and 2020, insects and crop disease damaged 269,937 acres of field crops, causing the RMA to provide $22,878,707 in indemnities to farmers.

### *State Assets, Critical Facilities, and Infrastructure*

Critical facilities assessed in this plan would not be directly impacted by agricultural pests or diseases; however, the food and agriculture industry is considered critical to the State of South Dakota. Impacts to the infrastructure that supports this industry, such as farms, diary operations, and processing facilities would have debilitating effects on food security, the economy, and public health and safety. Farms and ranches in the State, and the associated food processing facilities would be directly impacted economically by long-term disruptions in the food supply associated with crop losses due to agricultural pests and disease.

### *Economy*

According the 2017 census of agriculture hogs and pork represented $577,034,000 of the livestock sold in in South Dakota, and cattle and calves represented $3,191,493,000 in sales. As of the December 31, 2017, there were 1,560,522 hogs and pigs and 3,988,183 cattle and calves in the State. A serious illness affecting pig herds in the county could have a devasting impact on the State economy as well as employment of those in the agricultural industry. The same would be true for a disease affecting cattle, such as Mad Cow Disease or FMD. The potential economic losses from a major epidemic among the State's livestock populations could be massive.

Nationally, it is estimated that invasive species cost the USA $138 billion per year. As noted above, pests and crop disease in South Dakota have caused $22,878,707 indemnity payments made. Statewide there was approximately $5.7 million in crop indemnity payments issued since the last HIRA update. The average annualized losses due to crop and plant disease is estimated to be $1,759,900. Economic impacts also include both prevention, response, and recovery costs.

### *Environment and Cultural Resources*

Invasive species typically harm native species through predation, habitat degradation and competition for shared resources; they can muscle native species out of natural habitats and are a leading cause of population decline and extinction in animals. As discussed above in the Climate Change Considerations section, the conditions which could help invasive species and diseases spread and establish may be on the rise in coming years. This presents a great deal of vulnerability, which is likely increasing, not only for agriculture but also for environmental and natural systems in South Dakota.

## Development Trends and Consequence Summary

Agriculture has a long history in South Dakota and continues to be a vital industry in the State. An agriculture pest or disease event can have devasting impacts on both the State's economy as well as the livelihood and mental health of individuals in the industry. With an annual probability of occurrence of 100% that an agriculture pest or disease event will occur in any given year, the State's vulnerability to this type of hazard event is not expected to decrease in the future. Counties with a higher presence of agricultural activities and economic value, such as Brown and Spink Counties, will remain more vulnerable to the impacts of agricultural pests and diseases. As noted within the Climate Change Consideration subsection, climate change is expected to increase winter and spring precipitation which may lead to disruptions in planting seasons. While summer season precipitation is projected to decrease, this may lead to an increase in drought events which in turn will continue to leave the State vulnerable to agricultural pests and diseases.

**Table 3-16 Risk Summary and Overall Significance**

| Category | Narrative |
|---|---|
| Impact on the Public | Potential for animal-to-human transfer of disease; potential for loss of livelihoods; potential for mental health issues due to severe economic hardship |
| Impact on the Economic Condition of the State | Potentially devastating depending on the pest or disease and its impacts; disease can wipe out whole herds; pests or disease can wipe out crops; incident may disrupt business operations of farms statewide; impacts could come from an incident in the State, or an incident in a nearby state; agriculture economy can be affected by something as simple as an unchecked rumor; significant implications for the potential expansion of the ranges of various pests and invasive species driven by climate change |
| Impact on the Environment | Zoonotic animal diseases may spread between livestock and wildlife; crop diseases or pests may spread between crops and surrounding flora; potential for widespread impacts depending on parameters of incident |
| Impact on Property, Facilities, and Infrastructure | No physical impacts to property; infected crops or livestock may be barred from slaughterhouses, co-ops, markets, and other agriculture sites |
| Impact on the Public Confidence in Government | Ability to respond and recover may be questioned and challenged if planning, response, and recovery is not timely and effective. |
| Impact on Responders | Isolation or quarantine can stress first responders needed to close roads or provide security |
| Impact on Continuity of Operations and Continued Delivery of Services | Need for personnel may stress limited resources |
| Cascading Hazards | N/A |

## 3.3.2 Flood

### Hazard Description

Throughout the United States, flooding is recognized as the most prominent disaster-producing phenomenon, generating annual losses in the billions of dollars. Floods are among the most serious, devastating, and costly natural hazards that affect South Dakota. The greatest impact of these phenomena has been to the eastern half of the state, principally, the Big Sioux, Vermillion, and James River basins, which have recurring problems and are unregulated (no dams) within South Dakota.

The following is extracted from "Flooding in South Dakota," a fact sheet written by Stan F. Pence from the South Dakota Department of Environment and Natural Resources.

#### *What Is a Flood?*

A flood occurs when water rises to flow over land that is normally dry. Floods happen in low-lying areas, such as valley bottoms, lake basins, and coastal areas. In South Dakota, flooding occurs mainly in valley bottoms, deep canyons, and lake basins when the amount of water moving through a river, or entering a lake, is so great that the natural or artificial banks can no longer contain all of the water. Therefore, the water overflows the banks of the river or lake and spreads out onto low-lying areas that are not normally covered with water.

#### *What Causes a Flood?*

In South Dakota, there are two main climatological causes of flooding: runoff from rainfall and runoff from melting snow. The water from rainfall or melting snow flows overland until it reaches a nearby river or lake. If the river or lake cannot hold all the water that is entering it, some of the water will begin to overflow the banks of the river or lake, causing flooding. The size of the flood is commonly influenced by such factors as the intensity of the rainfall, length of the rainfall, melting rate of the snow, and the infiltration rate of the water into the ground.

In addition to climatological reasons for flooding in South Dakota, floods can also result from the failure of dams. Dam failure can result from defective construction, poor maintenance or a poor foundation. Many small dams in South Dakota fail because their spillway is not big enough. Often, failure occurs as a result of extremely heavy rainfall that causes a large increase in the amount of water held by the dam. This increase in water behind the dam could place more stress (pressure) on the dam than it was designed to handle, causing the dam to fail.

#### *What Types of Floods Occur in South Dakota?*

Four types of floods can occur in South Dakota. The first type is commonly called a flash flood. A flash flood is the result of several inches or more of rain falling in a very short period of time, often tens of minutes. This high intensity rainfall is commonly caused by powerful thunderstorms that cover a small geographic area. Because so much water is falling onto the ground very rapidly, there is little time for the water to soak in, and most of the water runs off into nearby rivers or lakes. The flood that occurs as a result of this runoff happens very rapidly, hence the term "flash." This type of flood is generally very destructive, affecting a fairly small, localized area, commonly several tens of square miles or less. The flash flood often ends almost as quickly as it started. Probably the best-known flash flood in South Dakota occurred when Rapid Creek left its banks on June 9, 1972, in Rapid City. Fifteen inches of rain that fell in less than 6 hours caused the flooding. This flood was devastating both in terms of loss of human life and property damage. Two hundred thirty-eight people lost their lives in this flood and about $150 million (in 1972 dollars) of property damage occurred.

The second type of flooding is sometimes termed the long-rain flood and is the most common cause of major flooding. This type of flood results after several days or even weeks of fairly low-intensity rainfall over a widespread area, often hundreds of square miles. As a result, the ground becomes "waterlogged," and the water can no longer infiltrate into the ground; therefore, the water begins to flow toward rivers or lakes. The flooding that can result is often widespread, covering hundreds of square miles, and can last for several days or many weeks. Much of the flooding that occurred in eastern South Dakota during the summer of 1993 was this type of flooding.

The third type of flood in South Dakota is the result of melting snow in the spring. This type has characteristics that are almost a combination of the flash flood and long-rain flood. The area covered by this type of flood is generally not as large as that covered by the long-rain flood but is typically larger than that covered by the flash flood. Generally, the flood lasts for several days, occurring when large amounts of snow melt rapidly due to warm temperatures. The flooding can be made worse if the ground remains frozen while the snow is melting; this causes all of the melt water to run off to nearby rivers and lakes rather than infiltrate into the ground.

Some of the largest floods that have occurred in South Dakota were the result of melting snow and ice. These large floods have occurred along the entire length of the Missouri River. The Great Flood of 1881 is probably the most well-known of all the floods to take place in South Dakota. Ice jams on the river caused the flooding to become extremely devastating, destroying large amounts of property and causing many lives to be lost. Towns such as Yankton, Vermillion, Burbank, Meckling, and Pierre were all severely damaged by the flooding.

The fourth type of flood results from the failure of dams or levees. The four largest dams in South Dakota - Oahe at Pierre, Big Bend at Fort Thompson, Fort Randall at Pickstown, and Gavins Point at Yankton - are all located on the Missouri River. Large dams in the Black Hills are the Deerfield, Pactola, Sheridan, Angostura and Orman dams. If any of these large dams were to fail, flood damage could be very great. Fortunately, all of these dams are considered to be properly constructed and have been designed to hold back very large amounts of water; therefore, they are considered to be very safe, and the likelihood of failure is extremely small. Except for these Missouri and Black Hills dams, the majority of the dams in South Dakota are very small, and if they were to fail, flooding would likely be minimal. Levees protect many areas in South Dakota; however, many of these levees protect small areas from flooding (see Figure 3-17).

Further information regarding dam and levee failure and other flooding risk in South Dakota follows.

## Dam Failure

South Dakota has approximately 2,573 dams in the National Inventory of Dams (see Figure 3-17 in Location section below). The State defines a dam as follows: “a structure is a dam if the height to the dam crest is greater than or equal to 25 feet and the storage at the dam crest (not at the spillway elevation) is greater than 15-acre feet or if the height to the dam crest is greater than 6 feet and the storage at the dam crest (not at the spillway elevation) is greater than or equal to 50 acre feet. The height of the dam is the difference in elevation between the natural bed of the watercourse or the lowest point on the toe of the dam, whichever is lower, and the crest elevation of the dam.”

- 2,573 dams
- 97% of high hazard dams have an Emergency Action Plan (EAP)
- 4% of dams federally regulated
- 94% of dams state regulated

Of the 2,573 dams, 86 are high hazard dams and 97% of them have an EAP on file, with only three high hazard dams lacking an EAP. This represents a consistent improvement since 2007, when 21 dams had no EAP and in 2012, when 15 had no emergency action plans. All high hazard dams are required to have emergency action plans. Of the total dams, approximately 156 are significant hazard dams. Because of South Dakota's low population and low density, most of the State's dams are low hazard dams. In *Federal Guidelines for Dam Safety: Hazard Potential Classification Systems for Dams* (FEMA 2004), dams are classified as follows:

- **Low Hazard Potential** - Dams assigned the low hazard potential classification are those where failure or mis-operation result in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
- **Significant Hazard Potential** - Dams assigned the significant hazard potential classification are those dams where failure or mis-operation result in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
- **High Hazard Potential** - Dams assigned the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life as well as economic, environmental, and lifeline losses.

## Levee Failure

In addition to these dams, South Dakota also has levees that pose flood risks. Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Floodwalls are concrete structures, often components of levee systems, designed for urban areas where there is insufficient room for earthen levees. When levees and floodwalls and their appurtenant structures are stressed beyond their capabilities to withstand floods, levee failure can result in loss of life and injuries as well as damages to property, the environment, and the economy. In South Dakota, there are numerous levees ranging from small agricultural levees that protect farmland from high-frequency flooding to large urban levees that protect people and property from larger less frequent flooding events such as the 100-year and 500-year flood levels. For purposes of this discussion, levee failure will refer to both overtopping and breach of a levee as defined in the U.S. Army Corp of Engineers' Publication - S*o You Live Behind a Levee!* (https://mrcc.illinois.edu/1913Flood/awareness/materials/SoYouLiveBehindLevee.pdf).

- **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.
- **Breaching** - 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.

## Location

According to the NWS, flash floods are the deadliest natural disaster in South Dakota. They are caused by stationary or slow-moving thunderstorms that produce heavy rain over a small area. The Black Hills are especially vulnerable to flash floods, where steep terrain and narrow canyons can funnel heavy rain into small creeks and dry ravines, turning them into raging walls of water. Even on the prairie, normally dry draws and low spots can fill with rushing water during very heavy rain. The following map illustrates where

FEMA regulated floodplains have been mapped in the State of South Dakota, based on Digital Flood Insurance Rate Maps integrated into the National Flood Hazard Layer (NFHL).

**Figure 3-17 South Dakota FEMA DFIRM Floodplains**

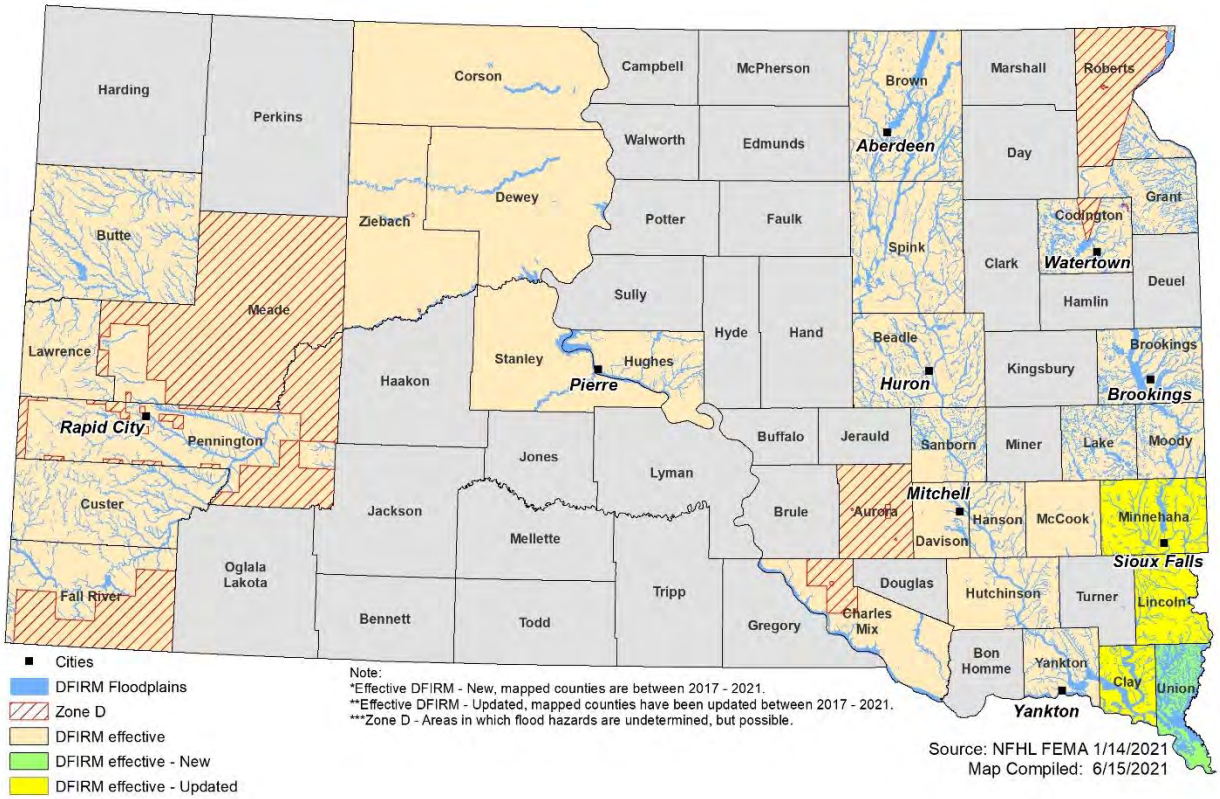


**Figure 3-18 South Dakotas 100-year Flood Zones based on Hazus**

South Dakota is divided into 14 river drainage basins (See Figure 3-19). These basins extend beyond the political boundary of the State. Although not discussed or included in this plan, an interstate understanding of water policy is required to fully analyze and comprehend South Dakota water systems.

**Figure 3-19 Drainage Basins of South Dakota**

Source: USDA Natural Conservation Resources Service South Dakota

## *Missouri River Basin*

The following description of the Missouri River Basin is from Microsoft Encarta Online Encyclopedia:

> Considered as a separate river, the Missouri is the longest in the United States. In combination with the Mississippi River into which it flows at St. Louis, it is the longest river system in the United States. The river begins where the Gallatin River, Jefferson River, and Madison River come together in the foothills of the Rockies in Montana. It flows through Montana, North Dakota, and South Dakota before forming the boundary between Iowa and Nebraska. It forms the extreme northeast border of Kansas before turning almost due east through the State of Missouri.
>
> South Dakota is drained almost entirely by the Missouri River and its tributaries. The only sections that are not lie in the extreme northeast and northwest. The Missouri flows southward and then southeastward across the State, in a deep, wide channel. It forms part of the South Dakota–Nebraska state line. Much of the South Dakota section of the river is now made up of a chain of four reservoirs impounded by large dams. These dams include Fort Randall, Gavins Point, Big Bend, and Oahe dams which were built for flood control and to provide water for irrigation and the generation of hydroelectricity. Lake Oahe is formed by Oahe Dam at Pierre. The James River, the Vermillion River, and the Big Sioux River, all in the eastern half of the State, flow southward in roughly parallel courses to join the Missouri. In the western part of the State the Grand, Moreau, Cheyenne, Bad, and White rivers flow generally eastward to join the Missouri.

South Dakota cities on the river include Pierre, Mobridge, Oacoma, Chamberlain, Pickstown, Fort Thompson, Ft. Pierre, Springfield, Yankton, and Lower Brule. The interstate effects of water policy are evident in the capital city of Pierre, where national policy objectives produce an ever-rising Missouri River to offset flooding in downriver states.

The largest natural lake in South Dakota is Lake Thompson in the east central part of the State. Other natural lakes of significant size in South Dakota are lakes Traverse and Big Stone, both in the northeastern corner of the State. Lake Traverse is a reservoir created by damming up the Boise Des Sioux Rivers near Rosholt. Big Stone Lake is a reservoir created by damming the Little Minnesota River near Big Stone City. In addition, there is the Waubay Lakes Chain and adjoining closed basins (discussed further in this section) located in the northeastern part of the State, which have continuous ongoing flooding issues. Numerous small lakes and sloughs dot the landscape of northeastern South Dakota, as well. The largest lakes are the reservoirs behind dams on the Missouri River, all of which were constructed as part of the Missouri River Basin Project.

### *Big Sioux River Basin*

The Big Sioux River Basin is the eastern most major river pattern in South Dakota. It is formed within a topographic feature known as the Coteau de Prairie Highlands. This glacial formed feature rises about 800 feet above the bordering Red River lowlands of Minnesota. It is also bordered on the west by the James River Lowland. The Coteau has what is known as a flatiron shape lying in a general northwest to southeast direction. It is about 200 miles long and 80 miles wide at the widest point. It has a variation in elevation from 2,050 feet at the highest point to 1,090 feet at the lowest point.

The northern part of the Coteau has geologically developed features of potholes, sloughs, and lakes. During periods of low precipitation, these features tend to hold backwater and do not contribute to the drainage of the Big Sioux River. Conversely, during wet years, this area can accumulate enough moisture to greatly increase the water supply to the drainage basin. There are about 1,970 square miles of land within the basin that is designated as noncontributing to the drainage system. The portion of the basin that does contribute to the Big Sioux River is about 7,280 square miles. A total of 4,280 square miles of the figure is located in South Dakota

The headwaters for the Big Sioux River are found in the Coteau Lake Region of Roberts and Day Counties. The river flows in a southerly direction to its junction with the Missouri River near Sioux City, Iowa. The variation in elevation from the headwaters to the mouth greatly influences the movement of water through the basin. The elevation decreases from 1,826 feet near Waubay to 1,281 at Sioux Falls. The Granite Falls formation of Sioux Falls has a 100-foot drop in elevation. Below the falls, the elevation varies from 1,281 feet to 1,098 feet at the river's mouth near Sioux City, Iowa.

Associated with the elevation is the slope profile of the river. The slope varies from 1.83 feet per mile near Watertown, 1.50 feet per mile at Sioux Falls, and 0.5 feet per mile at the junction with the Missouri River. The Big Sioux River has a steeper gradient than the James or Vermillion rivers. This steep slope causes water to move quickly down the drainage system and thus shortens the time of peak flooding in any given portion of the basin.

### *James River Basin*

The James River Basin is the largest of the East River Basin Systems. It is bordered on the east by highlands of the Coteau de Prairie and on the west by the high ground of the Coteau de Missouri. The valley is a nearly flat stretch of land about 216 miles long and averaging 60 miles wide. It is only in the southern portion that the topography becomes steeper. There is little variance in the elevation of the

basin. At Columbia, where the river basin forms in South Dakota, the elevation is 1,290 feet. At the southern terminus of the basin near Yankton, the elevation is 1,162 feet.

The James River drainage area encompasses all or part of 23 counties. It drains 12,609 square miles or over eight million acres of land in South Dakota. This represents 16.3 percent of the total land in the State. The river valley is about 400 miles long, 25 to 75 feet deep, and varies in width from a few hundred feet to three miles. The slope of the valley is 0.493 feet per mile and the average slope of the river is 0.280 feet per mile.

There are seventeen contributing streams within the James River Valley. These streams drain 10,606 square miles. The majority of the basin lacks good drainage features. This is due to the slight variance in elevation and limited slope of the river. Much of its drainage is noncontributing and remains in small swales and basins.

### *Vermillion River Basin*

The Vermillion River Basin is the smallest of the East River systems. It has its headwaters in the lake country of Kingsbury County. The river flows through McCook, Turner, and Clay Counties to join with the Missouri River near Burbank, South Dakota. The west branch originates in Miner County and connects with the main stem near Parker in Turner County.

The Vermillion River Basin is formed in the Dakota Valley or what is more commonly called the James River Lowland. This area is more than 200 miles long and about 60 miles wide and occupies a portion of the lower half of the basin. The gradient of this river system is approximately 400 feet throughout the length of the river. The east branch elevation is 1,518 feet and the elevation near Vermillion is 1,119 feet. The slope profile is approximately four feet per mile.

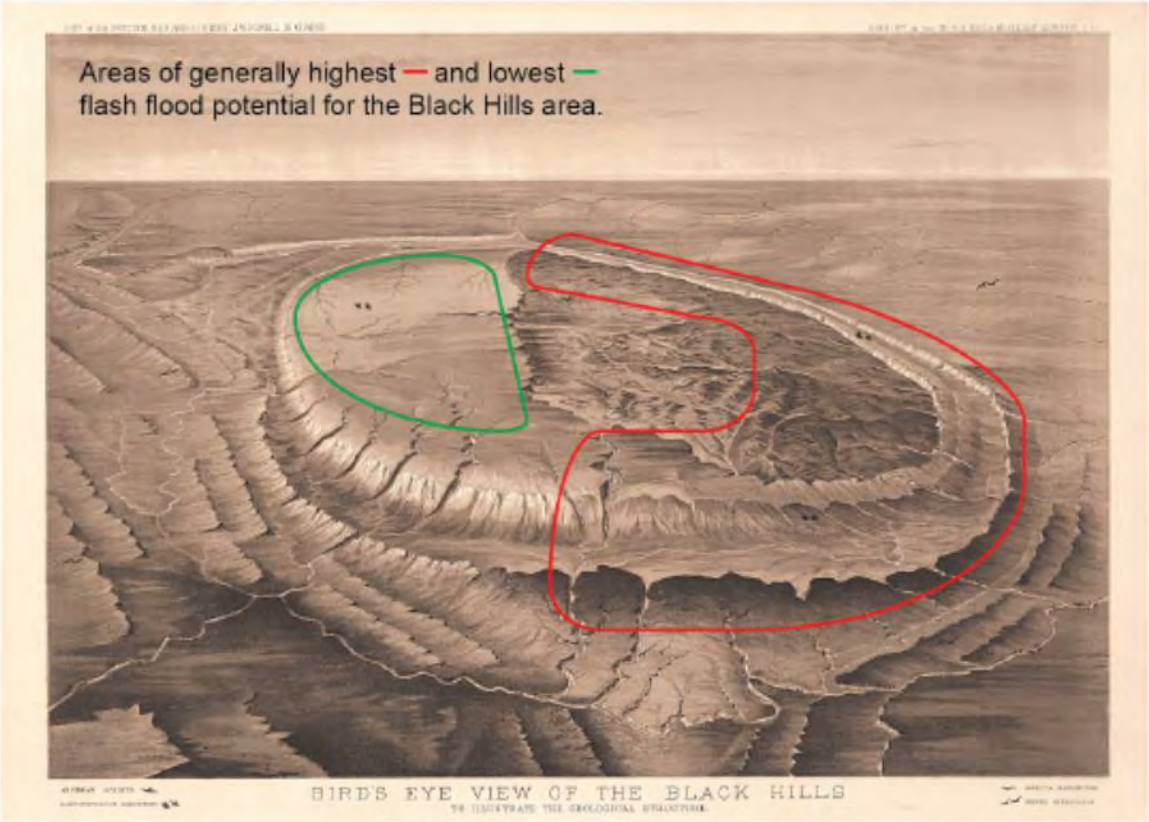
The drainage system is supplied with water from both the east and west portion of the basin. The major tributaries are the Little Vermillion River, Turkey Ridge Creek, and Saddle Creek. There are also a number of very small tributaries contributing to its drainage pattern.

### *Black Hills Region*

The western most drainage system is found in the Black Hills Region. The Black Hills lie within the states of Wyoming and South Dakota with the majority in western South Dakota. The region is 125 miles long and 60 miles wide. The general shape of the Black Hills is elliptical. This formation presents a startling contrast to the surrounding topography. Its eastern side rises from the prairie to a height from 2,600 to 3,500 feet. The western part of the Black Hills varies in elevation from 3,500 to 7,200 feet at Black Elk Peak.

The major drainage creeks of Alkali, Battle, Bear Butte, Beaver, Box Elder, Elk, French, Rapid, Spearfish, Spring, and Whitewood are all capable of causing heavy flooding and flood-related damage. These eleven creeks drain about 7,500 square miles of land. Figure 3-20 below is a diagram of the Black Hills Region's susceptibility to flash flooding.

**Figure 3-20 Generalized Potential for Flash Flooding in the Black Hills Area (modified from Driscoll and others, 2010)**




Source: Driscoll, Huft, and O'Connor, Extreme Floods in the Black Hills Area: New Insights from Recent Research, 2012

### *Waubay Lakes Chain and Adjoining Closed Basins*

The Waubay Lakes Chain is part of a 409 square mile closed basin area in the Big Sioux River Basin in northeastern South Dakota (mostly in Day County). The 10 major lakes in this chain are glacial in origin and include Bitter Lake, Blue Dog Lake, Enemy Swim Lake, Hillebrands Lake, Minnewasta Lake, Pickerel Lake, Rush Lake, Spring Lake, Swan Pond, and Waubay Lake. In closed basins, under most circumstances, water does not have a direct drainage path to a river outside the closed basin and the water would have to evaporate into the atmosphere for lake levels to recede. The northeastern area of South Dakota is much like a giant bathtub. Water fills the basin until it overflows the sides. Because the area is atop a flat area of high ground, the sides of the tub are higher than the normal drainage routes (e.g., the Big Sioux and the James Rivers), leaving the accumulated runoff without a natural outlet.

Rising waters have inundated portions of Day County and the surrounding areas in the past, in particular during the 1990s. Significant increases in lake levels within the Waubay Lakes Chain have occurred mainly due to greater-than-normal precipitation along with less-than-normal evaporation. In September 1998, FEMA issued a mission assignment to the U.S. Geological Survey to provide oversight, coordination, and hydrologic expertise for a study of the Waubay Lakes Chain and the adjoining closed basins. This study, including pertinent maps, is on file with the OEM and FEMA Region VIII. The U.S. Army Corps of Engineers also provided technical expertise and analysis for the study as well as possible structural mitigation solutions. The Natural Resource Conservation Service provided soils data. This study found that from 1991 until the report was published in 1999, the Waubay Lakes Chain experienced a wet climatic period that can be expected to occur less than once every 100 years, on average. Due to periods of above normal

precipitation and below normal evaporation, significant increases in lake levels and inundation areas within closed basins in northeastern South Dakota have been observed.

Based on the study of the Waubay Lakes Chain the lake levels for Bitter, Hillebrands, Minnewasta, Rush, Spring, and Waubay lakes and Swan Pond have significantly increased. The total surface area of the ten major lakes increased by 74 percent between 1991 and 1998. The water levels for Bitter, Hillebrands, Spring, and Waubay lakes and Swan Pond increased between 15 and 18 feet from 1991 to 1998. Blue Dog, Enemy Swim, and Pickerel lakes have concrete weir outlet structures and experienced lake level increases of 2.7, 1.8, and 0.1 feet respectively between fall 1991 and fall 1998. Minnewasta and Rush lakes experienced lake level increases of 9.2 feet and 3.9 feet respectively.

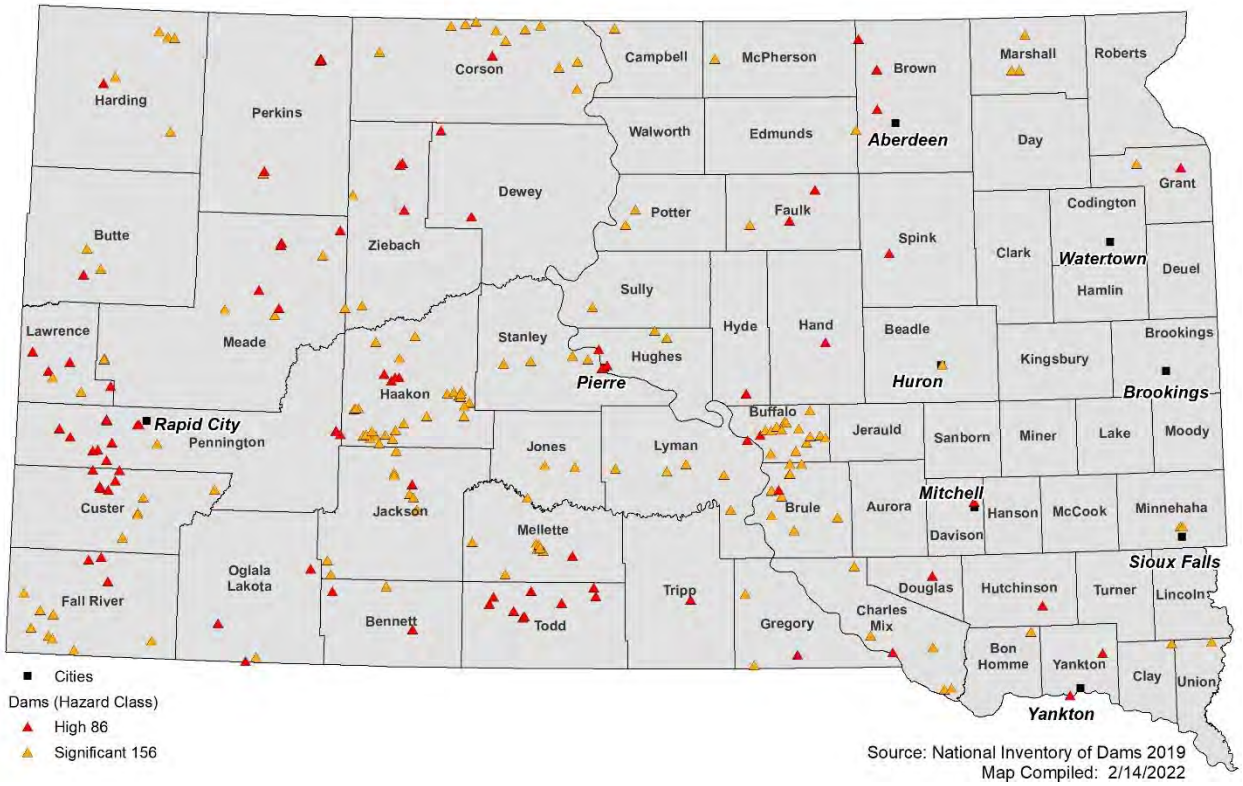
At the time the study was published, the U.S. Army Corps of Engineers' hydrologic model simulation suggested that flooding problems would persist in the region for the next few years, regardless of whether the climate was wet or dry. It would take at least a decade of drought similar to that experienced in the 1930s to return the lakes to pre-1992 conditions. If relatively wet climate conditions persist, the lakes would continue to climb until Bitter, Blue Dog, Rush, and Waubay lakes form a single lake that will inundate over 60,000 acres and the natural drainage divide south of Bitter Lake could overflow and spill to the Big Sioux River. This scenario, however, would require nearly 15 years of wet conditions.

Rising water levels in the Waubay Lakes Chain have resulted in substantial damage to public and private properties in the basin. Several presidential declarations in the 1990s allowed for funding to be used to address the immediate problems of inundated roads and structures for emergency access purposes. Numerous public roads and highways have been damaged or closed because of high water, and some have been raised at great cost. Many parks and recreational facilities have been adversely affected as well. The available data show that the greatest impacts from flooding have been to agriculture and transportation. The federal government had spent over $71 million in northeastern South Dakota for response and recovery efforts and emergency measures during the 1990s. However, because a major storm event or flash flood did not cause the damage (it was caused by an accumulation of annual runoff and a lack of evaporation), established FEMA disaster programs could not adequately address the situation. Since that time 29 homes have been acquired in Waubay with FEMA HMA funding in 2012, which should mitigate some of the losses to residential structures in this area in the future.

### *South Dakota Dams*

The four largest dams in South Dakota in terms of normal storage capacity are Oahe at Pierre, Big Bend at Fort Thompson, Fort Randall at Pickstown, and Gavins Point at Yankton. These are U.S. Army Corps of Engineers Dams on the Missouri River. Large dams in the Black Hills are the U.S. Department of the Interior Bureau of Reclamation's (BOR) Deerfield, Pactola, and Angostura dams, the U.S. Forest Service's Sheridan Lake dam and the Orman dam which is associated with the Belle Fourche Irrigation District. Shadehill Reservoir, while not in the Black Hills, is a significant BOR dam which stores water for irrigation (6,700 acres) and flood control purposes. Figure 3-21 shows the locations of the high and significant hazard dams in South Dakota.

**Figure 3-21 South Dakota High and Significant Hazard Dams**




## *South Dakota Levees*

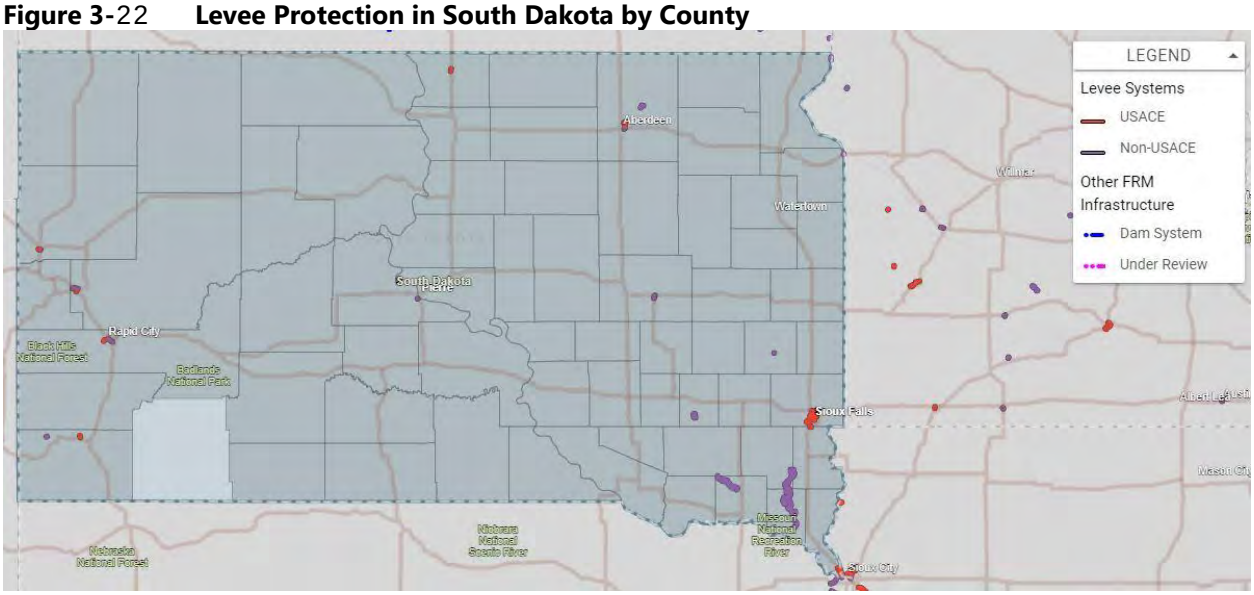
As mentioned previously, South Dakota contains numerous levees ranging from small agricultural levees that protect farmland from high-frequency flooding to urban levees protecting large urban populations and property from larger less-frequent flooding events such as 100-year and 500-year floods. According to the U.S. Army Corps of Engineers National Levee Database, there are 105 levee systems in South Dakota containing 118 miles of levees. 16 of these systems, containing a total of 41 miles of levees, are USACE constructed systems. Table 3-17 shows the location of the U.S. Army Corp of Engineers Levees, as well as detail about each levee. These are also graphically depicted on Figure 3-22. The following table is not a comprehensive inventory of levees in the State. The SHMT noted that there are several levees along the James River in Spink and Brown Counties that are not certified and frequently overtopped. Although these are not represented in the FEMA database of levees, the James River Water Development District (JRWDD) commissioned a LiDAR survey of the floodplain and now maintains GIS data of all of the levee locations along the James River. This information is being used by the JRWDD to identify specific mitigation actions within the watershed. JRWDD and Brown County are exploring opportunities to commission LiDAR for the entire county.

**Table 3-17 U.S. Army Corps of Engineers Owned Levees by County in South Dakota**

| County | City | System Name | Construction Completion Date | What's Behind the Levee? | | |
|---|---|---|---|---|---|---|
| | | | | Population | Buildings | Property Value (Millions) |
| Brown | City of Aberdeen | Aberdeen – Moccasin Creek RB | - | 5,453 | 2,126 | $591 |
| Butte | City of Belle Fourche | Belle Fourche RB | 6/1/1938 | 435 | 166 | $54.2 |

| County | City | System Name | Construction Completion Date | What's Behind the Levee? | | |
|---|---|---|---|---|---|---|
| | | | | Population | Buildings | Property Value (Millions) |
| Campbell | Town of Herreid | Herreid - Spring Creek RB | 10/19/1953 | 382 | 251 | $39.2 |
| Fall River | City of Hot Springs | Hot Springs - Fall River Channel West System | 7/25/1949 | 41 | 28 | $17.3 |
| Fall River | City of Hot Springs | Hot Springs - Fall River Channel East System | 7/25/1949 | 125 | 39 | $17.2 |
| Lincoln, Minnehaha | City of Sioux Falls | Sioux Falls - Big Sioux RB and Skunk Creek RB | 1/1/1961 | 8,492 | 249 | $513 |
| Meade | City of Sturgis | Sturgis - Deadman Gulch RB | 6/26/1980 | 82 | 31 | $14.7 |
| Minnehaha | City of Sioux Falls | Sioux Falls - Diversion Channel LB - South | 1/1/1961 | 1 | 4 | $3.9 |
| Minnehaha | City of Sioux Falls | Sioux Falls - Diversion Channel LB - North | 1/1/1961 | 7,026 | 176 | $429 |
| Minnehaha | City of Sioux Falls | Sioux Falls - Big Sioux RB and Skunk Creek LB | 1/1/1961 | 1,695 | 458 | $249 |
| Minnehaha | City of Sioux Falls | Sioux Falls - Big Sioux RB | 1/1/1961 | 326 | 75 | $54.9 |
| Minnehaha | City of Sioux Falls | Sioux Falls - Big Sioux LB North and Diversion Channel RB | 1/1/1961 | 8,120 | 1,798 | $1,100 |
| Minnehaha | City of Sioux Falls | Sioux Falls – Big Sioux LB Downtown | | 154 | 6 | $9.72 |
| Minnehaha | City of Sioux Falls | Sioux Falls – Big Sioux River LB South | | 3,830 | 418 | $252 |
| Pennington | City of Rapid City | Rapid City - Rapid Creek RB | 11/26/1978 | 304 | 119 | $56.4 |
| Union | City of North Sioux City | North Sioux City - Union County - Big Sioux River RB | 10/20/1981 | 1,093 | 450 | $188 |

**Figure 3-22 Levee Protection in South Dakota by County**




Source: USACE National Levee Database

## Past Events

According to the NCEI Storm Events Database, there were 2,914 floods or flash floods reported in South Dakota between 1993 and August 2021. This is more than double the number of events reported during the time period between 1993 and 2015. It should be noted that some of these counts include individual events which may have impacted more than one county or city and been reported multiple times, however, the associated counts of damages and casualties are comprehensive. Total property and crop damage for these events is estimated at $1.131 billion. This suggests that South Dakota experiences an average of 104 floods and $403.9 million in flood losses (property and crop) annually. This is a dramatic increase in reported losses to flooding over the previous analysis. There were also seven deaths and five injuries during this 22-year time period. Table 3-18 describes some of the floods that have occurred in South Dakota, specifically those that have led to a federal disaster declaration.

South Dakota is remarkable in that as early as the late 1800s, flood mitigation efforts were pursued and implemented. The first effort was after the 1886 flood of the Vermillion and Missouri rivers that wiped out the town of Vermillion. The town was relocated on the bluffs behind the former town to prevent another recurrence. This was the first recorded hazard mitigation effort by a government entity in South Dakota and possibly in the nation.

The second effort followed the 1972 Black Hills/Rapid City flood. This flood stands out in South Dakota history as the deadliest and most expensive in terms of damage. Following the flood, Rapid City refused to allow rebuilding in the floodway, effectively launching federal government efforts to create a hazard mitigation program.

While there have been failures of low hazard dams in recent years, no deaths or injuries were reported, and property damage was minimal. The only significant failures of high hazard dams are the breach of Canyon Lake Dam in 1972 (Rapid City flood) and the failure of Menno Dam in 1984 (see event descriptions below). Rose Hill Dam in Hand County failed in 2010 due to heavy rains. Two people were stranded, hanging from a tree as floodwaters rushed past, until first responders were able to rescue them. Over the course of the 2019 floods, the Hidden Timber, Okobojo, and Quinn Dams each failed over the

course of the spring months and resulted in washed out roads downstream, but none of these incidents resulted in property damage or injuries.

**Table 3-18 Significant South Dakota Flood Events**

| Date | Comments |
|---|---|
| September 12, 2019 | Severe Storms, Tornadoes, and Flooding (**FEMA-4469-DR**)<br>Heavy rainfall from September 10-12 totaling 7 to 8 inches near Mitchell led to widespread areal flooding. Travel was significantly hampered across most of the county, including the closure of Interstate 90. Smaller creeks and ponding resulted in the closure of most township and county roads. Five miles south of Mitchell, a bridge over Enemy Creek was washed out, requiring a swift water rescue of one person who was overwhelmed by the current. Three residents located one-half mile east of this bridge were also evacuated from waist deep waters. This bridge was one of nine damaged across the county. A no-wake order was placed on Lake Mitchell due to extremely high water. Significant street flooding occurred around Mitchell for the better part of three days. Property damages totaled $22.2 million. Flooding also resulted in the loss of crops, with an estimated $2.4 million in losses provided by the USDA. |
| June 30-July 21, 2019 | Severe Storms, Tornadoes, and Flooding (**FEMA-4467-DR**)<br>A continuation of flooding from June, relentless rainfall during July 2019 brought basin averages from 6 to 10 inches north of Interstate 90 and 4 to 6 inches south of Interstate 90. As a result, flooding along the Big Sioux River either continued, or was renewed, during the month. |
| May 26, 2019 | Severe Storms and Flooding (**FEMA-4463-DR**)<br>After major to record flooding due to widespread heavy precipitation during the previous week, conditions were primed for additional flooding when rain began May 26. As much as four inches of rain was observed near Faith, while one to two inches of rain fell over portions of the White River basin. Approximately $2.35 million in property damages were reported to the NCEI. |
| March 14, 2019 | Severe Storms and Flooding (**FEMA-4440-DR/FEMA-4448-DR**)<br>This event occurred during the wettest period on record in the U.S., from January to May of 2019. Beginning in mid-March with rainfall of one to three inches on frozen ground and into a snowpack with between 2 and 5 inches of liquid water equivalent resulted in considerable overland flooding. One of the hardest hit areas was around Yankton, where a No Travel Advisory was issued for the city on March 13-14. Businesses along north Highway 81 toward Yankton Mall had considerable ponding of water. Water rescues were necessary as cars stalled in high water in low spots around Yankton. Two people were also rescued from their inundated vehicle on Jim River Road east of Yankton. Water also got into power substations and caused spotty power outages and necessitated temporary evacuation of residents. State government offices across the area were closed on March 14 due to the flooding and a Federal Disaster was declared on June 7, 2019. The Federal Disaster Designation ultimately included all but eight counties in the State.<br>Flooding occurred all throughout the State along the Missouri River and its tributaries, continuing into Nebraska, Iowa, and Missouri. High water levels persisted across the State through April and into May, with flood stage conditions persisting in many rivers throughout the Midwest for almost the entirety of 2019. Ultimately three deaths and upwards of $58.9 million in damages was reported statewide in this event. Almost $1 billion in crop losses statewide can also be attributed to the conditions created by this event, as it resulted in the loss of or inability to plant crops. |
| June 24, 2015 | Severe Storms, Tornadoes, Straight-line Winds, and Flooding (**FEMA-4233-DR**)<br>Strong thunderstorms over western and central Pennington County dumped three to four inches of rain during the evening and overnight hours of June 23-24. Runoff from the heavy rain caused areas of flooding along streams. |

| Date | Comments |
|---|---|
| | Runoff from heavy rain caused flooding in Rapid Valley. Green Valley Drive was flooded for a quarter of a mile and Anderson Road was impassable. Flooding was also observed at two gauging stations along Rapid Creek. The river gauge near Rapid Valley crested 2.1 feet over flood stage and the river gauge at Farmingdale crested 0.9 feet over flood stage. Total property damage in those counties is estimated to be more than $20,000. |
| May 19, 2015 | Severe Storms, Straight-line Winds, and Flooding (**FEMA-4237-DR**)<br>Record flooding occurred along the White River from the Nebraska state line to Badlands National Park. The White River was over 200 yards wide and at least two feet deep on BIA Highway 41 north of Oglala, where a vehicle was swept off the highway and the passengers had to be rescued. BIA Highway 32 near Slim Butte was washed out and a culvert on BIA Highway 27 washed out and the road was damaged north of Rockyford. Total property damage in those counties is estimated to be more than $20,000. |
| June 14-18, 2014 | Severe Storms, Tornadoes, and Flooding (**FEMA-4186-DR**)<br>Repeating heavy rain caused record flooding of the lower Big Sioux River from June 15th through June 26th. Considerable flooding of farmland and other lowlands included numerous roads, with some roads damaged and a few washed out. A few farm homes and other buildings were damaged by floodwaters. There was considerable damage to counties including Union, Minnehaha, Lincoln, Turner, Jackson, Lake, Yankton, Clay, Hutchinson, McCook, Moody, Butte, Harding, Meade, Perkins, and Ziebach.<br>Repeated heavy rains caused record flooding of the Big Sioux River. Farmland and other lowlands including numerous roads were flooded. Some roads were damaged, and some secondary roads were washed out. A few farm homes, other farm buildings, and some fences were damaged by floodwaters. The river crested at a record 12.92 feet above flood stage at Hawarden, Iowa on June 17th. Interstate 29 was temporarily closed along a 22 mile stretch to facilitate levee building to divert some Big Sioux River water to McCook Lake, but the interstate was reopened when the river crested at a lower level than was feared. A levee breach across the river from Akron, Iowa, briefly aggravated lowland flooding before it was repaired. Total property damage in those counties is estimated to be more than $1 million. |
| October 11, 2013 | Severe Winter Storm, Snowstorm, and Flooding (**FEMA-4155-DR**)<br>Heavy rain falling on snow remaining from the October 3-5 blizzard caused flooding over portions of western South Dakota. One to three inches of rain fell on October 10 and 11. The runoff and melted snow caused flash flooding in Keystone and flooding along creeks and streams on the plains of western South Dakota.<br>Water covered Elk Creek Road and Antelope Creek Road north of Box Elder, Curlew Road and Pioneer Road north of New Underwood, and Coyote Lane and Golden Valley Drive north of Rapid City. Some fields and pastures in southern Meade County also flooded. The river gauge on Elk Creek at Elk Vale Road north of Rapid City reached a height of 12.6 feet, which is 3.6 feet over flood stage. Total property damage is estimated to be more than $50,000. |
| June 1, 2013 | Severe Storms, Tornadoes, and Flooding (**FEMA-4137-DR**)<br>A large upper level low-pressure system pushed across the Northern Plains, bringing heavy rain to the northern Black Hills. Embedded thunderstorms produced additional heavy rain, with four to six inches of rain falling over a 24-hour period. Runoff caused minor flooding along the Belle Fourche River and its tributaries. Several county roads were closed or washed out and culverts were damaged.<br>Redwater River, Crow Creek, and several small creeks and streams experienced flooding. Water reached the edge of a house along the Redwater River and some low water crossings were flooded. Total property damage in those counties is estimated to be more than $200,000. |
| May 29, 2013 | Severe Storms, Tornado, and Flooding (**FEMA-4125-DR**)<br>Thunderstorms developed along the eastern slopes of the Black Hills and adjacent plains from Nisland to Sturgis to the Rapid City area. As these storms moved toward the northwest, they redeveloped and became stationary over the eastern foothills. As much as six inches of |

| Date | Comments |
|---|---|
| | rain fell in a few hours. Flash flooding was reported in Rapid City; Sturgis; and rural areas of Butte, Meade, and Pennington Counties. Runoff from the rainfall quickly inundated city streets, overflowed small creeks, and breached a few private stock dams.<br>After heavy during the early evening caused flash flooding in south central Butte County, additional rain overnight exacerbated the flooding. High water from several tributaries caused minor flooding along the Belle Fourche River, which was two feet deep over the Bismarck Bridge east of Vale. Total property damage is estimated to be more than $25,000. |
| March 11 – July 22, 2011 | Severe Storms and Flooding (**FEMA-1984-DR**)<br>A deep and expansive snowpack across the area began to melt bringing many areas of flooding to central and northeast South Dakota beginning in mid-March and continuing into early April. Many roads along with countless acres of crop and pastureland remained flooded. Roads, culverts, and bridges were damaged across the region. Several roads were washed out with many closed. Many homes were threatened with some surrounded by water. Rising lake levels in northeast South Dakota also threatened and flooded many homes. Many people had to use four-wheelers to get to their homes. A Presidential Disaster was declared for all of the counties due to the flooding damage. The total damage estimates, including March, were from 4.5 to 5 million dollars for the area. High water and groundwater levels resulting from record precipitation in the previous year contributed to the slowness of any improvement in the flooding situation until the spring. The flooding diminished across much of the area into May.<br>Flash flooding events began in May and continued through July. Heavy rains and thunderstorms produced flash floods around the State. Storms dropped several inches of rain over the already saturated soils in a matter of hours. |
| September 22-23, 2010 | Severe Storms and Flooding (**FEMA-1947-DR**)<br>Persistent thunderstorms developed in the late morning over southeast South Dakota and continued through the afternoon and evening. All of the storms through early afternoon produced large hail, with one report of damaging wind gusts. Large hail, heavy rain, and flash flooding were noted during the evening. Some of the flash flooding continued through the night and next day as flooding. |
| July 21-30, 2010 | Flooding (**FEMA-1938-DR**)<br>A powerful storm dumped heavy rain causing flash flooding in South Dakota. As much as nine inches of rain fell in the southeastern part of the State, flooding homes and neighborhoods. The heavy rain also forced Sioux Falls officials to discharge untreated wastewater into the Big Sioux River. The storms in late-July affected counties where soils already were saturated, and roads, bridges and culverts had been damaged from the earlier flooding and storms. Rain gauge readings ranged from 3.69 inches to 4.15 inches. The NWS says the previous July 21 record at Mitchell was 2.32 inches in 1907. Total damage to public infrastructure in those counties is estimated to be more than $4 million from heavy rains and severe storms during the period between July 21 and July 30, 2010. |
| March 10, 2010 | Flooding (**FEMA-1915-DR**)<br>Floodwaters closed roads, filled basements, and soaked agricultural fields in southeastern South Dakota in late March 2010. A combination of snowmelt, ice jams, and heavy rains drove the Vermillion, Big Sioux, and James Rivers over their banks. Some residents described the flooding as the worst in living memory, according to the Associated Press. This event also resulted in a presidential disaster declaration. |
| March 20, 2009 | Severe Storms and Flooding (**FEMA-1844-DR**)<br>Rapid snowmelt and ice jamming caused the Elm River near Westport to rise above flood stage on March 20th. The Elm River reached an all-time record level of 22.69 feet on March 25th almost 9 feet above flood stage. The previous record was 22.11 feet set on Apri1 10th, 1969. The flood stage for the Elm River at Westport is 14 feet. The city of Westport was evacuated with the flood waters causing damage to many homes and roads in and around Westport. Also, many other roads and agricultural and pastureland along the river were |

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| | flooded. The Elm River slowly receded and fell below flood stage on March 30th. The flood waters from the Elm River flowed south and into the northern portion of Moccasin Creek. Subsequently, the Moccasin Creek rose as the water flowed south into the city of Aberdeen. Flooding became a concern for Aberdeen and for areas along the creek north of Aberdeen. The governor signed an emergency declaration which allowed the State to help with flood response efforts, including sending 50,000 sandbags to the area. Also, the National Guard was activated to move a variety of heavy equipment. Some sandbagging and a falling Elm River kept the Moccasin Creek from causing any significant flooding in and north of Aberdeen. Although, some township and county roads were flooded from the creek. |
| June 1 – June 6, 2008 | Severe Storms and Flooding (**FEMA-1774-DR**)<br>A series of intense storms impacted more than twenty counties across the State over a period of five days, incurring several million dollars' worth of damage and causing flash flooding, hail and wind damages to livestock, wildlife, property and cropland, and resulting in a presidential disaster declaration. Periodic flash flooding continued for another four days, incurring several hundred thousand dollars more of damage. |
| May–June 2007 | Severe Storms, Tornadoes, and Flooding (**FEMA-1702-DR**)<br>Flooding brought on by record-setting rainfall on May 4 and 5 caused widespread damage to homes, businesses, farmland, infrastructure, and utilities across eastern South Dakota. Houses were destroyed; with basement walls collapsing, and critical utilities were nonfunctional. Thousands of acres of farmland were flooded that could not be planted, resulting in financial impacts to the individual operations as well as businesses dependent on the farming community. State and local governments also sustained damage to infrastructure. Flooding along the James River in Yankton County exposed URD cable. The Bon Homme Yankton Electric Association was forced to relocate the cable. Additionally, the flooding shut down one irrigation system for the entire summer. The Association's emergency repair and restoration costs were estimated at $20,023. |
| May–June 2004 | Severe Storms and Flooding (**FEMA-1531-DR**)<br>Thunderstorms developed from northern Turner County to western Yankton County on May 29. These storms produced large hail and strong winds across the area and saw very little movement over an eight-hour period. As a result, three to six inches of rain fell in portions of Yankton, Turner, and Minnehaha Counties, including Sioux Falls and the towns of Parker, Hartford, Crooks, and Marion. Urban flooding resulted with rapid runoff from streets across Sioux Falls. Willow Creek in Crooks and Skunk Creek in Hartford rose several feet in only a couple of hours. In western Sioux Falls, Skunk Creek reached its highest level in 20 years. River flooding continued the following two days.<br>On June 16, strong thunderstorms developed in western Sioux Falls and moved east. As the storms moved east, new storms developed just west of Sioux Falls, resulting in repeated episodes of heavy rain in the Sioux Falls metropolitan area. Rainfall amounts were similar to May 29, but the rate of rainfall was much higher. Over two inches of rain fell in one hour at the Sioux Falls airport, and multiple locations around the city received more than three inches of rain in two hours. The highest amount of rainfall reported in Sioux Falls was 7.79 inches. There were numerous reports of three to six inches across the city. The large amount of rainfall in a short period of time produced excessive runoff across the city and Skunk Creek and the Big Sioux River rose rapidly as a result.<br>At the time, the 31 days up to and including June 16 marked the wettest 31-day period on record for Sioux Falls (12.74 inches at Joe Foss Field).<br>Source: NWS Sioux Falls |
| April 2001 | Severe Storms (Flooding) (**FEMA-1375-DR**)<br>This presidentially declared disaster was precipitated by an onset of flooding that began during a spring thaw in early March 2001. On April 6, a series of rainstorms that dropped from two to six inches of rain resulted in flooding of the James, Vermillion, and Big Sioux |

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| | rivers. According to the NWS, the James River, at Huron, reached its highest crest of 18.1 feet (flood stage of 11 feet) on April 10, the second highest crest on record.<br>On April 11, a second similar weather system produced more heavy rains in the Aberdeen, Huron, Watertown, and Brookings areas. Flooding of the James River occurred in and around Huron and Mitchell. The west fork of the Vermillion River caused flooding around Parker and Centerville. The Big Sioux River flooded in and around Watertown, Dells Falls, and Sioux Falls. At Mitchell, the James River reached its highest crest of 21 feet (flood stage of 14 feet) on April 11, the second highest crest on record according to the NWS. Peak crests on the Vermillion and West Vermillion rivers were two to four feet above flood stage. The Big Sioux River in Sioux Falls crested at 22 feet (flood stage of 16 feet) on April 24.<br>A third major system passed through South Dakota on April 21-22. The Black Hills, in the western part of the State, received up to 22 inches of heavy wet snow and the eastern portion of the State received 4-8 inches.<br>Beadle, Brookings, Brown, Buffalo, Clark, Codington, Day, Deuel, Edmunds, Grant, Gregory, Hamlin, Hanson, Jerauld, Kingsbury, Marshall, Mellette, Moody, Roberts, Sanborn, Spink, Todd, Turner, and Tripp Counties were included in the disaster declaration. The major impact was to public infrastructure. Due to ice and wind damage to utility poles and lines, electrical services to some areas were interrupted. Numerous bridges and roads were impacted as well. There was damage to county and township roads in the eastern and northeastern portion of the State that had previously not been affected by floodwater. Some of the damaged roads included school bus, mail, and farm-to-market routes. Travel on these roadways involved significant risk. Several roads were temporarily impassable, requiring residents to travel greater distances because of detours. Many farmers were unable to access their fields to begin spring planting. In Mellette County, ice jam fluctuations substantially damaged a bridge, which caused the county to close the bridge to through traffic, resulting in a 40-mile detour for residents needing to cross the White River. This disaster also heavily impacted South Dakota's agricultural and livestock community. |
| April-June, 1998 | Flooding, Severe Storms, and Tornadoes (**FEMA-1218-DR**)<br>Heavy rain of 2 to 4 inches with some amounts nearing 5 inches fell across a large part of the six-county area mainly on the evening of the 11th. This round of heavy rain only exacerbated the already extensive flooding occurring from many years of above normal precipitation. Day county was most affected by this round of heavy rain where area lakes were already at new record levels. Blue Dog, Waubay, Rush, and Bitter Lake in Day County were just a few of the lakes hard hit again. In fact, extensive sandbagging was done around Blue Dog Lake to save many homes. Some residents of Blue Dog Lake said they had never seen the lake so high in over 35 years of living there. |
| February–May 1997 | Severe Storms/Flooding (**FEMA-1173-DR**)<br>This disaster had its roots in past flooding events. Beginning in 1992, the State had a series of weather-related events of sufficient magnitude and impact to warrant eight presidential disaster declarations prior to this event; five for flooding, four for ice/snow; and one for just snow. These events kept the water table saturated, which prevented much of the winter snow melt and the spring/summer rains from soaking into the ground, thus contributing to flooding.<br>The first significant winter storm of 1996 hit the eastern part of the State in mid-November, dumping up to 10 inches of snow across the northeast and producing a major ice storm with widespread damage across the southeast (see Winter Storms). In 1997, major winter storms were fairly frequent throughout January with several blizzards, mostly in the northeast part of the State (see Winter Storms). From mid-November to mid-February, the general weather across the eastern part of the State was cold and wet with below normal temperatures (in excess of 30□F below zero) and record-setting above normal snowfall.<br>The persistent cold greatly limited snowmelt between storms, allowing up to 48 inches of snow to accumulate across much of the northeastern part of the State. Mid-February snow |

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| | depths elsewhere across eastern South Dakota ranged from 10 to 24 inches. The NWS snow water equivalent measurements of February 12 ranged from approximately two inches near the Missouri River to over six inches in Marshall County. Snow water equivalent values from 4 to 5 ½ inches were common over the central and northern portions of the James and Big Sioux River basins. Seasonably cool and relatively dry weather prevailed across the eastern part of the State from mid-February to early April.<br>An early April blizzard added to the remaining snowpack, which gradually melted south to north by the end of April. Heavy rain and snowstorms in April, compounded by severe winter blizzards and existing saturated soil conditions, resulted in persistent flooding throughout the State. Many people were evacuated from their homes and farms, while others had limited or no access or escape. Heavy snowmelt and pounding rains turned prairie potholes into lakes, pushed people from their homes, and prevented farmers from planting thousands of acres of land. The JRWDD estimated that five years of flooding destroyed or severely damaged approximately 75 percent of the forested areas in the James River Valley. Riverine flooding destroyed or damaged many homes and businesses, impacted water and sewage treatment plants, and damaged or destroyed many roads and bridges. All counties were included in the presidential disaster declaration. This flood caused approximately $82.5 million in damage (2006 dollars) and two deaths. |
| March–May 1995 | Severe Storms, Flooding (**FEMA-1052-DR**)<br>The entire State had above normal precipitation between January and May, ranging from about one to two inches above normal in the southwest to five to nine inches above normal in the east. This is up to 200 percent of normal. Many official reporting stations, including Huron, Mitchell, and Sioux Falls, experienced their all-time wettest springs on record. Most damage to public facilities was caused by ground saturation and flooding due to very high residual groundwater tables from 1994, heavy winter snow and spring rain, and rapid snowmelt. Many roads were under water or unusable due to high groundwater saturation of the subgrade, causing interruption of emergency services. Damage to power transmission and distribution facilities owned by rural electric cooperatives was also reported. Preliminary damage surveys identified over 3,000 homes with some type of damage. The vast majority of damage was from one to three inches of groundwater seepage into basements. In many areas, the water table rose to near land surface levels, saturating septic drain fields and preventing proper treatment of residential sewage. Preliminary damage surveys estimated $9.3 million in damage to infrastructure of public facilities. Roads and Bridges and Utilities incurred the most damage with almost $5.7 million and $2.6 million in estimated damages, respectively. Federal aid system roads received $7.1 million in damage. |
| March–July 1994 | Severe Storm/Flooding (FEMA-1031-DR)<br>Flooding in northeastern South Dakota began in mid-February 1994, as a result of very high residual groundwater tables from 1993's extremely high levels of precipitation (snow and rain) and rapid melting of the snowpack. Flooding continued into late March 1994 and then subsided. Rain continued throughout the spring and summer months, but the remainder of the snowmelt was gradual and did not significantly contribute to flooding. On July 6, a significant storm system passed through central and northeastern South Dakota. Severe winds caused damage in the Pierre area, and the town of Milbank in Grant County received approximately six inches of rain in two to three hours. The thunderstorm in Milbank caused the town's storm and sanitary sewer systems to overload and water backed into basements of several homes. Damage was estimated at approximately $4 million. The vast majority of damage was to county and township roads (which had significantly deteriorated because of saturation from near ground-level water tables), culverts, and bridges. Many roads remain under water, as once small (or dry) glacial lakes with no drainage outlets, grow in size and encroach upon nearby roadways. In 1995, total damages were estimated to be $36.5 million. |
| March–September 1993 | Flooding, Severe Storms, Tornadoes (**FEMA-999-DR**) |

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| | Early and rapid snowmelt resulted in localized flooding along portions of the three eastern river basins. Major problems began in May when severe weather spawned tornadoes and floods in five eastern counties, injuring 12 and killing one. Heavy rains continued throughout May, June, and July, which included a 6.5-inch deluge in Sioux Falls on May 23 that backed up sewage into 190 basements and damaged city streets. By the end of June, the Big Sioux River was over a mile wide in places, flooding many communities along its banks. During early July, the swollen Vermillion and James Rivers inundated thousands of acres of farmland and surrounding communities. Heavy July rains developed flash flood torrents on small drainages in Madison and Yankton, while rising lake levels flooded numerous communities on lake shores. Overall, the disaster heavily impacted 39 counties in South Dakota, over half the State, and contributed to four deaths, approximately $2 million damage to business, $12 million damage to public facilities, $10 million to private residences, and $204 million to agriculture. Federal aid system roads received $3 million. |
| June 1992 | Flooding, Severe Storm, Tornadoes (**FEMA-948-DR**)<br>On June 13 and 14, a major spring storm resulted in severe weather in Harding County. Golf ball size hail and 10 ½ inches of rain occurred in a three-hour time span. Crops were destroyed and over 500 sheep were killed. On the afternoon and evening of the June 16, several violent thunderstorms (super cells) produced large amounts of rain and several large, damaging tornadoes. Heavy rain was experienced in the Davison, Miner, Kingsbury, Lyman, Buffalo, Moody, Brookings, Deuel, Minnehaha, and Hamlin Counties. The heavy rains occurred in an area already saturated by previous rains. Over a two to three-day period, 15 to 20 inches of rain fell in the Clear Lake/Watertown area resulting in widespread flooding of the Big Sioux River. The rains subsided late in the week. Some flooding was experienced by South Dakotans as far south as Sioux Falls. |
| May 1986 | Severe Storms, Flooding (**FEMA-764-DR**)<br>The above average fall rains and heavy winter storms during 1985-86 created a condition of supersaturated ground and record water levels in the lakes and Big Sioux River Basin in the northeast part of the State. The snowmelt runoff into the numerous lakes forced the already full lakes to overflow and seriously impact residences, cottages, resort business, and agribusiness. A severe winter storm covered the entire State the week of April 14, adding one to three inches of precipitation to the area.<br>Flood damage was estimated at approximately $25.9 million, $20.6 million of which was to agriculture. |
| Spring 1984 | Severe Storms, Flooding (**FEMA-717-DR**)<br>The winter of 1983-84 was the third snowiest on record (75 inches of snow at Sioux Falls). The heaviest snows occurred in November 1983 and in March 1984. Severe snowmelt flooding began March 20 and after the fourth wettest April on record, caused near record flooding on the Big Sioux, Vermillion, and lower James Rivers in April. These rivers did not go below flood stage until the end of April. Numerous reports of water damage were recorded in the communities of Mt. Vernon, Parkston, Tabor, and Volin.<br>June was the wettest June on record in southeast South Dakota and was the sixth wettest month on record at Sioux Falls. Between June 4 and June 22, many large storms crossed the region and dumped approximately 30 inches of rain, which caused repeated flash floods. Numerous roads and bridges were heavily damaged. Many areas had severe urban flooding, because sewers and storm drains were unable to handle the load. As a result, many basement walls collapsed. The Lake Menno Dam (Hutchinson County) collapsed on June 12, killing 450 hogs, destroying one car and damaging two, moving a farmhouse 75 feet off its foundation, scattering and destroying farm machinery, and completely sweeping away grain bins. On June 16, three feet of water was flowing through downtown Davis (Turner County). Vermillion Lake Dam (McCook County) and many smaller dams sustained severe erosion. The Fulton Lake Dam (Hanson County) was severely weakened and in imminent danger of failing but held. |

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| | On June 18, a train was derailed at Parker (Turner County) due to washed out tracks. On June 20, Lake Dimock Dam (Hutchinson County) gave way, destroying the dam and causing flooding in Milltown. A 400-yard sandbag dike saved the Lake Carthage Dam (Miner County) from destruction.<br>Widespread flash flooding caused severe erosion; washed out or weakened many roads, bridges, and culverts; and washed away crops in low-lying areas. Many small stock dams collapsed, washing out roads, bridges, and culverts beneath them. In Mt. Vernon (Davison County), there was three to four feet of water in homes. Twenty homes were evacuated along Dry Run Creek in Mitchell (Davison County). Sewage was five to six feet deep in parts of Mitchell.<br>Estimates by the U.S. Geological Survey place the flooding on the Big Sioux River drainage at about a 10 to 30 year recurrence interval, the Vermillion River at about a 100–500 year recurrence interval, and the lower James River at about a 100–300 year recurrence interval. By June 22, over one million acres of cropland in the region were under water. Total damage was estimated at $289 million. |
| June 1976 | Flash Flooding, Mudslides (**FEMA-511-DR**)<br>In a 24-hour period on June 13-14, 3 to 10 inches of rain fell in the northern Black Hills. And additional two to three inches of rain plus heavy snow was recorded over this area on the June 15 and 16. The runoff from this precipitation did considerable damage in the counties of Lawrence, Meade, Butte, and Harding. Physical structures, streets, roads, sewers, and water systems sustained about $1.5 million in damage. Deadwood, Spearfish, Belle Fourche, Sturgis, and Galena received most of this damage. Throughout the region, a number of bridges and culverts were washed out and many of the roads suffered water erosion. Debris damage was not as great as in 1972, however, there was considerable movement of rocks and gravel. There was also a problem with mudslides and landslides. One death resulted from this flood. |
| June 1972 | Heavy Rains, Flooding (**FEMA-336-DR**)<br>On June 9-10, 1972, extremely heavy rains over the eastern Black Hills of South Dakota produced record floods on Rapid Creek and other streams in the area. Scattered showers had occurred throughout the Black Hills area on several days prior to the heavy rains that began on June 9. Near Pactola Dam, these earlier showers left the soil saturated, which increased the amount of runoff for the flood of June 9-10. Rainfall began in the Black Hills area on the afternoon of June 9, when a group of almost-stationary thunderstorms formed over the eastern Black Hills.<br>Precipitation totals for June 9-10 ranged from 4 inches to more than 12 inches in the Rapid Creek watershed between Pactola Dam and Rapid City. In the Boxelder Creek watershed, 15 inches of rain during a six-hour period was measured at Nemo. The heaviest rainfall averaged about four times the six-hour amounts that are to be expected once every 100 years in the area.<br>The resulting runoff produced record floods (highest peak flows recorded) along Battle, Spring, Rapid, and Boxelder creeks. Smaller floods also occurred along Elk Creek and Bear Butte Creek. The floods struck quickly and forcefully, but they did not last long, nor did they make much impact farther downstream in the basins. Nonetheless, the Black Hills Region sustained millions of dollars of damage to roads, streets, and bridges (very few bridges were left standing).<br>Rapid City - Evacuation of residents along Rapid Creek was ordered by 10:15 p.m. Flood and debris-laden water flowed into Canyon Lake and clogged the dam's chute spillway. This caused a 300-foot breach in the dam and sent a wall of water and debris pouring down on residents below the dam. The effect of this dam failure on the subsequent flood wave into urban Rapid City has been difficult to assess because the amount of water coming down Rapid Creek and several tributaries (accounting for 86 percent of the peak flow) far overshadowed the amount of water in the small lake. The peak flow was carried through Rapid City via Rapid Creek at about midnight on June 9, while many people were asleep and |

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| | unaware of the impending flood. The stage of Rapid Creek (measured above Canyon Lake) rose more than 13 feet in five hours during the flood.<br>The toll of the flood-produced carnage was staggering. At least 238 people died (including five listed as missing and presumed dead). Thousands of people barely escaped death and hundreds of people were forced to climb, stand, or cling to objects which saved them from being swept away. Property damage exceeded $79 million. 436 houses were destroyed, and 930 houses damaged. 710 mobile homes were either damaged or destroyed. 36 businesses were wiped out and 236 more sustained damage. About 5,000 cars were reported lost to the flood.<br>Keystone - Motels, shops, bars, and restaurants, which cater to tourists were either damaged or destroyed. Many campgrounds located along the creeks were washed away. At least 10 campers died. Total damage was set at $1.4 million.<br>Black Hawk and Box Elder - These cities incurred $2 million in damage as the flood destroyed or damaged 75 homes and 180 mobile homes along Box Elder Creek.<br>Sturgis - Sturgis sustained over half a million dollars in damage; 275 houses and 25 businesses were affected. |
| Spring 1969 | Flooding (**FEMA-257-DR**)<br>Big Sioux River - This flood surpassed the flood of 1881 in magnitude with water discharge rates more than twice those of 1962. It resulted from a large buildup of snow. Snow fell in December (1968) in normal amounts, but the accumulations for January and February set a record. The temperatures during March were below the seasonal average, so little runoff occurred. The entire basin was ice free by April 6. The upper part of the basin received an inch of rain on April 7 and compounded the flood. One-eighth of Watertown was under water. Dempster, Estelline, and Castlewood had flood damage as did the lower portion of Dell Rapids. Fifty families were evacuated from Moody County, and fifty people had to be removed from Renner. Sioux Falls was more fortunate as they had developed a flood control system, which was credited with preventing more than $12 million in flood damage.<br>Vermillion River - This flood was greater than the 1962 flood. The town of Centerville was surrounded by water. Within the town, the sewers backed up and the disposal plant was flooded. In the surrounding country, the damage was about the same as in the previous floods. Three bridges were washed out and numerous roads damaged. 450 feet of one highway was completely washed away. The dike system did not contain the water and the lowlands flooded. The U.S. Geological Survey placed the damage to the basin at $1 million.<br>James River - The river was in flood during all of April. The creeks in the lower portion of the basin started flooding early in the month. Their discharge of water started breaking up ice on the main stem of the James. The massive flow of the smaller tributaries caused a backing up of water along the James and increased the problem of flooding. Huron recorded a flood crest of 16.7 feet, almost one foot higher than registered in the previous 30 years. In that area, damage was estimated at $750,000.<br>In the northern part of the State, Moccasin Creek flooded from water coming out of Richmond Lake. This caused some flooding in Aberdeen, as well as extensive flooding in the surrounding countryside. Total damage to the basin was over $16 million. Most of the damage was incurred by farmland, bridges, and roads. |
| May 18, 1965 | Flooding (**FEMA-197-DR**)<br>Black Hills - Flash flooding brought widespread damage to Deadwood, Spearfish, and Sturgis. Heavy snows in excess of 30 inches and 7 inches of rain triggered an avalanche of water shooting down the creeks and gullies. Some houses were swept away in the Spearfish-Sturgis area while others sustained major damage. One resident whose home was near a creek lost everything. He reportedly had a 70-ton concrete retaining wall between the house and the creek - this was completely washed away. Flood damage to the Black Hills area was estimated at over $2 million. |
| Summer 1962 | Flooding, Tornadoes (**FEMA-132-DR**) |

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| | Black Hills - A summer storm dumped more than three inches of rain on Rapid City. The resulting damage: 120 mobile homes, two motels, and over 400 homes had water damage. Bridges, roads, sewer systems, streets, and recreation areas along Rapid Creek were also damaged. Total damage to Rapid City alone was over $800,000. Sturgis, Deadwood, and Whitewood received extensive damage to roads and bridges. Road equipment lost during this flood was estimated at $200,000. |
| April 1960 | Floods (**FEMA-99-DR**)<br>Vermillion River - Between 10 and 15 thousand acres were flooded when the dikes were unable to retain the rapid runoff. Many fences were destroyed due to ice and debris pile up. Also, county road systems were damaged due to erosion. The town of Davis received about one foot of water. |

Source: If not otherwise sourced in the table, the NCEI and FEMA Disaster Declarations page are the information source.

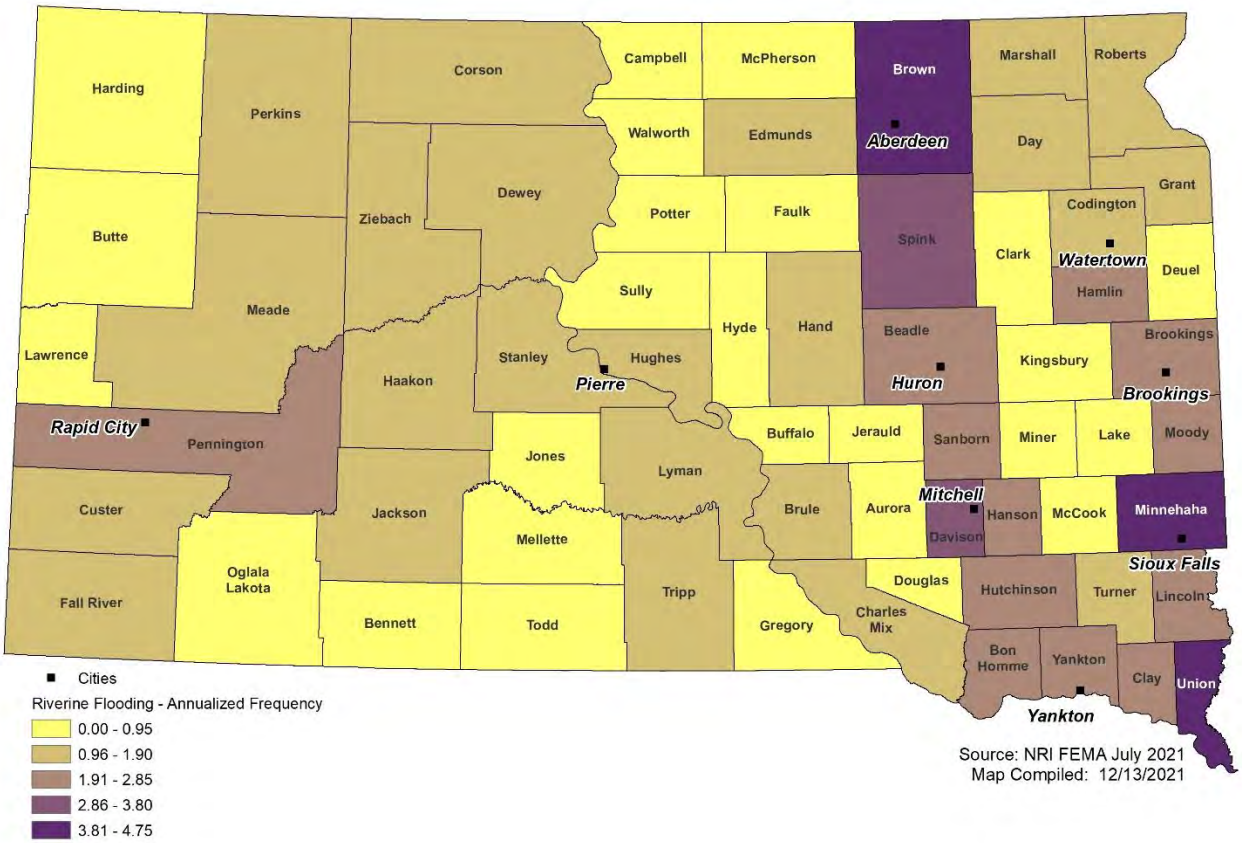
## Probability of Future Occurrence

FEMA flood studies provide mapping and detailed flood information for floodplains where the water body has a one percent chance of occurrence in any given year in identified special flood hazard areas. Smaller and more frequent damaging events occur in the State on an annual basis. Floods result in $403.9 million per year in average annualized losses to the State. Based on the frequency of past occurrences in South Dakota, a flood event can be expected somewhere in the State annually.

USGS, South Dakota Department of Transportation, and other state and federal agencies published a study in June 2012 titled "Extreme Floods in the Black Hills Area: New Insights from Recent Research." One of the most significant findings of the study is that massive floods as large as or larger than the 1972 flood have occurred multiple times over the past millennium in many drainage basins of the eastern Black Hills. According to the study, geologic evidence indicates that 12 floods exceeding 66,000 cfs occurred in the past 2,000 years, with the largest one occurring 440 years ago. The study found that "the steep terrain and narrow canyons along the eastern periphery of the Black Hills are most susceptible to flash flooding. Here the thin, rocky soils absorb little rainfall, and the steep slopes cause rapid runoff into the stream channels. The steep and narrow canyons further amplify ferociously fast and deep floods." Figure 3-23 depicts the areas of the Black Hills with the highest and lowest potential for flash flooding based on the USGS/South Dakota Department of Transportation (SDDOT) study.

The NRI developed by FEMA includes a comparison of the annualized frequency of several hazards by county. This is depicted in Figure below. The annualized frequency provides an estimate of the likelihood for future flood occurrences in South Dakota by taking the average number of recorded riverine flood events per year over the 24-year period of record from the NRI. This gives the estimated number of events per year by county, as shown in the map legend. Based on the NRI analysis, counties in the eastern half of the State and those along the Missouri River generally have a higher probability for flooding compared to the rest of the State.

**Figure 3-23 Annualized Frequency of Riverine Flooding by County**




## Magnitude/Severity (Extent)

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 in the State of South Dakota 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.

Floods present a risk to life and property, including buildings, their contents, and their use. Floods can affect crops and livestock. Floods can also affect lifeline utilities (e.g., water, sewerage, and power), transportation, jobs, tourism, the environment, and the local and regional economies. The impact of a flood event can vary based on geographic location to waterways, soil content and ground cover, and construction. The extent of the damage of flooding ranges from very narrow to widespread based on the type of flooding and other circumstances such as previous rainfall, rate of precipitation accumulation, and the time of year.

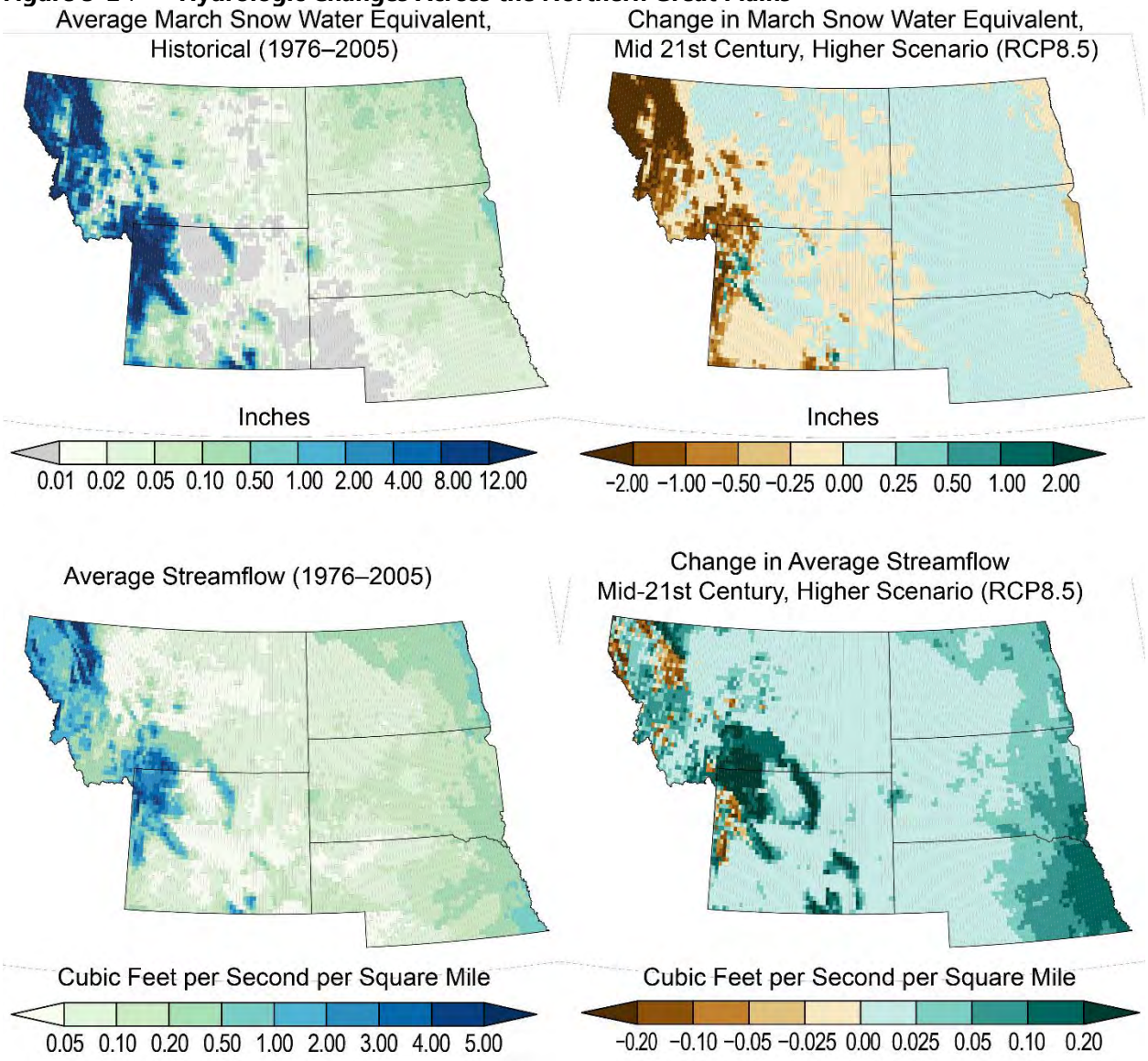
The magnitude and severity of the flood hazard is usually determined by not only the extent of impact it has on the overall geographic area, but also by identifying the most catastrophic event in the previous flood history. Sometimes it is referred to as the "event of record." The flood of record is almost always correlated to a peak discharge at a gauge, 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 in South Dakota is considered to be the series of floods which impacted the entire State throughout the year 2019. During this prolonged flood event the James River in South Dakota remained at flood stage for 17 consecutive months. Overall, this series of related floods resulted in five different federal disaster declarations and approximately $94.6 million in federal assistance, as detailed in Table 3-3.

## Climate Change Considerations

The nature and frequency of flooding could be altered by climate change. Globally, higher temperatures will result in increased atmospheric water vapor available to form precipitation. Precipitation extremes and their hydrological impacts (e.g. floods) are expected to become larger because in most places.

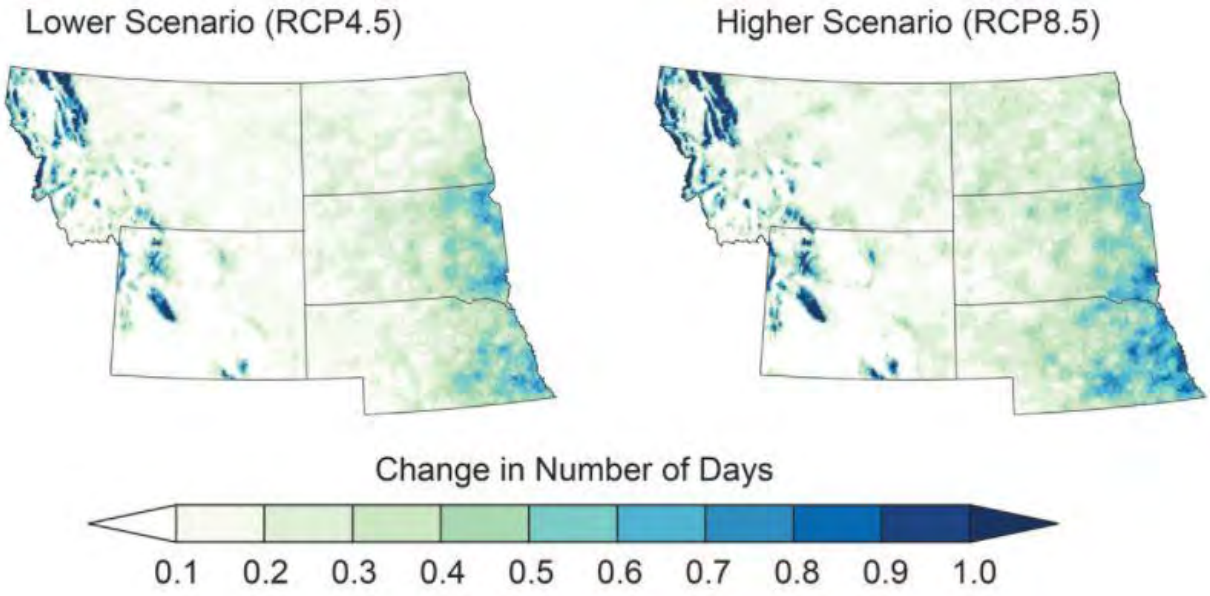
According to the Fourth National Climate Assessment, the Upper Missouri River Basin is very sensitive to climatic fluctuations. Trends over the past 50 years indicate an increase in runoff in the eastern portion of the Northern Great Plains, where South Dakota is located. Figure 3-24 illustrates projected mid-21$^{st}$ century hydrologic changes in the Northern Great Plains compared to the historical average from 1976-2005. The top two maps show average values for March to provide historical and future end-of-season estimates of snow water equivalent, which is the amount of liquid water contained within snowpack and therefore the amount of water that will be released when the snowpack melts. This illustrates projected warming and potential snow loss. Similarly, annual streamflow's are expected to increase across much of the eastern part of the region. Figure 3-24 below illustrates the projected changes in the number of days with precipitation exceeding 1 inch by mid-21$^{st}$ century, indicating that significant portions of South Dakota are projected to see increasing frequency of high precipitation events. These projected changes coupled together could result in increased frequencies of events such as the 2019 floods, where runoff, high precipitation, and waterlogged or frozen soils lead to water flow rates which overwhelm the capacity of stream channels.

**Figure 3-24 Hydrologic Changes Across the Northern Great Plains**




Source: Fourth National Climate Assessment

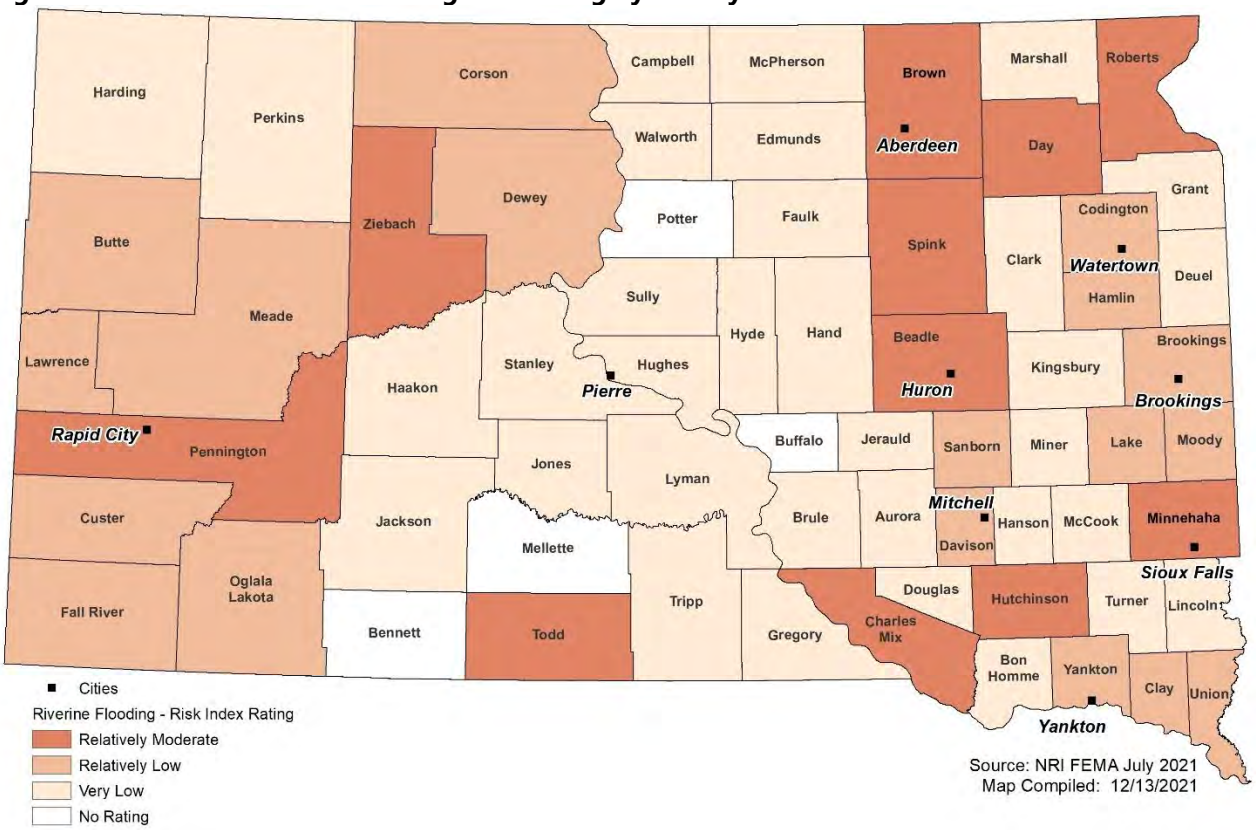
**Figure 3-25 Change in the Number of Days with Precipitation Exceeding 1 inch, Mid-21st Century**




## Vulnerability Assessment

While there are some benefits associated with flooding, such as the replenishment of sediments and nutrients to agricultural lands, it is considered a hazard to development in floodplains. Severe flooding has the potential to inflict significant damage to people and property South Dakota. Mitigating flood damage requires that the State remain diligent and notify local officials of potential flood (and flash flood) prone areas near infrastructure such as roads, bridges, and buildings. In order to analyze the State's vulnerability to flood, the NRI was used as a primary tool during the 2021 HIRA update. The NRI defines risk as the potential for negative impacts as a result of a natural hazard and determines a community's risk relative to other communities by examining the expected annual loss and social vulnerability in a given community in relation to that community's resilience. This composite risk rating is illustrated in Figure 3-26 below, showing the risk to riverine flooding by county in South Dakota.

**Figure 3-26 NRI Riverine Flooding Risk Rating by County in South Dakota**




## *People*

Vulnerable populations in South Dakota include those that live within known floodplains or near areas vulnerable to flash floods, as well as people traveling through or recreating in areas prone to flash flooding. 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, or temporary shelters, people who do not speak English well, tourists and visitors, and those with developmental, physical, or sensory disabilities. The impacts of flooding on vulnerable populations can be more severe. Families may have fewer financial resources to prepare for or recover from a flood, and they may be more likely to be uninsured or underinsured. Individuals with disabilities may need more time to evacuate, so evacuation notices will need to be issued as soon as feasible, and communicated by multiple, inclusive methods.

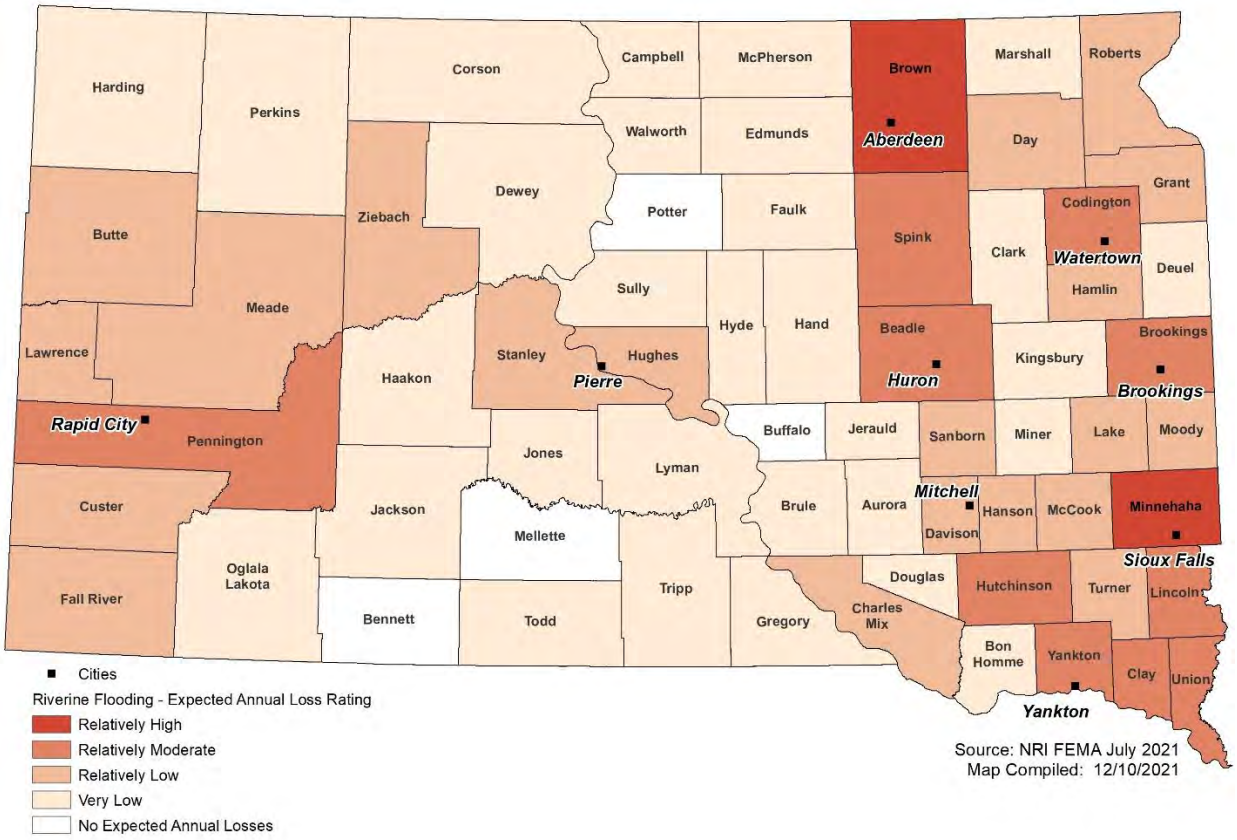
## *Property*

Buildings in the floodplain throughout South Dakota are susceptible to damages by rising waters; damages could also require costly and time-consuming cleanup during the recovery process. Flood recovery can take years for affected communities to be rebuilt, depending on the severity of the flood.

The NRI also utilizes EAL as an indicator of risk. EAL represents the average economic loss in dollars resulting from natural hazards each year. It is calculated for each hazard type and quantifies loss for relevant consequence types: buildings, people, and agriculture. EAL is calculated using a multiplicative equation that includes exposure, annualized frequency, and historic loss ratio risk factors for 18 natural hazards, including riverine flooding. Figure 3-27 below illustrates the EAL for each county in South Dakota.

As the map shows, the highest expected annualized losses are for Brown and Minnehaha Counties. Counties located in the Big Sioux and James River basins have generally higher EAL ratings.

**Figure 3-27 Riverine Flooding Expected Annual Loss Rating in South Dakota**




## *National Flood Insurance Program (NFIP) Claims Analysis*

The National Flood Insurance Program (NFIP) aims to reduce the impact of flooding on private and public structures by providing affordable insurance to property owners and by encouraging communities to adopt and enforce floodplain management regulations. These efforts help mitigate the effects of flooding on new and improved structures. The State has analyzed NFIP flood-loss data to determine areas of South Dakota with the greatest flood risk. South Dakota flood-loss information was obtained from FEMA's "NFIP Policy and Claims Report" for South Dakota, which documents losses from 1978. This section was updated based on information obtained from FEMA through OEM current as of late 2021.

There are several limitations to analyzing flood risk entirely on this data, including:

- Only losses to participating NFIP communities are represented,
- Communities joined the NFIP at various times since 1978,
- The number of flood insurance policies in effect may not include all structures at risk to flooding, and
- Some of the historical loss areas have been mitigated with property buyouts.

Despite these limitations, the data depict a pattern of historical flood losses in the State. The greatest losses have changed to be in Lake, Lincoln, and Codington Counties. Table 3-19 shows the details of the 10 South Dakota counties with the greatest historical dollar losses. Union County was not within the top ten list in the 2010 plan update but is now number four behind Lake, Lincoln and Codington counties.

Lake has replaced Codington as the leader in terms of overall dollars paid. Codington's polices, however, decreased from 524 in 2016 to 367 in 2021. Since 2016, Lake County has increased dollars paid over $6.5 million, and increased its number of current policies from 169 to 235 as of 2021. Other notable changes include Minnehaha Country rising from number ten to nine in dollars paid out. Spink County was also supplanted by Yankton County in the top ten for dollars paid out. South Dakota's State NFIP coordinator explained the policy count decrease as partly related to the historic Missouri River flood of 2011, which caused a spike in policies. Union County has continued the trend of lower flood policies from 403 to 317 since 2016. A notable decrease occurred in 2018 in the City of Sioux Falls, which had their levee system certified by the Corps of Engineers which resulted in 1,600 structures no longer being required to have flood insurance when effective maps took place 10/01/2017. NFIP policy summary statistics from FEMA for Region VIII continues to show a decline in NFIP policies within the designated sates including South Dakota.

**Table 3-19 Top Ten Counties for Flood Insurance Dollars Paid (Historical), 1978 - 2021**

| County | Dollars Paid ($ Historical) | Flood Claims | Current Policies | Coverage ($) |
|---|---|---|---|---|
| Lake | $7,970,816 | 303 | 235 | $43,015,200 |
| Lincoln | $6,676,182 | 227 | 359 | $117,493,900 |
| Codington | $6,411,610 | 463 | 367 | $75,010,500 |
| Union | $5,282,237 | 430 | 317 | $105,319,900 |
| Hamlin | $5,159,410 | 431 | 72 | $17,705,400 |
| Day | $4,152,879 | 261 | 14 | $2,062,800 |
| Brown | $3,283,855 | 486 | 187 | $41,978,700 |
| Stanley | $2,555,208 | 118 | 133 | $38,186,600 |
| Minnehaha | $2,319,203 | 192 | 118 | $25,036,700 |
| Yankton | $1,603,545 | 64 | 87 | $19,435,800 |

Source: FEMA, NFIP Insurance Report, 2021

Information about flood insurance losses and policies for all South Dakota counties is in Appendix 3B. Based on this data the average annual insured losses are about $1 million.

### *Repetitive Loss Analysis*

A high priority in South Dakota and nationwide is the reduction of losses to repetitive loss structures. These structures strain the National Flood Insurance Fund. They increase the NFIP's annual losses and the need for borrowing and, more importantly, they drain resources needed to prepare for catastrophic events. The NFIP defines a repetitive loss property as "any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. At least two of the claims must be more than 10-days apart."

Table 3-20 lists the number of South Dakota's 336 repetitive loss properties by county, to include historical numbers from 2016, 2018 and 2021. Overall, the number of repetitive loss properties in the State have increased considerably. Hamlin and Codington Counties have the most repetitive loss properties, followed by Minnehaha, Lake and Brown Counties. Five new counties were added to this list since 2021: Hand, Kingsbury, Lyman, McPherson and Stanley counties. This shows that repetitive losses to flood damages are increasing throughout South Dakota. This also shows that focusing mitigation activities on repetitive losses could help alleviate a significant number of losses and repeated hardship. Also shown below are 27 severe repetitive loss structures, of which nine are in Codington County. These properties should be applicable to utilize NFIP programs such as the Increased Cost of Compliance (ICC) and or Flood-proofing, Relocation, Elevation or Demolition (FRED) mitigation activities. This could aid reducing

NFIP payouts in places like Codington County which is in the top three in flood insurance payouts historically.

**Table 3-20 Repetitive Loss Properties by County**

| County* | Rep Loss 2016 | Rep Loss 2018 | Rep Loss 2021 | Difference 2018-2021 | Severe Repetitive Loss 2021 |
|---|---|---|---|---|---|
| Beadle | 1 | 2 | 2 | 0 | 1 |
| Brookings | 4 | 4 | 9 | +5 | 0 |
| Brown | 13 | 14 | 24 | +10 | 0 |
| Butte | 1 | 1 | 2 | +1 | 0 |
| Charles Mix | 1 | 1 | 2 | +1 | 0 |
| Clark | 2 | 2 | 2 | 0 | 1 |
| Clay | 1 | 1 | 1 | 0 | 0 |
| Codington | 32 | 38 | 53 | +15 | 9 |
| Davison | 1 | 1 | 3 | +2 | 0 |
| Day | 19 | 20 | 23 | +3 | 3 |
| Grant | 4 | 4 | 7 | +3 | 1 |
| Hamlin | 38 | 39 | 56 | +17 | 1 |
| Hand | 0 | 0 | 1 | +1 | 0 |
| Hanson | 1 | 1 | 2 | +1 | 0 |
| Hughes | 4 | 4 | 4 | 0 | 1 |
| Kingsbury | 0 | 0 | 2 | +2 | 0 |
| Lake | 2 | 3 | 30 | +27 | 2 |
| Lincoln | 6 | 6 | 1 | -5 | 0 |
| Lyman | 0 | 0 | 2 | +2 | 0 |
| Marshall | 2 | 2 | 2 | 0 | 0 |
| McCook | 1 | 1 | 5 | +4 | 0 |
| McPherson | 0 | 0 | 1 | +1 | 0 |
| Meade | 2 | 2 | 2 | 0 | 0 |
| Minnehaha | 17 | 19 | 53 | +34 | 4 |
| Moody | 7 | 7 | 9 | +2 | 3 |
| Pennington | 1 | 3 | 6 | +3 | 1 |
| Roberts | 5 | 5 | 4 | -1 | 0 |
| Spink | 8 | 8 | 8 | 0 | 0 |
| Stanley | 0 | 0 | 1 | +1 | 0 |
| Turner | 1 | 1 | 3 | +2 | 0 |
| Union | 1 | 2 | 11 | +9 | 0 |
| Yankton | 2 | 2 | 5 | +3 | 0 |
| **Total** | **177** | **193** | **336** | **+143** | **27** |

Source: South Dakota Emergency Management, FEMA's "NFIP Insurance Report," 2016
* County includes policy and loss information for both incorporated and unincorporated areas
** Includes insured and uninsured properties

Table 3-21 shows repetitive loss claims by county. Lincoln, Codington, and Day Counties are the top three by repetitive loss dollars paid. Repetitive loss claims have increased through the State since 2018, mainly due to the significant 2019 flooding.

**Table 3-21 Repetitive Loss Claims by County**

| County* | 2018 | 2021 | Difference 2018-2021 | 2018 | 2021 | Difference 2018-2021 |
|---|---|---|---|---|---|---|
| Beadle | 6 | 6 | 0 | $116,289 | $368,084 | +$251,795 |

| County* | 2018 | 2021 | Difference 2018-2021 | 2018 | 2021 | Difference 2018-2021 |
|---|---|---|---|---|---|---|
| Brookings | 9 | 15 | +6 | $103,500 | $966,934 | +$863,434 |
| Brown | 29 | 52 | +23 | $206,324 | $3,283,855 | +$3,077,531 |
| Butte | 2 | 2 | 0 | $6,593 | $11,833 | +$5,240 |
| Charles Mix | 3 | 2 | -1 | $227,915 | $504,260 | +$276,345 |
| Clark | 5 | 5 | 0 | $117,455 | $189,919 | +$72,464 |
| Clay | 2 | 2 | 0 | $4,880 | $50,954 | +$46,074 |
| Codington | 97 | 162 | +67 | $1,971,014 | $6,411,610 | +$4,440,596 |
| Davison | 2 | 4 | +2 | $17,207 | $840,402 | +$823,195 |
| Day | 43 | 53 | +10 | $1,186,524 | $4,152,879 | +$2,966,355 |
| Grant | 10 | 17 | +7 | $107,408 | $242,103 | +$134,695 |
| Hamlin | 88 | 155 | +67 | $1,498,552 | $5,159,410 | +$3,660,858 |
| Hand | 0 | 4 | +4 | $0 | $77,210 | +$77,210 |
| Hanson | 2 | 7 | +5 | $5,770 | $166,928 | +$161,158 |
| Hughes | 8 | 9 | +1 | $75,263 | $693,582 | +$618,319 |
| Kingsbury | 2 | 2 | 0 | $382,290 | $382,290 | +$0 |
| Lake | 6 | 62 | +56 | $81,511 | $7,970,816 | +$7,889,305 |
| Lawrence | 0 | 1 | +1 | $279,219 | $279,219 | +$0 |
| Lincoln | 13 | 46 | +33 | $2,690,957 | $6,676,182 | +$3,985,225 |
| Lyman | 0 | 4 | +4 | $383,909 | $383,909 | +$0 |
| Marshall | 6 | 6 | 0 | $23,766 | $144,193 | +$120,427 |
| McCook | 2 | 11 | +9 | $4,431 | $447,310 | +$442,879 |
| Meade | 5 | 5 | 0 | $28,627 | $52,781 | +$24,154 |
| Minnehaha | 46 | 103 | +57 | $422,858 | $2,319,203 | +$1,896,345 |
| Moody | 19 | 30 | +11 | $180,728 | $840,422 | +$659,694 |
| Pennington | 6 | 14 | +8 | $48,068 | $490,194 | +$442,126 |
| Roberts | 10 | 12 | +2 | $142,522 | $645,757 | +$503,235 |
| Spink | 19 | 25 | +6 | $446,931 | $1,016,507 | +$569,576 |
| Stanley | 3 | 3 | 0 | $2,555,208 | $2,555,208 | +$0 |
| Turner | 2 | 6 | +4 | $28,259 | $341,115 | +$312,856 |
| Union | 4 | 24 | +20 | $126,216 | $5,282,237 | +$5,156,021 |
| Yankton | 4 | 11 | +7 | $15,052 | $1,603,545 | +$1,588,493 |
| **Total** | **448** | **860** | **409** | **$9,884,620** | **$54,550,851** | **$41,065,605** |

Source: South Dakota Emergency Management, FEMA's "NFIP Insurance Report," 2018
* County includes policy and loss information for both incorporated and unincorporated areas

The Flood Insurance Reform Act of 2004 identified another category of repetitive loss, severe repetitive loss, and defined it as "a single family property (consisting of one-to-four residences) that is covered under flood insurance by the NFIP and has incurred flood-related damage for which four or more separate claims payments have been paid under flood insurance coverage with the amount of each claim payment exceeding $5,000 and with cumulative amount of such claims payments exceeding $20,000; or for which at least two separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property." In South Dakota, as of January 2022, there are 27 properties that potentially meet this definition according to FEMA data provided by SD OEM.

As noted in the table below, in the State of South Dakota more properties outside the Special Flood Hazard Area have sustained repetitive loss damages than the properties located in the SFHA. In the data noted there were 283 repetitive loss properties located in Zone X, B or C zones, meaning low risk zones. This is twelve more properties than the 271 buildings located in the designated SFHA or areas known to have at least a 1% chance of an annual flood event. This is not an unusual trend. Based on nationwide

statistics, according to the NFIP Between 2015 and 2019 more than 40% of the National Flood Insurance claims came from properties outside the high-risk food areas.

The data underscores the importance of flood insurance, even if a property is located in an area that is considered "low risk". Other reasons for this trend could be a lack of extensive or adequate flood hazard maps, or areas that historically have not flooded are beginning to due to climate change and/or land development, or high groundwater ponding in areas outside of floodplains.

**Table 3-22 State Repetitive Loss Summary**

| Repetitive Loss Type | AE, A1-30, AO, AH, A | B, C, X | Total |
|---|---|---|---|
| RL Buildings | 271 | 283 | 556 |
| RL Buildings (Insured) | 39 | 33 | 72 |
| RL Losses (Total) | 424 | 437 | 863 |
| RL Losses (Insured) | 76 | 52 | 128 |
| RL Payments (Total) | $7,234,533.51 | $10,352,485.32 | $17,605,647.21 |
| Building | $6,645,455.57 | $8,497,380.74 | $15,161,464.69 |
| Contents | $589,077.94 | $1,855,104.58 | $2,444,182.52 |
| RL Payments (Insured) | $1,999,258.60 | $1,539,807.10 | $3,539,065.70 |
| Building | $1,879,684.05 | $1,389,402.35 | $3,269,086.40 |
| Contents | $199,574.55 | $150,404.75 | $269,979.30 |

Source: FEMA NFIP Policy and Claims Report for South Dakota, January 2022

As summarized in Table 3-23 below. There are five Post-FIRM Repetitive Loss buildings in South Dakota at the time of this assessment. There also are a total of four properties with flood insurance with four or more repetitive losses. Throughout the State there are also 38 properties with 2-3 loss greater than the total value of the property itself. There is also a total of 42 targeted repetitive loss buildings within the State. These properties should be applicable to utilize NFIP programs such as the ICC and or FRED mitigation activities.

**Table 3-23 Target Repetitive Loss Properties Summary**

| Repetitive Loss Buildings | Total Number of Buildings |
|---|---|
| Post – FIRM RL Buildings | 5 |
| Insured Bldgs. With four or more Losses | 4 |
| Insured Buildings with 2-3 Losses > Building Value: | 38 |
| Total Target RL Bldgs | 42 |

### *State Assets, Critical Facilities, and Infrastructure*

Key support facilities and structures most necessary to withstand the impacts of, and respond to, natural disasters are referred to as critical facilities. Examples of these critical facility types include utilities, transportation infrastructure, and emergency response and services facilities, given failures of components along major lifelines or even closures or inaccessibility to key emergency facilities could limit if not completely cut off transmission of commodities, essential services, and other potentially catastrophic repercussions.

Vulnerable critical assets include at risk population facilities, essential services, hazmat facilities and vital services. Major flooding could have devastating impacts on any of these facilities, including life safety

issues, structural damage, access issues, and temporary or permanent disruption of the delivery of services, which in turn can impede the ability of the State or local municipalities to respond to and recover from a major flood event.

A GIS overlay analysis was performed to determine vulnerability of state facilities to flooding. The latest available NFHL (1% and 0.2% annual chance flood zones) and Hazus-MH modeled base flood extents (in areas where NFHL was not available) were used. Areas protected by levee were extracted from NFHL data and also analyzed to provide an overview of state-owned building exposure by county in each flood hazard zone. The Department of Transportation has the highest number of buildings potentially at risk; additional details can be referenced in Appendix 3C.

**Table 3-24 State Buildings at Risk to Flood Hazards**

| County | 1% Annual Chance Count | 0.2% Annual Chance NFHL Count | Area Protected by Levee | 1% Annual Chance Hazus |
|---|---|---|---|---|
| Brown County | 4 | - | - | - |
| Codington County | 1 | 1 | - | - |
| Fall River County | 7 | - | - | - |
| Hughes County | - | 1 | - | - |
| Lawrence County | 6 | 3 | - | - |
| McCook County | 1 | - | - | - |
| Meade County | - | 1 | - | - |
| Minnehaha County | 4 | 1 | 10 | - |
| Moody County | - | 1 | - | - |
| Pennington County | 3 | - | - | - |
| Turner County | - | - | - | 2 |
| Walworth County | - | - | - | 7 |
| Yankton County | 1 | - | - | - |
| **Total** | **27** | **8** | **10** | **9** |

Source: State of South Dakota, FEMA NFHL

**Table 3-25 State Buildings at Risk to Flood Hazards by State Agency**

| Agency | 1% Annual Chance Count | 0.2% Annual Chance NFHL Count | Area Protected by Levee | 1% Annual Chance Hazus |
|---|---|---|---|---|
| Department of Transportation | 13 | 0 | 0 | 9 |
| Dept Of Human Services | 1 | 0 | 2 | 0 |
| Dept of Revenue | 3 | 1 | 1 | 0 |
| Dept of Health | 1 | 1 | 3 | 0 |
| Dept of Game, Fish & Parks | 3 | 0 | 1 | 0 |
| Unified Judicial System | 1 | 1 | 0 | 0 |
| Dept of Social Services | 1 | 1 | 0 | 0 |
| Dept of Labor & Regulations | 2 | 0 | 0 | 0 |
| Bureau of Administration | 1 | 0 | 0 | 0 |
| Dept of Public Safety | 1 | 0 | 1 | 0 |
| Office of the Attorney General | 0 | 1 | 0 | 0 |
| Bureau of Information and Telecommunications | 0 | 1 | 1 | 0 |

| Agency | 1% Annual Chance Count | 0.2% Annual Chance NFHL Count | Area Protected by Levee | 1% Annual Chance Hazus |
|---|---|---|---|---|
| Dept of Military | 0 | 2 | 1 | 0 |
| **Total** | **27** | **8** | **10** | **9** |

Source: State of South Dakota, FEMA NFHL

A similar GIS overlay analysis was performed to identify trends in vulnerabilities to critical facilities/lifelines. The results are captured in the table below. Trends indicate a high number of wastewater facilities, schools, hazardous materials facilities, and fire stations.

**Table 3-26 Critical Facilities/Lifelines at Risk to Flood Hazards**

| Critical Facility | 1% Chance Hazus | 1% Chance NFHL | 0.2% Chance NFHL | Levee NFHL | Total |
|---|---|---|---|---|---|
| Aviation | - | 2 | 2 | 1 | **5** |
| Bridge | 77 | 2,362 | 75 | 22 | **2,536** |
| Bridge Scour | 3 | 118 | 8 | - | **129** |
| College/University | - | - | - | 1 | **1** |
| Courthouse | - | - | 1 | - | **1** |
| EMS Station | - | 6 | 6 | 6 | **18** |
| Fire Station | - | 11 | 7 | 3 | **21** |
| Hospital | - | - | 2 | - | **2** |
| Local EOC | - | - | 1 | 1 | **2** |
| Local Law Enforcement | - | 1 | 3 | - | **4** |
| Power Plant | - | 2 | - | - | **2** |
| Prison | - | - | 2 | 3 | **5** |
| Private School | - | 1 | 2 | 8 | **11** |
| Public School | - | 13 | 11 | 3 | **27** |
| RMP Facility | - | - | 1 | 4 | **5** |
| State EOC | - | - | - | - | **-** |
| TRI Facility | - | 9 | 10 | 24 | **43** |
| Wastewater Facility | 3 | 46 | 9 | - | **58** |
| Water Facility | - | 1 | 1 | - | **2** |
| Weather Radar Station | - | - | - | 1 | **1** |
| **Total** | **83** | **2,572** | **141** | **77** | **2,873** |

Source: State of South Dakota OEM, HIFLD, South Dakota OpenData, FEMA NFHL, Wood GIS analysis

The National Bridge Inventory (NBI), which was developed by the Federal Highway Administration, includes a "scour index" that is used to quantify the vulnerability of bridges to scour during a flood. Bridges with a scour index between one and three are considered "scour critical," or a bridge with a foundation element determined to be unstable for the observed or evaluated scour condition. Based on the NBI information submitted to the Federal Highway Administration as of January 26, 2022, there are 126 state-owned bridges identified as scour critical and nine local government bridges. Additionally, there are 1,697 state-owned bridges in the inventory with unknown foundations. These bridges are shown in Figure 3-28 below, with their conditions of good, fair, or poor shown in Figure 3-29 below.

**Figure 3-28 State Owned Bridges**

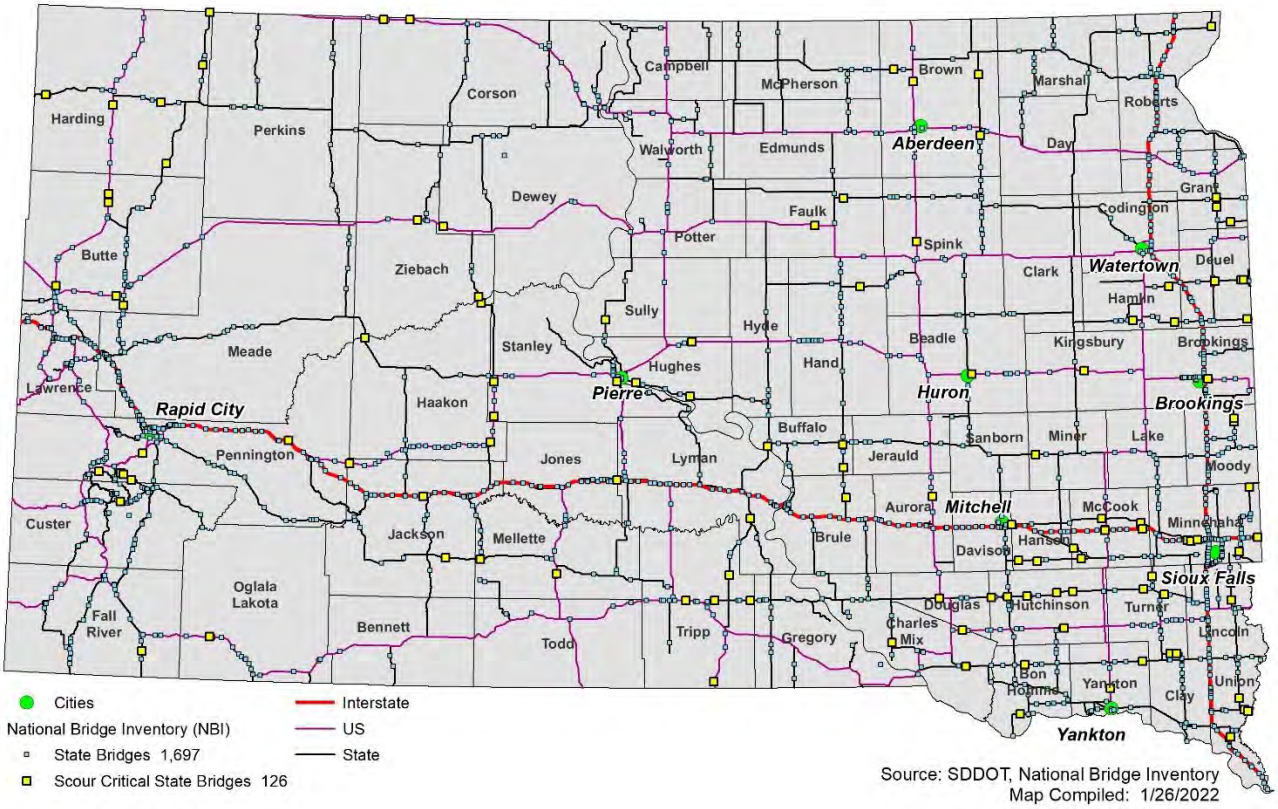
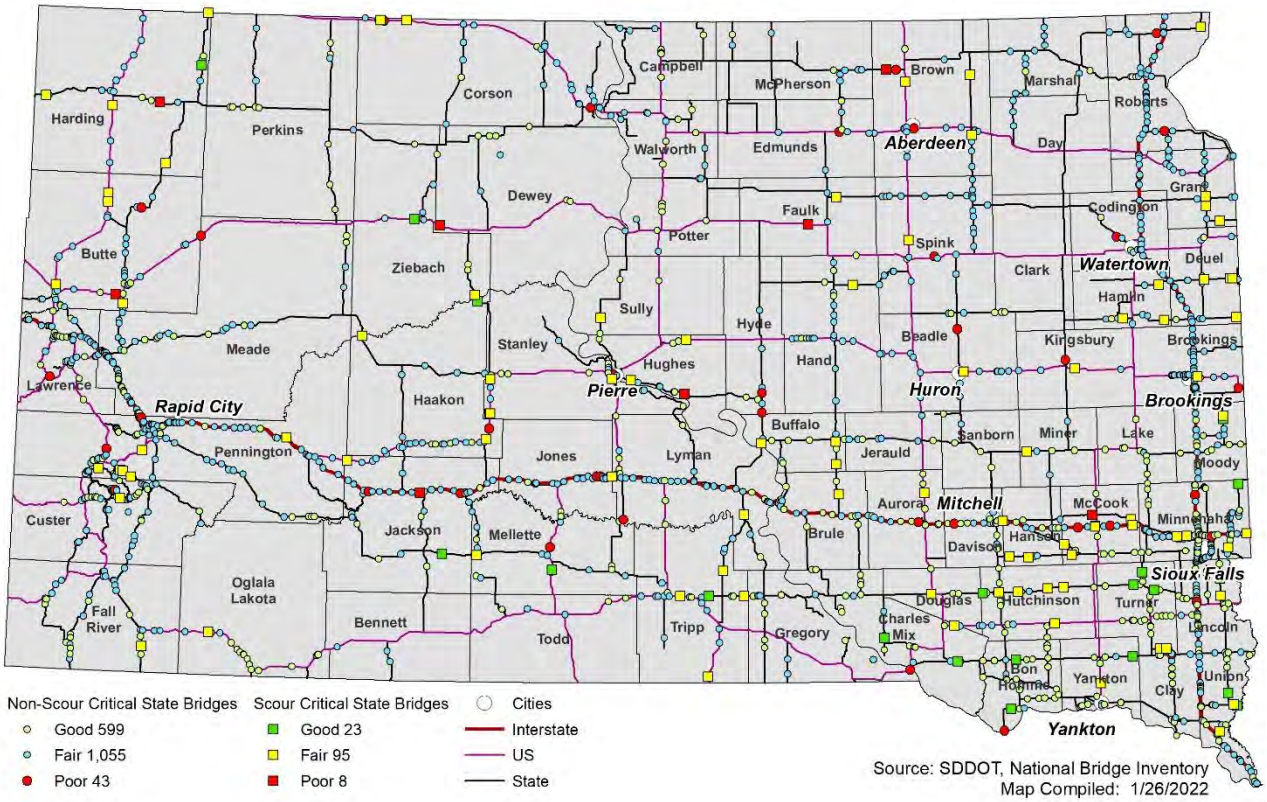



**Figure 3-29 Condition of State-Owned Bridges**



Railroads are vital to the rural farming economy in South Dakota, and past floods have impacted railroad bridges, delaying rail shipments of agricultural supplies for days or weeks. The NBI bridge database does not contain railroad bridges so further analysis of vulnerability could not be determined. Also noted during the planning process were the number of repeated culvert washouts and replacements on gravel roads from multiple flood disasters; some of the losses associated with this damage is reflected in the FEMA Public Assistance program expenditures noted in the disaster declaration summaries in the introduction section of the HIRA.

### *Economy*

Flooding can have major negative impacts on the local and regional economy, including indirect losses such as business interruption, lost wages, reduced tourism and visitation, and other downtime costs. Flood events can cut off customer access to a business as well as close a business for repairs or permanently. A quick response to the needs of businesses affected by flood events can help a community maintain economic vitality in the face of flood damage. Responses to business damages can include funding to assist owners in elevating or relocating flood-prone business structures. Additionally, flooding can impact the economy through the direct damages and losses to property and costs to recover, as summarized in the property section above.

### *Environment and Cultural Resources*

Natural resources are generally resistant to flooding and floodplains provide many natural and beneficial functions. Nonetheless, with human development factored in or in areas after periods of previous disasters such as drought and fire, flooding can impact the environment in negative ways. 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. Migrating fish can wash into roads or over dikes into flooded fields, with no possibility of escape. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods, these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

Tourism and outdoor recreation are an important part of the State's economy. If part of the planning area were damaged or rendered inaccessible by flooding for an extended period of time, tourism and outdoor recreation could potentially suffer.

## Development Trends and Consequence Summary

The counties experiencing the most development pressures in the State all participate in the NFIP and many communities have also taken steps to also participate in the CRS. Despite the pressures from population growth and increased development being felt in some counties, the overall flood risk should not be increasing assuming county floodplain regulations and standards are being effectively implemented and local mitigation measures are taking place. However, as the flood insurance loss analysis demonstrates, significant flood losses are occurring outside of mapped flood hazard areas. More extensive and improved flood hazard mapping should improve flood risk determinations to existing and future development over time, though the areas experience the most growth are mapped. The risk of flooding may be increasing over time, given long-term climate trends including the potential for more extreme precipitation events that could exceed mapped flood hazard areas.

**Table 3-27 Flood Consequence Table**

| Category | Narrative |
|---|---|
| Impact on the Public | Impacts on people will change with characteristics of event (e.g., flash flood in a canyon, river flood on the plains, etc.); residents/ property owners without flood insurance may be impacted greater than those with coverage; residents may be displaced due to evacuation, damage, or inaccessibility to homes; persons within flood areas have the potential for direct contact with hazardous materials; potential for drowning or personal injury; increased potential for exposure to disease |
| Impact on the Economic Condition of the State | Local economy and finances may be adversely affected, possibly for an extended period of time depending on damage and length of investigation; potential for businesses to permanently close; localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services |
| Impact on the Environment | Localized impact expected to be severe for incident areas and moderate to light for other areas affected by flood; wetland impacts due to flooding can result in water quality impacts and wildlife habitat impacts; potential for hazardous materials impacts if a release occurs |
| Impact on Property, Facilities, and Infrastructure | Vulnerabilities to critical infrastructure, facilities and property in floodplain areas; High potential for flooded basements; foundation damage; transportation corridor (road, bridge, rail line) washouts; culvert damage |
| Impact on the Public Confidence in Government | Ability to respond and recover may be questioned and challenged if planning, response, and recovery are not timely and effective. |
| Impact on Responders | Need for evacuation support such as door-to-door notification and traffic management may increase responder risk; widespread flooding could stretch first responder personnel thin some areas; potential impacts to transportation corridors and communications lines may affect ability to effectively respond; possibility of responder injury or death; higher risk to responders in flash flood |
| Impact on Continuity of Operations and Continued Delivery of Services | Damage to facilities/personnel in incident area may require temporary or permanent relocation of some operations |
| Cascading Hazards | Hazardous Materials Incidents, Dam Failure, Levee Failure |

### 3.3.3 Summer Storm

#### Hazard Description

Summer storms are not limited to one area of the State, and historically occur from early spring to early fall. Summer storms can include high winds, heavy rains and flooding, lightning, and hail; they can also spur the development of funnel clouds and tornadoes. They can vary in intensity from mild to severe, and can cause injury or death, destroy property, and kill livestock. Winds, flooding, and tornadoes are discussed further in other sections. This section covers two types of hazards caused by summer storms: hail and lightning.

#### *Hail*

Damaging hail events occur sporadically throughout South Dakota, usually associated with severe summer storms and wind events. Hail is formed when water droplets freeze and thaw as they are circulated high into the upper atmosphere by the violent internal forces of thunderstorms. Recent studies suggest that super-cooled water may accumulate on frozen particles near the backside of a storm as they are pushed forward across and above the updraft by the prevailing winds near the top of the storm. Eventually, the hailstones encounter downdraft air or become too heavy to remain suspended and fall to the ground.

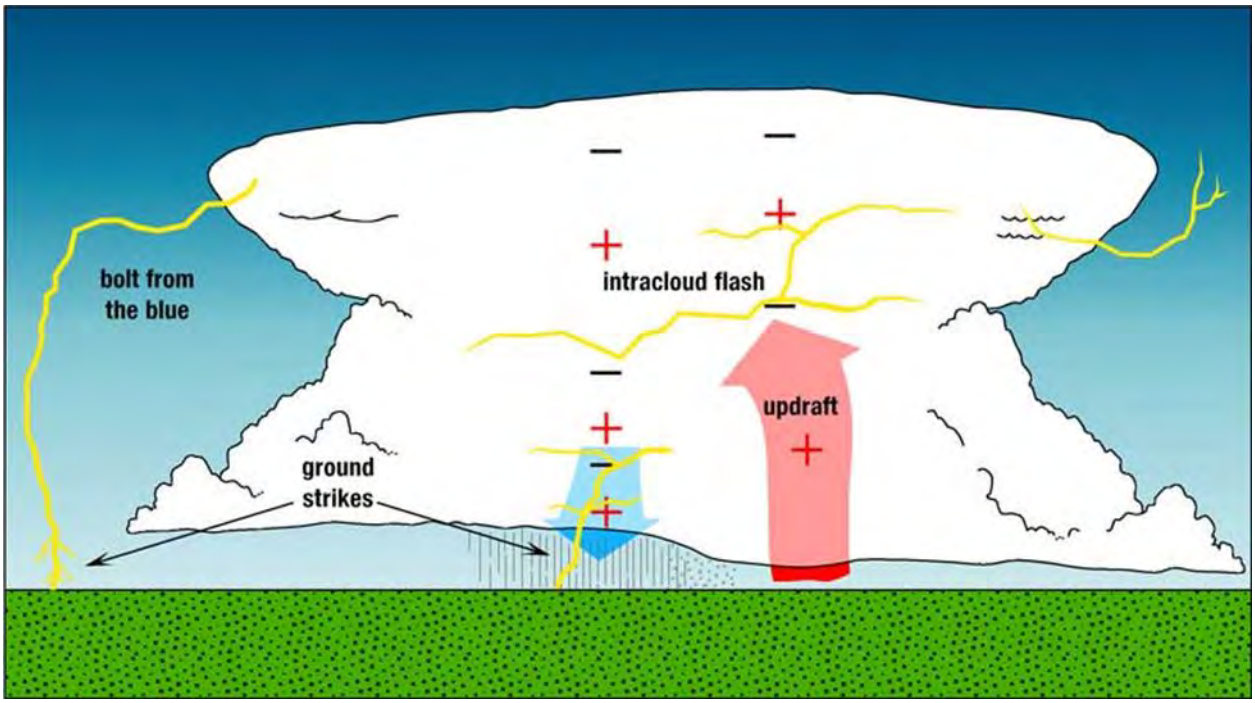
Nationally hail causes more than $1 billion of property damage each year. Hail is often associated with severe storms within South Dakota. Severe hailstorms can be quite destructive, causing damage to roofs, buildings, automobiles, vegetation, and crops. Hailstones are usually less than two inches in diameter and can fall at speeds of 120 miles per hour (mph). The largest hailstone ever recorded fell in Vivian, South Dakota on July 23, 2010, and measured approximately 8 inches in diameter. Hail diameter is usually referenced in comparison to everyday objects; a hail size comparison chart is presented below under the Magnitude/Severity (Extent) section.

#### *Lightning*

Lightning is defined as any and all of the various forms of visible electrical discharge caused by thunderstorms. Cloud to ground lightning can kill or injure people by direct or indirect means. Objects can be struck directly, which may result in an explosion, burn, or total destruction of the object or structure. Damage may also be indirect, when the current passes through or near an object, which generally results in less damage. Refer to 3.3.5 Wildfire for more information related to the risk associated with lighting in igniting wildland fires in the Blacks Hills and prairie ecosystems.

Cloud to ground lightning is the most damaging and dangerous type of lightning. Most flashes originate near the lower-negative charge center and deliver negative charge to earth. However, a large minority of flashes carry positive charge to earth. These positive flashes often occur during the dissipating stage of a thunderstorm's life. Positive flashes are also more common as a percentage of total ground strikes during the winter months. This type of lightning is particularly dangerous for several reasons. It frequently strikes away from the rain core, either ahead or behind the thunderstorm. It can strike as far as 5 or 10 miles from the storm in areas that most people do not consider to be a threat. Positive lightning also has a longer duration, so fires are more easily ignited. Additionally, when positive lightning strikes, it usually carries a high peak electrical current, potentially resulting in greater damage.

**Figure 3-30 Cloud to Ground Lightning**

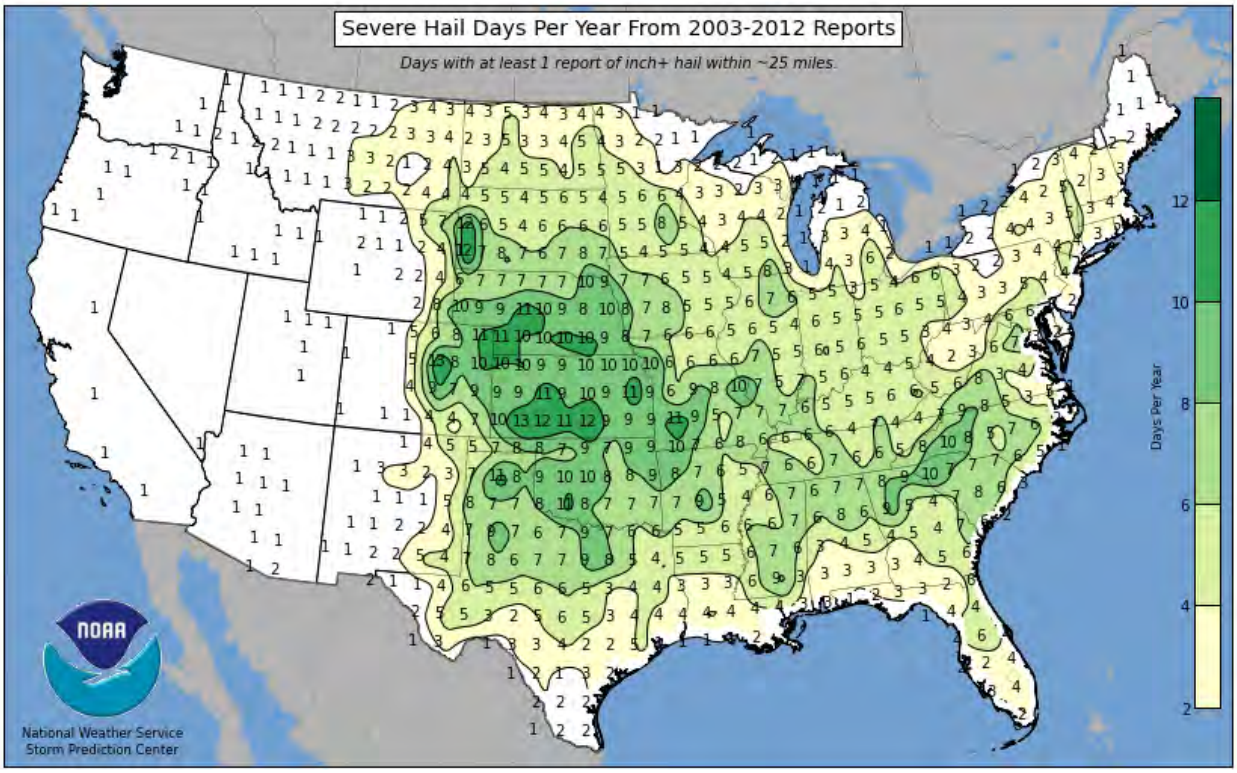



Source: NWS

## Location

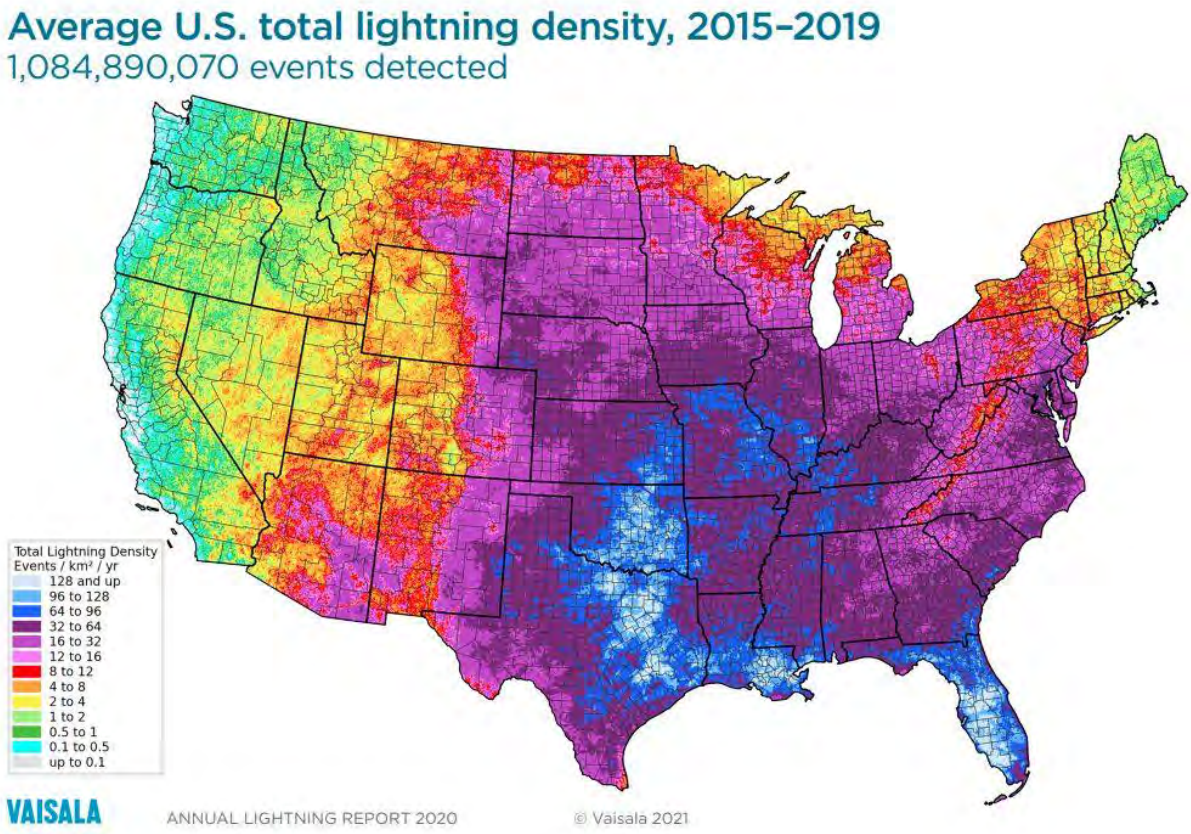
Summer storms can occur anywhere across the State, though the higher elevations of the Black Hills have more potential for lightning strikes. Figure 3-31 below shows the average number of days with severe hail per year across the U.S. Figure illustrates the average annual lightning strike density nationwide from 2015-2019. This shows that the frequency of these events varies across the State, in general occurring much more often in the Black Hills and southern areas of South Dakota. More location information is in the following section on past events and Vulnerability Assessment subsection.

**Figure 3-31 Severe Hail Days per Year (2003-2012)**




Source: NOAA

**Figure 3-32 Average Annual Lightning Density, 2015-2019**




Source: Vaisala Lightning Detection Network

## Past Events

According to the NCEI South Dakota has experienced 11,613 separate hail incidents between 1996 and 2020. It is important to note that these incidents may be separate impact areas caused by the same storm; it is also important to note that while NCEI is the best available free source for data on hazard impacts, the data can sometimes be imperfect.

NCEI data shows that the hail caused $162,706,750 in property damage and $44,869,000 in crop damage over this time period. Data on crop indemnity payments due to hail was also obtained from the USDA RMA. This data showed that, from 2007 to 2020, over 3,942,000 acres of crop land were damaged by hail and $455,119,168 in indemnity payments were made to farmers in South Dakota.

The NCEI records include 41 injuries and no fatalities caused by hail over this same timeframe. Amongst recent hail events since the last update of the HIRA, there was one event of significance taking place in Lawrence County and amounted to $2 million in property damages. The following table analyzes the percentage of these incidents that caused recorded impacts.

**Table 3-28 Impacts by Incident-Hail**

| Impact | Total | Number of Incidents w/ Impact | Percentage of Incidents with Recorded Impacts |
|---|---|---|---|
| Property Damage | $162,706,750 | 513 | 4.4% |

| Impact | Total | Number of Incidents w/ Impact | Percentage of Incidents with Recorded Impacts |
|---|---|---|---|
| Crop Damage | $44,869,000 | 96 | .83% |
| Injuries | 41 | 14 | .12% |
| Fatalities | 0 | N/A | N/A |

Figure 3-33 shows past hail occurrences in South Dakota, from 1955-2019, by the magnitude of the hail.

**Figure 3-33 South Dakota Hail Occurrences, 1955-2019**

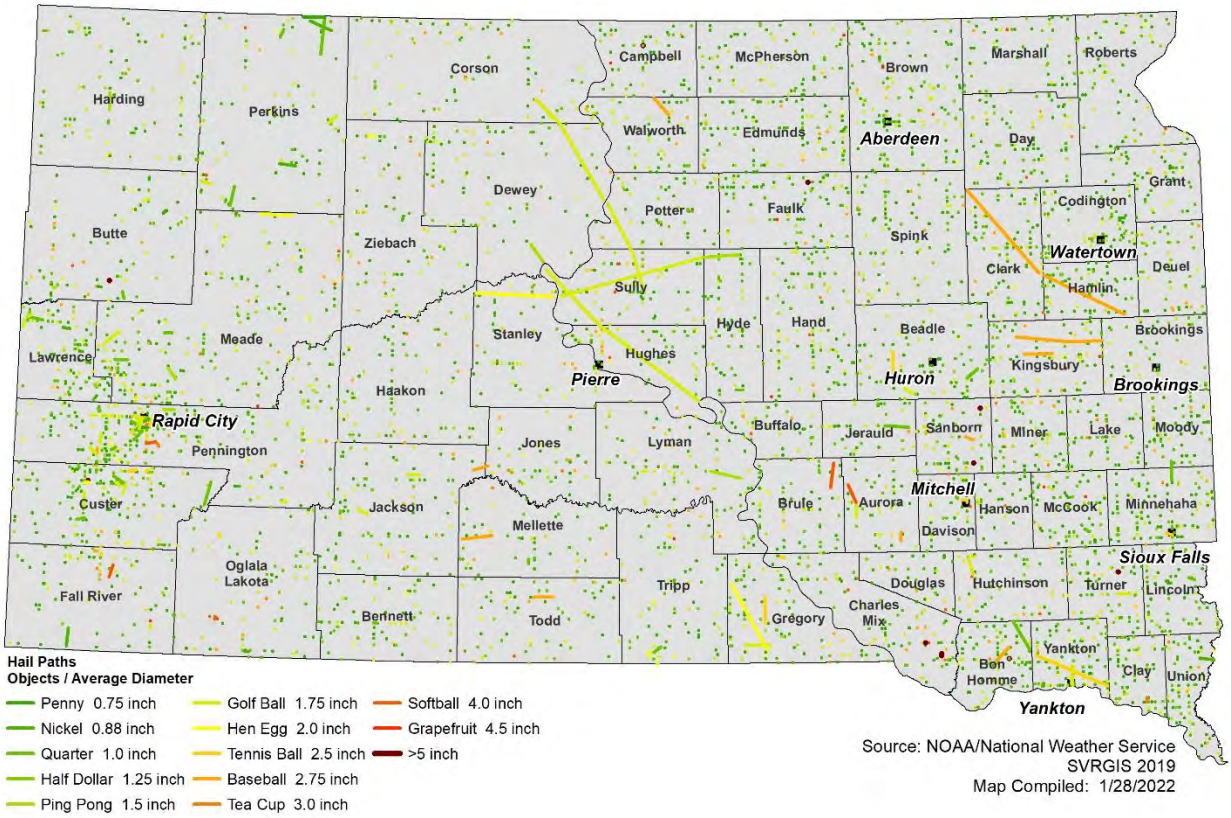



Table 3-29 lists recorded hail incidents by county between 1996 and 2020. The top five counties for recorded hail incidents are Pennington (888), Meade (567), Custer (460), Lawrence (355), and Minnehaha (315). Pennington County has also experienced the highest reported cumulative losses, with an estimated $67.6 million in damages reported to the NCEI over this time period.

**Table 3-29 Number of Hail Incidents by County (1996-2020)**

| County | Total Listed Events | Total Cumulative Damage |
|---|---|---|
| Aurora | 124 | $475,000 |
| Beadle | 185 | $134,000 |
| Bennett | 163 | $2,087,000 |
| Bon Homme | 159 | $455,000 |
| Brookings | 118 | $9,548,000 |
| Brown | 257 | $0 |
| Brule | 135 | $7,312,000 |
| Buffalo | 67 | $0 |

| County | Total Listed Events | Total Cumulative Damage |
|---|---|---|
| Butte | 200 | $4,532,000 |
| Campbell | 107 | $0 |
| Charles Mix | 205 | $4,962,000 |
| Clark | 164 | $0 |
| Clay | 124 | $282,000 |
| Codington | 153 | $0 |
| Corson | 240 | $0 |
| Custer | 460 | $4,556,000 |
| Davison | 135 | $5,350,000 |
| Day | 140 | $0 |
| Deuel | 67 | $0 |
| Dewey | 171 | $0 |
| Douglas | 64 | $1,286,000 |
| Edmunds | 210 | $0 |
| Fall River | 242 | $2,720,250 |
| Faulk | 130 | $0 |
| Grant | 93 | $0 |
| Gregory | 188 | $5,035,000 |
| Haakon | 162 | $160,500 |
| Hamlin | 137 | $0 |
| Hand | 247 | $0 |
| Hanson | 82 | $67,000 |
| Harding | 258 | $250,500 |
| Hughes | 127 | $0 |
| Hutchinson | 120 | $7,422,000 |
| Hyde | 104 | $0 |
| Jackson | 221 | $1,127,500 |
| Jerauld | 87 | $2,285,000 |
| Jones | 92 | $0 |
| Kingsbury | 126 | $3,506,000 |
| Lake | 114 | $1,560,000 |
| Lawrence | 355 | $7,763,000 |
| Lincoln | 134 | $4,200,000 |
| Lyman | 168 | $0 |
| Marshall | 125 | $0 |
| McCook | 127 | $135,000 |
| McPherson | 149 | $0 |
| Meade | 567 | $3,677,500 |
| Mellette | 117 | $170,500 |
| Miner | 85 | $110,000 |
| Minnehaha | 315 | $28,361,000 |
| Moody | 96 | $1,812,000 |
| Oglala Lakota | 247 | $616,000 |
| Pennington | 888 | $67,584,000 |
| Perkins | 238 | $2,051,000 |
| Potter | 91 | $0 |
| Roberts | 88 | $0 |
| Sanborn | 90 | $2,747,000 |
| Spink | 166 | $0 |

| County | Total Listed Events | Total Cumulative Damage |
|---|---|---|
| Stanley | 135 | $0 |
| Sully | 118 | $0 |
| Todd | 193 | $573,000 |
| Tripp | 200 | $741,000 |
| Turner | 142 | $2,551,000 |
| Union | 116 | $586,000 |
| Walworth | 125 | $0 |
| Yankton | 187 | $18,034,000 |
| Ziebach | 173 | $751,000 |
| Grand Total | 11,613 | $207,575,750 |

Source: NCEI

Table 3-30 shows selected hail incidents by hail size. It is noteworthy that the hailstone from Vivian on July 23, 2010, currently holds the record as the largest hailstone by diameter, circumference, and weight in the United States. It measured 8 inches in diameter, 18.75 inches circumference, and 1.938 pounds.

**Table 3-30 Selected South Dakota Hail Events**

| County | Area | Date | Hail Size in Inches | Deaths | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|---|
| Lyman | Vivian | 7/23/2010 | 8 | 0 | 5 | $0 | $0 |
| Charles Mix | Dante | 8/21/2007 | 6.88 | 0 | 0 | $0 | $0 |
| Charles Mix | Wagner | 8/21/2007 | 6.13 | 0 | 0 | $0 | $0 |
| Butte | Nisland | 6/19/2015 | 6 | 0 | 0 | $25000 | $0 |
| Butte | Newell | 6/29/2018 | 4.5 | 0 | 0 | $0 | $0 |
| Pennington | Pactola Reservoir | 8/8/2020 | 4.5 | 0 | 1 | $0 | $0 |
| Mellette | Norris | 8/26/2020 | 4.5 | 0 | 0 | $0 | $0 |
| Minnehaha | Hartford | 7/13/1997 | 4.5 | 0 | 0 | $20,00,000 | $2,000,000 |
| Meade | Piedmont | 6/1/2015 | 4.5 | 0 | 0 | $500,000 | $0 |
| Kingsbury | Lake Preston | 7/28/2002 | 4.5 | 0 | 0 | $100,000 | $0 |
| Lawrence | St. Onge | 6/19/2015 | 4.5 | 0 | 0 | $10,000 | $0 |
| Meade | Howes | 6/26/1998 | 4.5 | 0 | 1 | $0 | $0 |
| Faulk | Faulkton | 8/4/2000 | 4.5 | 0 | 0 | $0 | $0 |
| Fall River | Oelrichs | 6/12/2001 | 4.5 | 0 | 0 | $0 | $0 |
| Brown | Barnard | 6/23/2002 | 4.5 | 0 | 0 | $0 | $0 |
| McPherson | Leola | 7/9/2002 | 4.5 | 0 | 0 | $0 | $0 |
| Meade | Elm Springs | 8/26/2002 | 4.5 | 0 | 0 | $0 | $0 |
| Lyman | Presho | 6/11/2003 | 4.5 | 0 | 0 | $0 | $0 |
| Butte | Newell | 6/19/2015 | 4.5 | 0 | 0 | $0 | $0 |
| Pennington | Rapid City | 8/3/2007 | 4.25 | 0 | 0 | $500,000 | $0 |
| Pennington | Johnson Siding | 8/30/2013 | 4.25 | 0 | 0 | $500,000 | $0 |
| Todd | Rosebud | 7/13/2009 | 4.25 | 0 | 0 | $200,000 | $0 |
| Todd | St Francis | 3/18/2012 | 4.25 | 0 | 0 | $100,000 | $0 |
| Fall River | Edgemont | 6/22/2012 | 4.25 | 0 | 0 | $100,000 | $0 |
| Oglala Lakota | Oglala | 8/17/2014 | 4.25 | 0 | 0 | $100,000 | $0 |
| Fall River | Angostura Reservoir | 5/24/2010 | 4.25 | 0 | 0 | $40,000 | $0 |
| Custer | Fairburn | 6/21/2013 | 4.25 | 0 | 0 | $25,000 | $0 |
| Todd | Lakeview | 7/20/2005 | 4.25 | 0 | 0 | $20,000 | $0 |
| Harding | Camp Crook | 7/22/2011 | 4.25 | 0 | 0 | $10,000 | $0 |

| County | Area | Date | Hail Size in Inches | Deaths | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|---|
| Meade | Faith | 6/7/2005 | 4.25 | 0 | 0 | $5,000 | $0 |
| Sully | Agar | 8/24/2006 | 4.25 | 0 | 0 | $0 | $0 |
| Douglas | Delmont | 9/16/2006 | 4.25 | 0 | 0 | $0 | $0 |
| Aurora | White Lake | 6/21/2007 | 4.25 | 0 | 0 | $0 | $0 |
| Aurora | White Lake | 6/21/2007 | 4.25 | 0 | 0 | $0 | $0 |
| Sully | Clifton | 6/21/2007 | 4.25 | 0 | 0 | $0 | $0 |
| Sully | Clifton | 6/21/2007 | 4.25 | 0 | 0 | $0 | $0 |
| Turner | Center Pt | 5/1/2008 | 4.25 | 0 | 0 | $0 | $0 |
| Custer | Hermosa | 6/1/2008 | 4.25 | 0 | 0 | $0 | $0 |
| Brown | Westport | 7/17/2010 | 4.25 | 0 | 0 | $0 | $0 |
| Lyman | Vivian | 7/23/2010 | 4.25 | 0 | 0 | $0 | $0 |
| Hughes | Blunt | 8/26/2018 | 4 | 0 | 0 | $0 | $0 |
| Bennett | Swett | 7/10/2020 | 4 | 0 | 0 | $0 | $0 |
| Pennington | Pactola Reservoir | 8/8/2020 | 4 | 0 | 0 | $0 | $0 |
| Brown | Winship | 8/23/2020 | 4 | 0 | 0 | $0 | $0 |
| Butte | Belle Fourche | 7/5/1998 | 4 | 0 | 3 | $3,000,000 | $0 |
| Lake | Countywide | 7/11/2000 | 4 | 0 | 0 | $500,000 | $1,000,000 |
| Custer | Buffalo Gap | 5/24/2010 | 4 | 0 | 0 | $75,000 | $0 |
| Meade | Piedmont | 6/14/1997 | 4 | 0 | 0 | $0 | $0 |
| Hughes | Pierre | 6/30/1997 | 4 | 0 | 0 | $0 | $0 |
| Roberts | Wilmot | 7/19/1997 | 4 | 0 | 0 | $0 | $0 |
| Pennington | Wall | 8/2/1997 | 4 | 0 | 0 | $0 | $0 |
| Oglala Lakota | Oglala | 6/4/1999 | 4 | 0 | 0 | $0 | $0 |
| Butte | Belle Fourche | 6/25/2007 | 4 | 0 | 0 | $0 | $0 |
| Bon Homme | Avon | 8/8/2009 | 4 | 0 | 0 | $0 | $0 |
| Davison | Betts | 8/8/2009 | 4 | 0 | 0 | $0 | $0 |
| Spink | Spink Colony | 6/21/2013 | 4 | 0 | 0 | $0 | $0 |

While not as prominent as hail, NCEI records include 124 lightning incidents between 1996 and 2020 (note that NCEI only counts lightning strikes that were significant enough in some way to be reported; the actual number of lightning strikes is undoubtedly far higher). The recorded lightning strikes caused $4,892,200 in property damage and $5,000 in crop damage; five fatalities and 19 injuries were attributed to these events. The following table presents lightning incidents in the State that caused damages, injuries, or fatalities.

**Table 3-31 South Dakota Damaging Lightning Events 1996-2020**

| County | Area | Date | Deaths | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|
| Lake | Chester | 5/7/1996 | 0 | 0 | $1,000 | $0 |
| Kingsbury | Lake Preston | 5/18/1996 | 0 | 0 | $2,000 | $0 |
| Douglas | Armour | 7/6/1996 | 0 | 0 | $10,000 | $0 |
| Bon Homme | Springfield | 8/6/1996 | 0 | 0 | $10,000 | $0 |
| Lincoln | Sioux Falls | 10/16/1996 | 0 | 0 | $20,000 | $0 |
| Davison | Mitchell | 7/16/1997 | 0 | 0 | $1,000 | $0 |
| Fall River | Edgemont | 7/23/1997 | 0 | 0 | $5,000 | $0 |
| Davison | Mitchell | 7/24/1997 | 0 | 0 | $4,000 | $0 |
| Clay | Vermillion | 7/27/1997 | 0 | 0 | $20,000 | $0 |
| Minnehaha | Brandon | 9/8/1997 | 0 | 0 | $20,000 | $0 |

| County | Area | Date | Deaths | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|
| Lincoln | Beresford | 5/15/1998 | 0 | 0 | $40,000 | $0 |
| Bon Homme | Running Water | 6/17/1998 | 0 | 0 | $20,000 | $0 |
| Pennington | Rochford | 7/8/1998 | 0 | 1 | $0 | $0 |
| Beadle | Huron | 7/18/1998 | 0 | 0 | $10,000 | $0 |
| Moody | Flandreau | 7/18/1998 | 0 | 0 | $5,000 | $0 |
| Brookings | Volga | 7/20/1998 | 0 | 0 | $5,000 | $0 |
| Hutchinson | Parkston | 8/5/1998 | 0 | 1 | $0 | $0 |
| McCook | Bridgewater | 8/23/1998 | 0 | 0 | $10,000 | $0 |
| Kingsbury | De Smet | 6/4/1999 | 0 | 0 | $2,000 | $0 |
| Todd | Parmelee | 8/11/1999 | 0 | 1 | $0 | $0 |
| Marshall | Langford | 8/12/1999 | 0 | 0 | $50,000 | $0 |
| Lake | Madison | 5/17/2000 | 0 | 0 | $1,000 | $0 |
| Moody | Colman | 6/3/2000 | 0 | 0 | $70,000 | $0 |
| Minnehaha | Sioux Falls | 6/25/2000 | 0 | 0 | $100,000 | $0 |
| Brookings | Bruce | 7/9/2000 | 0 | 0 | $5,000 | $0 |
| Lawrence | Lead | 7/27/2000 | 0 | 0 | $5,000 | $0 |
| Brookings | Elkton | 4/22/2001 | 0 | 0 | $80,000 | $0 |
| Minnehaha | Sioux Falls | 4/22/2001 | 0 | 0 | $20,000 | $0 |
| Minnehaha | Sioux Falls | 4/22/2001 | 0 | 1 | $5,000 | $0 |
| Oglala Lakota | Pine Ridge | 6/9/2001 | 1 | 1 | $1,000 | $0 |
| Pennington | Sheridan Lake | 6/24/2001 | 1 | 2 | $0 | $0 |
| Yankton | Yankton | 7/7/2001 | 0 | 0 | $10,000 | $0 |
| Charles Mix | Lake Andes | 7/7/2001 | 0 | 0 | $1,000 | $0 |
| Brookings | Brookings | 7/22/2001 | 0 | 0 | $3,000 | $0 |
| Brookings | Brookings | 7/22/2001 | 0 | 0 | $3,000 | $0 |
| Bon Homme | Avon | 7/30/2001 | 0 | 0 | $5,000 | $0 |
| Aurora | Plankinton | 7/30/2001 | 0 | 0 | $1,000 | $0 |
| Custer | Custer | 8/1/2001 | 0 | 0 | $500,000 | $0 |
| Brookings | Brookings | 5/7/2002 | 0 | 0 | $5,000 | $0 |
| Moody | Flandreau | 6/10/2002 | 0 | 0 | $5,000 | $0 |
| Kingsbury | De Smet | 7/28/2002 | 0 | 0 | $10,000 | $0 |
| Brule | Kimball | 8/8/2002 | 0 | 0 | $20,000 | $0 |
| Kingsbury | Arlington | 8/12/2002 | 0 | 0 | $2,000 | $0 |
| Minnehaha | Sioux Falls | 9/19/2002 | 0 | 0 | $20,000 | $0 |
| Beadle | Huron | 5/29/2003 | 0 | 0 | $5,000 | $0 |
| Beadle | Huron | 5/29/2003 | 0 | 0 | $5,000 | $0 |
| Lincoln | Hudson | 7/3/2003 | 0 | 0 | $5,000 | $0 |
| Pennington | Rapid City | 7/8/2003 | 0 | 1 | $0 | $0 |
| Yankton | Midway | 7/20/2003 | 1 | 1 | $0 | $0 |
| Union | Elk Pt | 4/21/2004 | 0 | 1 | $2,000 | $0 |
| Miner | Howard | 5/21/2004 | 0 | 0 | $20,000 | $0 |
| Todd | Okreek | 6/8/2004 | 0 | 0 | $500,000 | $0 |
| Beadle | Hitchcock | 8/1/2004 | 0 | 0 | $5,000 | $0 |
| Hanson | Alexandria | 8/3/2004 | 0 | 0 | $50,000 | $0 |
| Yankton | Yankton | 8/22/2004 | 0 | 0 | $2,000 | $0 |
| Brule | Bijou Hills | 8/23/2004 | 0 | 0 | $20,000 | $0 |
| Davison | Mitchell | 8/31/2004 | 0 | 0 | $10,000 | $0 |
| Davison | Mitchell | 9/4/2004 | 0 | 0 | $2,000 | $0 |
| Kingsbury | De Smet | 5/7/2005 | 0 | 0 | $200,000 | $0 |

| County | Area | Date | Deaths | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|
| Lake | Madison | 6/29/2005 | 0 | 0 | $200 | $0 |
| Minnehaha | Sioux Falls | 7/7/2005 | 0 | 0 | $10,000 | $0 |
| Grant | Milbank | 8/10/2007 | 0 | 0 | $2,000 | $0 |
| Hughes | Pierre | 6/5/2008 | 0 | 0 | $50,000 | $0 |
| Minnehaha | East Sioux Falls | 7/31/2008 | 0 | 2 | $0 | $0 |
| Meade | Sturgis | 8/5/2008 | 0 | 3 | $0 | $0 |
| Brookings | Brookings | 5/4/2009 | 0 | 0 | $5,000 | $0 |
| Lincoln | Tea | 6/23/2009 | 0 | 0 | $30,000 | $0 |
| Moody | Colman | 9/30/2009 | 0 | 0 | $1,000 | $0 |
| Yankton | Yankton | 7/11/2010 | 0 | 0 | $5,000 | $0 |
| Moody | Flandreau | 5/10/2011 | 0 | 0 | $20,000 | $0 |
| Pennington | Rapid City | 6/24/2011 | 0 | 0 | $6,000 | $0 |
| Pennington | Wasta | 8/3/2011 | 1 | 0 | $0 | $0 |
| Custer | Buffalo Gap | 5/27/2014 | 0 | 1 | $0 | $0 |
| Brown | Aberdeen | 6/5/2014 | 0 | 0 | $2,000 | $0 |
| Pennington | Rockerville | 6/4/2015 | 0 | 0 | $2,000 | $0 |
| Pennington | Rapid City | 6/20/2015 | 0 | 0 | $50,000 | $0 |
| Lawrence | Spearfish | 7/12/2015 | 1 | 1 | $0 | $0 |
| Lincoln | South Sioux Falls | 8/27/2015 | 0 | 0 | $5,000 | $0 |
| Lincoln | Tea | 8/27/2015 | 0 | 0 | $5,000 | $0 |
| McCook | Salem | 5/25/2016 | 0 | 0 | $45,000 | $0 |
| Pennington | Rapid City | 6/13/2016 | 0 | 0 | $20,000 | $0 |
| Pennington | Rapid City | 8/8/2016 | 0 | 2 | $0 | $0 |
| Pennington | Rockerville | 8/14/2016 | 0 | 0 | $50,000 | $0 |
| Grant | Milbank | 8/18/2017 | 0 | 0 | $10,000 | $0 |
| Davison | Mitchell | 4/5/2019 | 0 | 0 | $50,000 | $0 |
| Hutchinson | Freeman | 7/17/2019 | 0 | 0 | $90,000 | $0 |
| Charles Mix | Geddes | 8/6/2019 | 0 | 0 | $0 | $5,000 |
| Union | McCook Lake | 8/10/2020 | 0 | 0 | $2,500,000 | $0 |
| McPherson | Eureka | 8/12/2020 | 0 | 0 | $1,000 | $0 |
| **Grand Total** | | | **5** | **19** | **$4,892,200** | **$5,000** |

Source: NCEI

Table 3-32 analyzes the percentage of lightning these incidents that caused impacts.

**Table 3-32 Impacts by Incident-Lightning**

| Impact | Total | Number of Incidents w/ Impact | Percentage of Incidents with Impact |
|---|---|---|---|
| Property Damage | $2,171,200 | 69 | 61% |
| Crop Damage | 0 | N/A | N/A |
| Injuries | 17 | 13 | 11% |
| Fatalities | 5 | 5 | 4.3% |

Source: NCEI

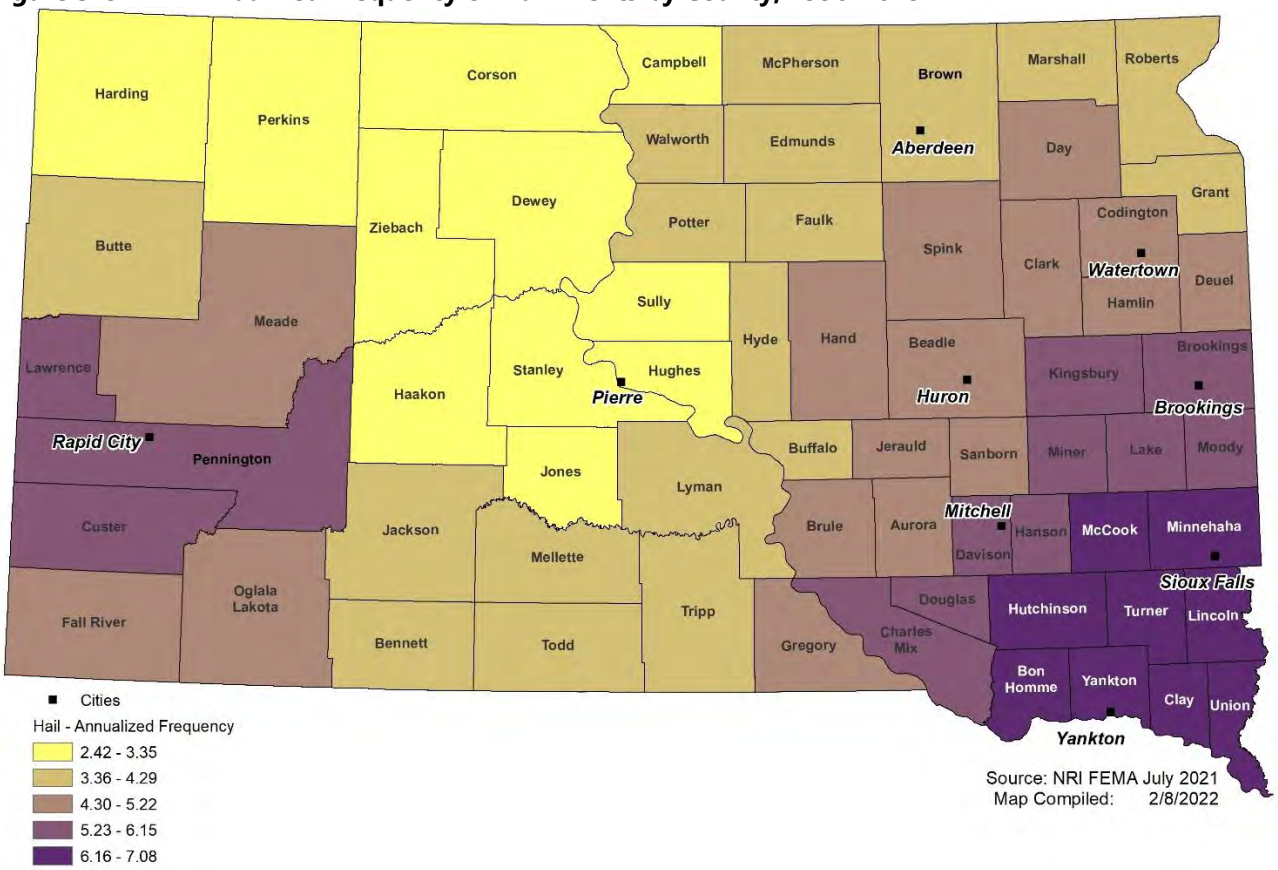
## Probability of Future Occurrence

According to the NCEI, there were 11,613 hail incidents in South Dakota between 1996 and 2020. The average hail stone size for these incidents was approximately 1.25 inches in diameter, though hail up to eight inches in diameter has been recorded in Vivian in Lyman County in July 2010. This suggests that South Dakota averages 484 separate hail incidents annually. Zero deaths and 41 injuries were attributed

to these events. Based on past history, South Dakota can expect few if any deaths, and almost 1-2 injuries each year caused by hail. Based on this information, the probability that multiple hailstorms will occur in South Dakota in any given year is 100 percent.

Figure 3-34 depicts the annualized frequency of hail events by county between 1996 and 2019 based on the FEMA NRI. The data indicates a higher frequency of events in the southeastern and western parts of the State.

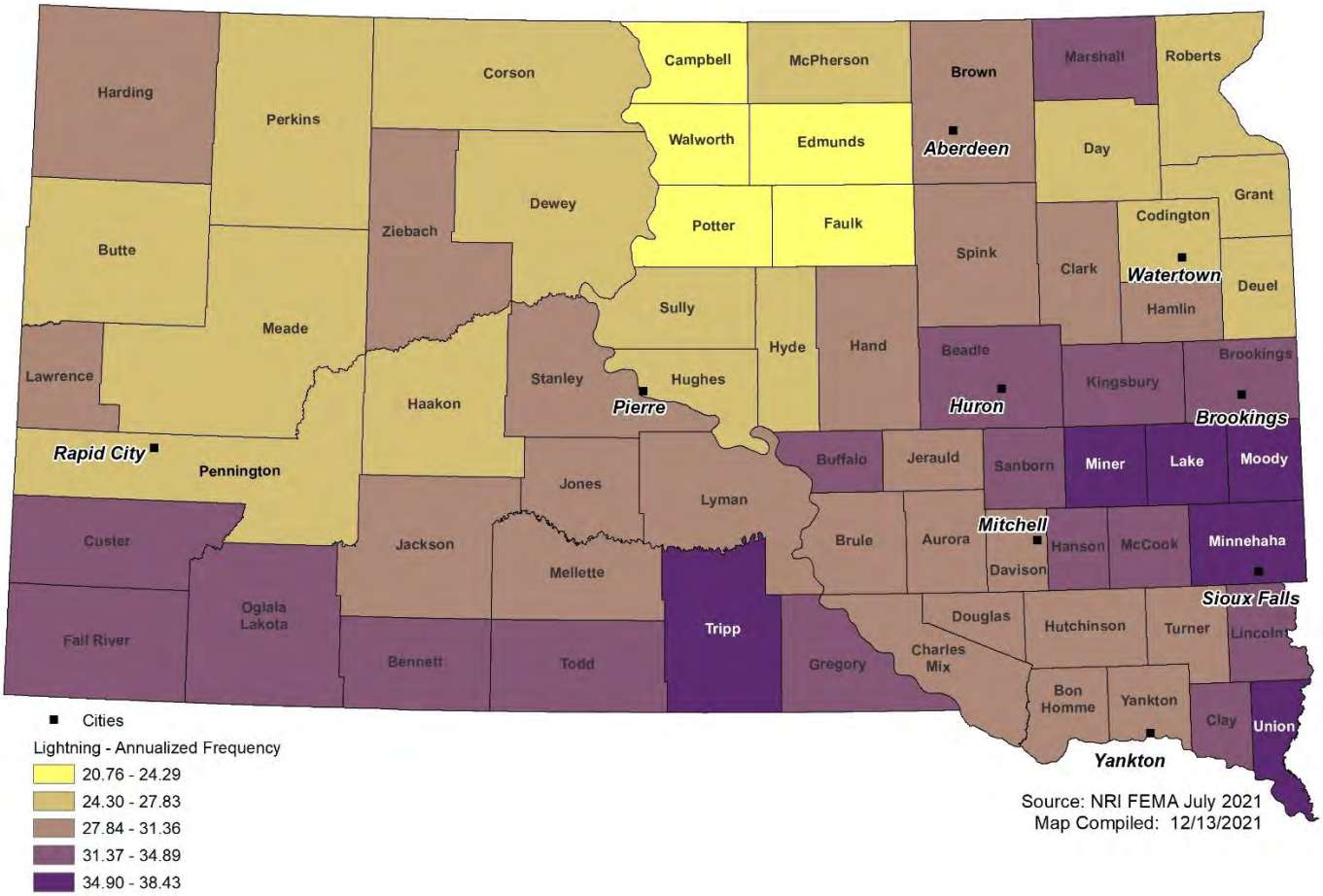
**Figure 3-34 Annualized Frequency of Hail Events by County, 1996-2019**




Lightning is a common event that occurs in every thunderstorm in the State. Most lightning is harmless to those on the ground, bouncing from cloud to cloud. However, when lightning does strike a target on the ground, it can do tremendous damage to people and property. Between May 1996 and 2020, NCEI recorded 124 separate lightning strikes, or approximately 5 per year. Cumulatively, these storms caused five deaths and nineteen injuries. Extrapolated into the future, the State of South Dakota can expect damaging lightning strikes annually; based on NCEI-recorded data, these strikes will cause one recorded injury every other year, and a lightning-caused fatality every four years.

Figure 3-35 depicts annualized frequency of lightning events by county between 1996 and 2019 based on the FEMA NRI. The data indicates a higher frequency of events in the southern and southeastern parts of the State.

**Figure 3-35 Annualized of Frequency of Lightning Event by County, 1996-2019**

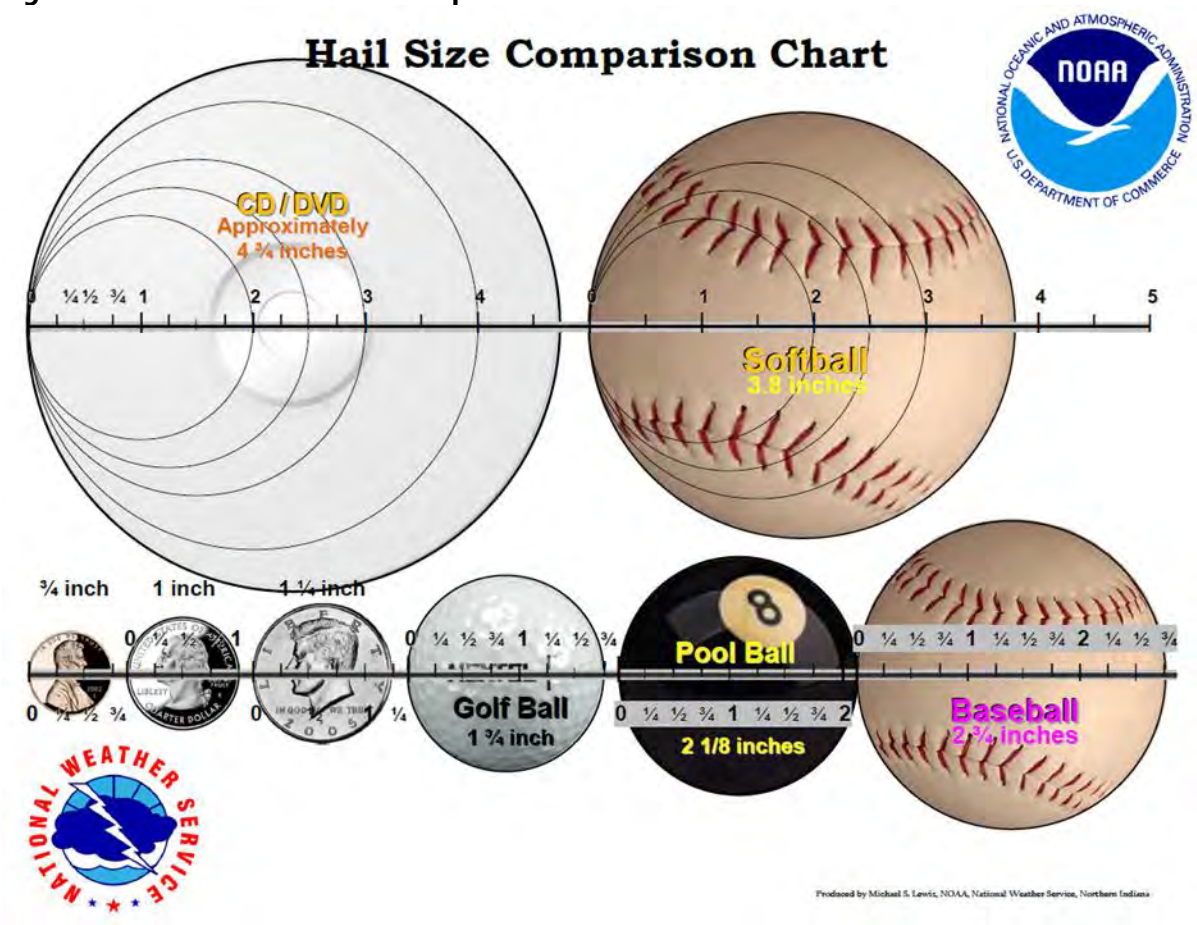



## Magnitude/Severity (Extent)

The NWS classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Figure 3-36 below shows the hailstone measurements utilized by the NWS.

There is no clear distinction between storms that do and do not produce hailstones. Nearly all severe thunderstorms probably produce hail aloft, though it may melt before reaching the ground. Multi-cell thunderstorms produce many hailstones, but not usually the largest hailstones. In the life cycle of the multi-cell thunderstorm, the mature stage is relatively short so there is not much time for growth of the hailstone. Supercell thunderstorms have sustained updrafts that support large hail formation by repeatedly lifting the hailstones into the very cold air at the top of the thunderstorm cloud. In general, golf ball sized hail or larger is associated with supercells, but non-supercell storms are also capable of producing golf ball size hail.

**Figure 3-36 NOAA Hail Size Comparison Chart**




Source: NWS

**Table 3-33 National Weather Service Hail Severity**

| Severity | Description | Hail Diameter Size (in inches) |
|---|---|---|
| Non-Severe Hail<br>Does not typically cause damage and does not warrant severe thunderstorm warning from NWS. | Pea | 1/4" |
| | Marble/mothball | 1/2" |
| | Penny | 3/4" |
| | Nickel | 7/8" |
| Severe Hail<br>Research has shown that damage occurs after hail reaches around 1" in diameter and larger. Hail of this size will trigger a severe thunderstorm warning from NWS. | Quarter | 1" (severe) |
| | Half Dollar | 1 1/4" |
| | Walnut/Ping Pong Ball | 1 1/2" |
| | Golf Ball | 1 3/4" |
| | Hen Egg/Lime | 2" |
| | Tennis Ball | 2 1/2" |
| | Baseball | 2 3/4" |
| | Teacup/Large Apple | 3" |
| | Softball | 4" |
| | Grapefruit | 4 1/2" |

Source: NWS

Common problems associated with lightning include the loss of utilities and related impacts. Loss of life is uncommon but can occur during severe storms. Loss of utilities, specifically power lines can occur due to strikes or downed trees from lighting.

Lightning is measured by the Lightning Activity Level (LAL) scale, created by the NWS to define lightning activity into a specific categorical scale. The LAL is a common parameter that is part of fire weather forecasts nationwide. Various areas of the State are at risk to experience lightning in any of these categories. The LAL is reproduced in Table 3-34.

**Table 3-34 Lightning Activity Level Scale**

| Lightning Activity Level | |
|---|---|
| LAL 1 | No thunderstorms |
| LAL 2 | Isolated thunderstorms. Light rain will occasionally reach the ground. Lightning is very infrequent, 1 to 5 cloud to ground strikes in a five-minute period |
| LAL 3 | Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a five-minute period |
| LAL 4 | Scattered thunderstorms. Moderate rain is commonly produced. Lightning is frequent, 11 to 15 cloud to ground strikes in a five-minute period |
| LAL 5 | Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and intense, greater than 15 cloud to ground strikes in a five-minute period |
| LAL 6 | Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag warning |

Source: NWS

## Climate Change Considerations

As the atmosphere warms further due to climate change, the increased heat in the atmosphere provides more energy for severe storms. The frequency of severe weather events has increased steadily over the last century. The number of weather- related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data shows that the probability for severe weather events increases in a warmer climate. The changing hydrograph caused by climate change could have a significant impact on the intensity, duration, and frequency of storm events. All of these impacts could have significant economic consequences in terms of direct damages as well as potential lost income due to agricultural impacts, for example.

The Climate Science Special Report (2017) states that damages from convective weather hazards (such as severe thunderstorms and tornadoes) have undergone the largest increase in damages, relative to other extreme weather, since 1980. Some studies have considered the number of days that will be favorable for severe thunderstorms as well. There is projected to be an increase in potential days for severe thunderstorms in the mid- to late 21st century. The largest increases, however, are in neighboring regions of the Midwest and Southern Plains. Also, storm intensity is projected to increase. There is some uncertainty in these projections, but severe thunderstorms and tornadoes will remain a hazard in South Dakota every year. The Fourth National Climate Assessment projects an increase in both the number of days above 90 degrees and the number of days with precipitation exceeding 1 inch by the mid-21$^{st}$ century for the Northern Great Plains region. Both of these shifts create conditions favorable to or

characteristic of severe thunderstorms. According to studies referenced by the National Lightning Safety Institute, it could be possible globally to see an increase of 10-20% in the incidence of lightning with each degree Celsius of global temperature increase. This could potentially lead to higher frequency of thunderstorm occurrence in South Dakota.

## Vulnerability Assessment

All counties in South Dakota are vulnerable to summer storms. In order to analyze the State's vulnerability to summer storms, the NRI was used as a primary tool. The NRI defines risk as the potential for negative impacts as a result of a natural hazard and determines a community's risk relative to other communities by examining the EAL and social vulnerability in a given community in relation to that community's resilience. This composite risk rating is illustrated in Figure 3-37 for hail and Figure 3-38 for lightning below, showing the risk to these aspects of summer storms by county in South Dakota. Because hail can occur anywhere, the hail risk within the NRI is based on the entire building, population, and agricultural value of each county when considering exposure. The NRI considers the same for exposure to lightning.

**Figure 3-37 Hail Risk Rating by County in South Dakota**

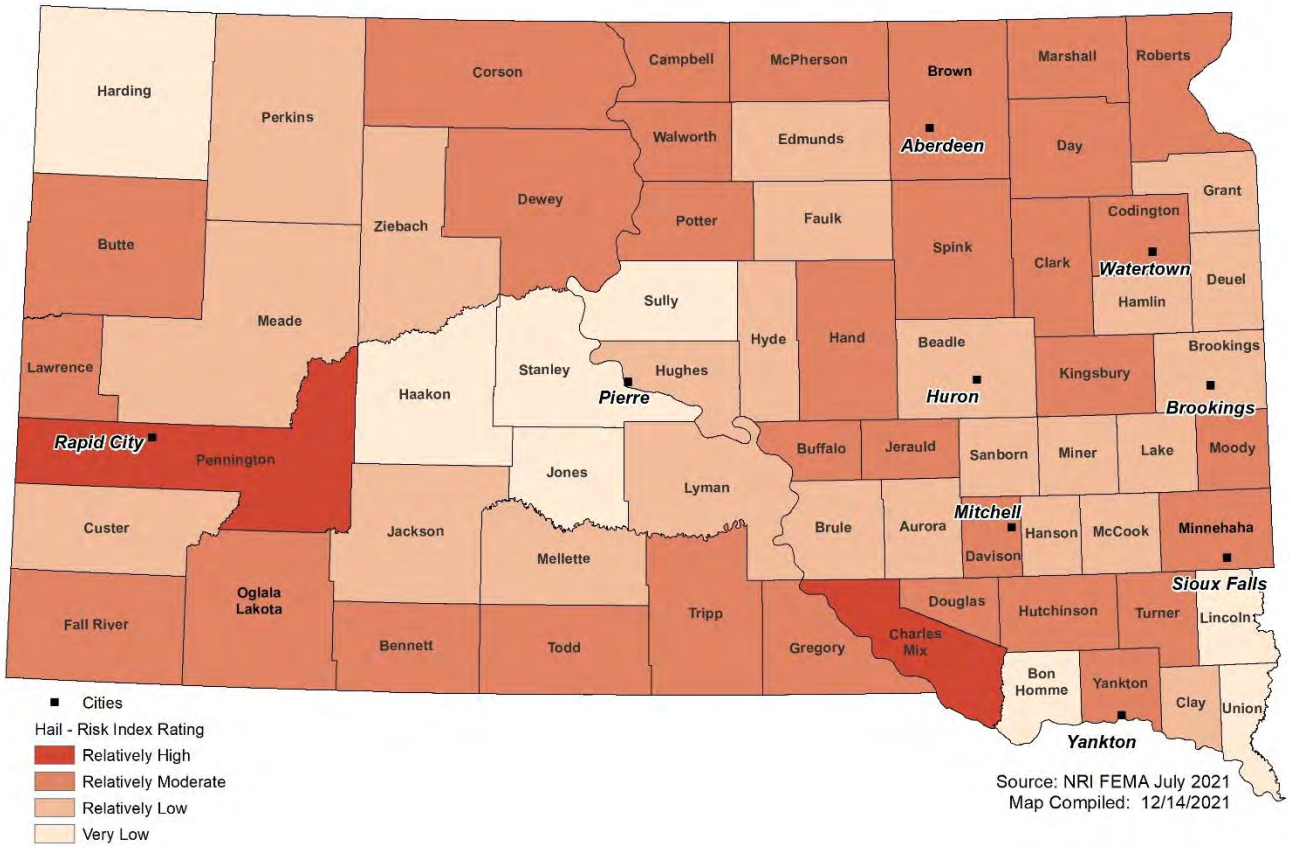
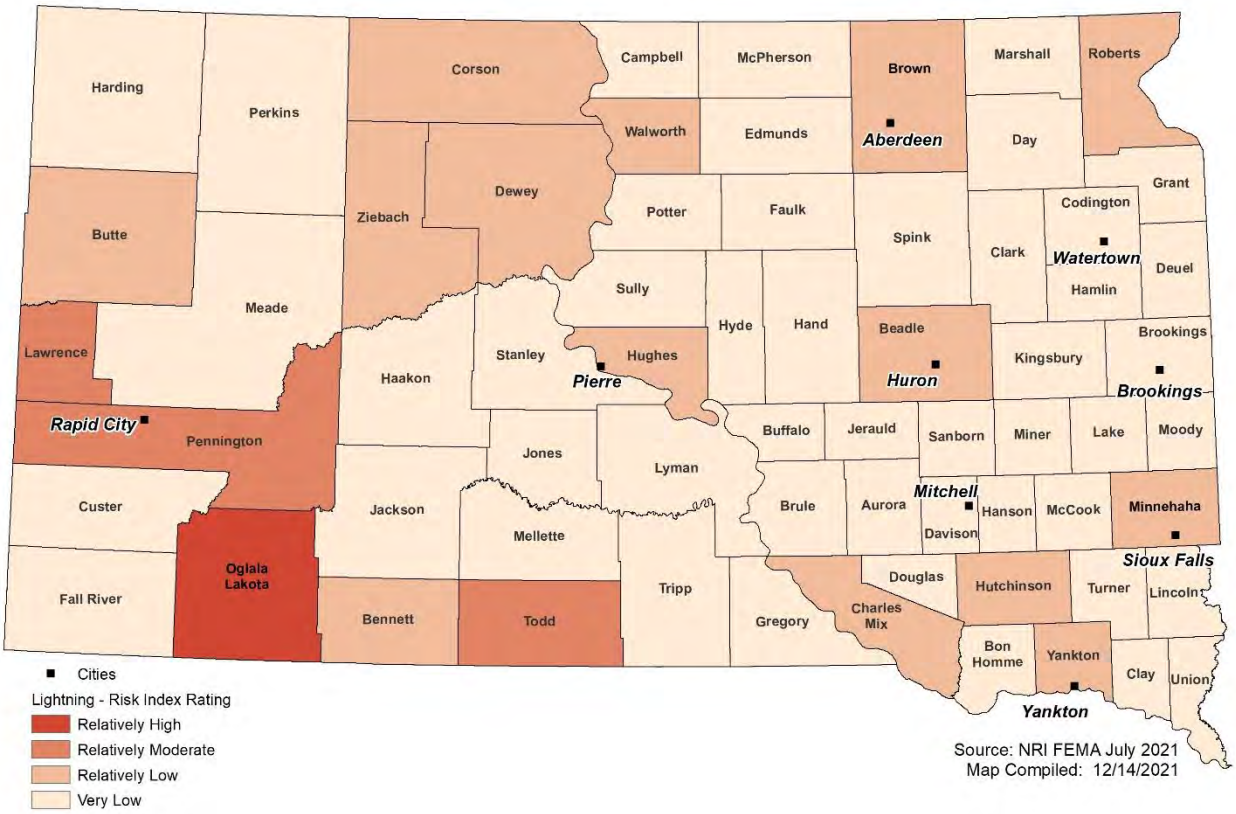


**Figure 3-38 Lightning Risk Rating by County in South Dakota**




## *People*

Exposure is the greatest danger to people from hail, for those caught outside in the open without shelter. Large hail has the potential to cause significant bruising, concussions, broken bones, and even death. The impacts of hail on vulnerable populations can be more severe. Low income families are more likely to live in poorly constructed homes that are more likely to be damaged, and are more likely to be uninsured or underinsured, making it more difficult for them to recover from hail events. Individuals with disabilities may need more assistance after a major event, especially if transportation or utility services are disrupted. Most injuries caused by hail are minor and go unreported.

Anyone that is caught in an exposed area during a thunderstorm could be at risk to a lightning strike. In South Dakota, 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 persons in jeopardy without warning. Outdoor recreation is a major economic contributor to South Dakota. People may often find themselves outside and need to be especially watchful of the weather during the summer months when afternoon thunderstorms are more common. Lightning caused five fatalities and nineteen recorded injuries between 1996 and 2020; these injuries were to people caught unprotected during a lightning storm.

Members of the population who rely on a constant, uninterrupted electrical supply may have a greater, indirect vulnerability to lightning. As a group, the elderly or disabled, especially those with home health care services may 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. Statewide an estimated 9,922 Medicare Beneficiaries rely on electricity to live independently in their homes. Isolation of these populations is a significant concern. These

populations face isolation and exposure during thunderstorm events and could suffer more secondary effects of the hazard. 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.

### *Property*

Hail can strike anywhere in South Dakota, and all structures are vulnerable. Hail can damage roofs, shingles, windows, siding, unsheltered vehicles, and any other property unprotected from the storm. Hail causes more than a billion dollars of property damage nationally each year. Most of this damage is to crops, but hail can also decimate structures, shatter windows, peel paint, and severely damage automobiles and equipment not protected or stored inside.

As mentioned in the past events section above, lightning has caused approximately $4.9 million in property damages since 1996 in South Dakota. This is equivalent to an expected annualized loss of approximately $204,167.

### *State Assets, Critical Facilities, and Infrastructure*

Hail can lead to the temporary incapacitation of roads when small hail stones build up so deep, they block roads. Hail has also been observed to block storm drains and prevent proper runoff, potentially resulting in flooding as a secondary hazard. Most structures, including the *State's* critical facilities, should be able to provide adequate protection from hail to their occupants but the structures themselves could suffer broken windows and dented exteriors. Those facilities with back-up generators are better equipped to handle a severe weather situation should the power go out.

Some essential infrastructures 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.

### *Economy*

The economic impact from hail can be severe on impacted areas, and potentially long lasting. As mentioned throughout this section, hail is the one of the costliest hazards experienced in South Dakota. While most damages due to hail are typically covered by private insurance, direct damages have totalled $207,575,750 over the last 24 years and severe indirect economic impacts can also be felt through businesses which may be forced to close for repairs. A review of the USDA RMA records shows between 2007 and 2020 over 3,942,000 acres of crop land were damaged by hail and $455,119,168 in indemnity payments were made to farmers in South Dakota. The estimated average annualized losses due to hail is $8,648,990.

Economic impacts of a severe thunderstorm are typically short-term. Lightning events can cause power outages and fires. Generally, long-term economic impacts arise more from hazards that cascade from a severe thunderstorm, including wildfires ignited by lightning. Similarly with the previous section, lightning can cause structural damage or damage to electrical systems to private buildings as well as critical infrastructure.

### *Environment and Cultural Resources*

While summer storms are a natural environmental process, they can cause significant environmental damage through their many impacts and cascading hazards. As discussed throughout this section hail and lightning are both capable of inflicting significant physical damage to the built environment, as well as the natural environment, breaking tree limbs, damaging trees and other plants in bloom, sparking fires, and destroying crops. Some cultural and historic properties may also be at risk of damage from hail.

## Development Trends and Consequence Summary

Many counties in South Dakota have seen a decrease in population growth and development pressures. However, a few specific counties have seen concentrated growth since the last census. Lincoln County experienced the greatest percentage of population gain of all the counties in South Dakota from 2010 to 2020, while Minnehaha saw the greatest absolute change in population over the same time period. Lincoln, Meade, Union, Minnehaha, and Beadle Counties have increased their population by more than 10% since 2010. Climate change is predicted to increase both the occurrence and intensity of summer storms. As these counties continue to grow, these increases in population and residential development exposed to these summer storm events will increase their vulnerability to the hazard. The agricultural industry, which is one of the State's primary industries will continue to be vulnerable to hail events. Counties that are particularly dependent economically on crops or livestock will have high vulnerability to this type of hazard event. (See agricultural pests and diseases vulnerability discussion).

**Table 3-35 Summer Storms Consequence Table**

| Category | Narrative |
|---|---|
| Impact on the Public | Exposure risks to motorists, outdoor workers, homeless persons, general public; risk to persons with energy dependent medical needs and pre-existing medical conditions |
| Impact on the Economic Condition of the State | Potential loss of facilities or infrastructure function or accessibility and uninsured |
| Impact on the Environment | Tree and vegetation damage, crop damage; animal impacts |
| Impact on Property, Facilities, and Infrastructure | Buildings, equipment, and utility infrastructure are exposed to heavy hail, sometimes complicated by strong winds; transportation system impacts; possibility of roof damage; potential power loss and strain on energy systems |
| Impact on the Public Confidence in Government | High expectations of government capabilities for reducing impact of hail events related to transportation |
| Impact on Responders | Exposure risks; adverse working conditions. Potential impacts to communications systems |
| Impact on Continuity of Operations and Continued Delivery of Services | Potential loss of facilities or infrastructure function; potential loss of ability or accessibility to provide services; possible power interruption; transportation system impacts |
| Cascading Hazards | Floods, Tornadoes, High Wind |

### 3.3.4 Winter Storm

#### Hazard Description

Winter storms are not limited to one area of the State and historically occur from late fall to the middle of spring. They vary in intensity from mild to severe. Winter storms regularly destroy property and kill livestock. They can immobilize a region, blocking roads and railways and closing airports, which can disrupt emergency and medical services, hamper the flow of supplies, and isolate homes and farms, possibly for days. Heavy snow can collapse roofs and knock down trees and power lines. Unprotected livestock may be lost. Economic impacts include cost of snow removal, damage repair, and business losses.

The NWS describes different types of snow events as follows:

- **Blizzard** - Winds of 35 mph or more with snow and blowing snow reducing visibility to less than ¼ mile for at least 3 hours.
- **Blowing Snow** - Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.
- **Snow Squalls** - Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant.
- **Snow Showers** - Snow falling at varying intensities for brief periods of time. Some accumulation is possible.
- **Snow Flurries** - Light snow falling for short durations with little or no accumulation.

Also associated with winter storms are ice, freezing rain, and sleet. Freezing rain coats objects with ice. This ice coating on sidewalks, roads, etc., creates dangerous conditions. Sleet does not generally cling to objects like freezing rain, but it does make the ground very slippery. Heavy accumulations of ice can bring down trees and topple utility poles and communication towers. Ice can disrupt communications and power for days while utility companies repair extensive damage; even small accumulations of ice can be extremely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

Winter storms can also generate flooding, usually as a result of ice jams or snowmelt, which can cause significant damage and loss of life. Ice jams form when long cold spells cause rivers and lakes to freeze and a rise in water level or a thaw breaks the ice into large chunks that become jammed at obstructions (e.g., a bridge). Water backs up at the jam, which is acting as a dam, and flooding results. The snowmelt hazard is defined as a sudden thaw of a heavy snowpack that often leads to flooding. Both snowmelt and ice jam floods are common in South Dakota.

Extreme cold often accompanies a winter storm or is left in its wake. It is most likely to occur in the winter months of December, January, and February. Prolonged exposure to the cold can cause frostbite or hypothermia and can become life threatening. Infants and the elderly are most susceptible. Pipes may freeze and burst in homes or buildings that are poorly insulated or without heat. Extreme cold can disrupt or impair communications facilities.

#### Location

Winter storm has an even probability across the State due to its topography. The inherent nature of temperature hazards makes them a regional threat, impacting most or all the planning area simultaneously as well as extending the effects into the surrounding jurisdictions. Prairie lands, which cover most of the State, offer little resistance to high winds and drifting snow. Even the Black Hills Region, which presents some resistance to wind conditions, is not excluded from blizzard conditions. Blizzards in

this region are often less severe than elsewhere in the State, but they can still produce heavy drifting snows. Early blizzards were so devastating that South Dakota had the dubious distinction of being called the Blizzard State.

According to the NWS, most of South Dakota has an annual mean snowfall of 24.1 to 36 inches. Some areas in the northeast, northwest, and southwest have an annual mean snowfall of 36.1 to 48.0 inches, and a small area in the southwest has an annual mean snowfall greater than 72 inches.

### Past Events

According to the NCEI, there were 2,136 winter storms (snow and ice events) recorded in South Dakota between January 1993 and December 2021, and 499 extreme cold events from January 1994 to December 2021. Winter storm events have resulted in 20 deaths and 127 injuries were attributed to these events. This suggests that South Dakota can expect approximately 1.4 deaths and five injuries each year. Total property damage for these events is estimated at $105 million dollars. This suggests that South Dakota averages 76 winter storms and $3.7 million in winter storm losses annually, as well as 18 extreme cold events each year.

The event of record took place on December 25, 2016. The blizzard event resulted in a presidential declaration for 24 counties. The table below provides more details on the event.

**Table 3-36 South Dakota Winter Storm Events**

| Date | Comments |
|---|---|
| April 10-11, 2019 | A historic late-season, multi-day winter storm developed rapidly across the central Plains on Wednesday, April 10. This system spiraled several periods of wintry precipitation through the region. The leading precipitation on April 10 was a mix of rain, freezing rain and sleet from far eastern South Dakota through the Interstate 90 areas of southwest Minnesota and northwest Iowa, changing to snow to the north and west. Heavy snowfall developed from the early morning of April 11 and continued into the early morning of April 12 across much of southeast South Dakota into northern portions of southwest Minnesota, which accumulated to 1 to 2 feet during the storm. The most persistent snowfall occurred for areas west to north of Sioux Falls, but even there, a brief period of freezing rain or sleet occurred at some point ahead of the main upper trough passage.<br><br>Ice accumulation and near blizzard conditions led to a shutdown of government offices and schools, and travel was not recommended due to the extremely hazardous conditions. A period of freezing rain, sleet and snow resulted in ice accumulations starting the afternoon of April 10 through early April 11 of one-third to one-half inch. As winds increased and gusted as high as 59 mph at Sioux Falls, widespread power outages resulted as power poles snapped and transmission lines were downed. Several communities were without power at times between the evening of April 10 and April 12, including Marion, Parker, Dolton and Viborg. At the peak, electric companies and cooperatives estimated as many as 25,000 customers were without power. Many areas were without power for a day or two due to the intensity of the storm. |
| January 1, 2017 | A couple became stranded northeast of Eagle Butte on Jan 1st in snow and low visibility when their vehicle went into the ditch. It was very cold when the couple decided to walk to safety with both of them freezing to death. A command center was set up with a large search and rescue operation occurring. Multiple search parties along with a helicopter were dispatched. The woman was located within 48 hours while the man was not located until nearly a month later. |
| December 25, 2016 | **Severe Winter Storm and Snowstorm (FEMA-4298-DR)**<br><br>An intense storm system moved across the Northern Plains, producing snow and strong winds across much of western South Dakota. Areas of freezing rain, freezing drizzle, sleet, |

| Date | Comments |
|---|---|
| | and snow developed over the area in the morning, before changing to snow. Snowfall was heaviest during the late afternoon and nighttime hours. Four to eight inches of snow were reported across much of western South Dakota, with local amounts as much as a foot. Embedded thunder was also noted with the precipitation. Strong winds developed late in the day and continued into the next morning, with blizzard conditions across much of the western South Dakota Plains. Interstate 90 was closed for a prolonged period from the Wyoming border to Chamberlain. Rural electric systems sustained significant damage to poles and wires due the snow, ice, and wind. A man died as he tried to walk home after his pickup truck went into a ditch. This storm resulted in a major disaster declaration for 24 counties. The NCEI records identifies $13,311,000 in combined property damage. FEMA Public Assistance totaled $9,632,647 for the event (federal share). |
| October 3-5, 2013; declared Nov 8, 2013 | Severe Winter Storm, Snowstorm, and Flooding (**FEMA-4155-DR**)<br>A multi-day blizzard in October 3-5 caused damage to public utilities, primarily in the western portion of the state. |
| April 8-10, 2013 | **Severe Winter Storm and Snowstorm (FEMA-4115-DR)**<br>A large spring snowstorm dumped heavy snow over most of western South Dakota April 8-10, 2013. The final NWS storm report showed that Deadwood received 30 inches of snow during the storm and Rapid City received 28.2 inches for some of the highest snowfalls in the State. April 2013 ended up being the snowiest month on record for South Dakota with 39.5 inches total, beating the previous record of 38.5 inches set in April 1927. This storm resulted in a major disaster declaration for seven counties. |
| January 17, 2011 | Northwest winds caused blowing and drifting snow over an area which extended from Brookings County into southwest Minnesota. Cold temperatures and wind chills approaching 20 degrees below zero developed during the event and continued through the night as the winds and blowing snow slowly decreased. There was a fatality from exposure in Brookings County during the event. A 65-year-old woman died of exposure after she left her vehicle which had become stuck in drifts on a township road near Elkton. |
| January 9, 2011 | Snow produced heavy accumulations of 8 to 10 inches in an area near the Missouri River in southeast South Dakota during a 24-hour period beginning in the late afternoon of January 9th. Lesser accumulations of 4 to 8 inches were reported further north and west in southeast South Dakota. An exposure fatality was reported in Sioux Falls during the snowfall. A 70-year-old woman died after wandering away from her assisted living facility at night. Wind chills at the time varied from zero to 5 above. |
| December 23, 2010 | An upper level disturbance passed over the region during the night and early morning, bringing milder air over cold air at the surface. Light freezing rain developed over western South Dakota, mixing with snow and sleet at times. The heaviest freezing rain fell across southwestern South Dakota, including the Black Hills, where as much as a quarter inch of ice accumulated. Roads became ice covered and caused many accidents during the morning. A total of $475,000 in damages (2010$) resulted from this event. NCEI did not record any injuries or fatalities. |
| December 10, 2010 | Snowfall ranging from 2 to 8 inches was accompanied by sustained northwest winds which reached 40 mph at times, with gusts as high as 55 mph. The snowfall, strong winds, and existing snow cover resulted in widespread blizzard conditions. Travel was made impossible in much of the area. There were several accidents and vehicles going into ditches, attributed to slick roads and low visibilities. Several motorists were stranded. Businesses were forced to close, and several school and other weekend activities were cancelled or postponed. |
| April 2, 2010 | **Severe Winter Storm (FEMA-1914-DR)** |

| Date | Comments |
|---|---|
| | The April 2, 2010, blizzard caused an estimated $1.6 million in damage in the three-county area. A band of heavy snow set up across Corson and Dewey Counties during the early morning hours of April 2nd. Along with heavy wet snow, northwest winds gusting up to 40 mph developed. By the time the snow ended in the late morning hours, 6 to 8 inches of snow had fallen. The heavy snow, combined with the strong winds, downed many power poles across the region along with making travel treacherous. Some snowfall amounts included: 4 inches at Eagle Butte; 6 inches at Timber Lake, McLaughlin, and 14 miles north of Isabel; 7 inches at Isabel and 6 miles southeast of McIntosh; 8 inches southwest of Keldron. Heavy snow and strong winds knocked down power lines and poles, cutting off electricity to more than 1,500 rural electric customers. More than 400 poles were lost to the heavy snow leaving approximately 800 people without power. Eighty linemen worked through the Easter weekend in the snow and mud. McLaughlin and Keldron were the hardest hit. Several hundred people were still without power on April 5th. Corson, Perkins, and Ziebach Counties were also among those struck by a late-January ice storm that qualified them for an earlier presidential disaster declaration. Some of the power lines damaged by the April storm had just been repaired from damage caused by the January ice storm. |
| January 20-26, 2010 | **Severe Winter Storm (FEMA-1887-DR)**<br><br>A powerful storm struck the northeast half of the State. The storm began with rain, turning to sleet, followed by heavy snow. Winds of up to 60 mph accompanied the storm. Power lines burdened by ice after several days of heavy fog began snapping and falling. FEM Electric lost over 4,300 utility poles in Edmunds, Faulk, McPherson, and Potter Counties. Customers of 1,600 meters were without power for 13 days. One customer was poisoned from inhaling generator exhaust. FEM Electric's business and economic impacts were estimated at $40,000,000, while emergency repair and restoration costs were estimated at $10,000,000. High winds and blizzard conditions across the eastern and north central regions of the State stalled traffic and further complicated relief efforts. Interstate 90 was closed from Chamberlain to the Minnesota border. Interstate 29 was closed from Sioux Falls to the North Dakota border. An estimated 7,600 customers across South Dakota were without power. Some phone systems also experienced outages. At least 31 emergency shelters were open across the hard-hit regions. Indian reservations were hit especially hard. The Cheyenne River Sioux Tribe had a breakdown at the water treatment plant as a result of the storm that left many residents without potable water. |
| December 23-27, 2009 | **Severe Winter Storm (FEMA-1886-DR)**<br><br>A powerful winter storm blanketed the entire State. The entire interstate highway systems were shut down for an extended period across South Dakota. Winds gusted as high as 76 mph in western South Dakota Preliminary storm totals from the State Climatologist across the State from the Christmas blizzard indicated that the large majority of the State received over 10" of snow in the storm with 20" or greater amounts in the southeast (Marion-Vermillion-Yankton), northeast (Sisseton and Clear Lake), central (Kennebec and Murdo) and northwest (Perkins County). The northern Black Hills recorded 40-50". The statewide average was 15.4". This would place it as one of the top few storms for snowfall totals statewide. |
| March 23-34, 2009 | A powerful spring storm brought rain, snow, and very strong winds to western South Dakota. Precipitation started as rain, then changed to snow, and blizzard conditions developed. The heaviest snow fell over the northern Black Hills, where 18 to 48 inches of snow was measured. Ten to 20 inches of snow fell across far northwestern South Dakota, with drifts as high as ten feet. Most other locations received at least six inches of snow. Sustained winds of 30 to 55 mph, with gusts over 80 mph, were reported. Interstate 90 and other highways were closed for more than 24 hours. Some power outages were reported, mainly across the |

| Date | Comments |
|---|---|
| | northern Black Hills and northwestern South Dakota. Tens of thousands of livestock perished. Damage estimates were slated in the millions. |
| November 5-7, 2008 | An intense fall storm brought heavy snow and gusty winds to much of the Black Hills. The heaviest snow fell across the northern Black Hills as upslope-enhanced snow fell for many hours. Snowfall amounts ranged from only a few inches across the southeastern slopes of the Black Hills to near five feet from Cheyenne Crossing to Lead and Deadwood in the northern Black Hills.<br><br>The next day, a strong area of low pressure moving across South Dakota and into Minnesota brought widespread rain, freezing rain, and snow to central, north central, and northeast South Dakota. Much of the freezing rain fell across central and north central South Dakota west of the Missouri River. As the freezing rain changed over to snow and the winds increased, the ice and snow buildup on the power lines and poles caused hundreds of power poles to break across Jones, Stanley, Dewey, and Corson Counties. East of the Missouri River, the colder air and stronger winds moved in changing the rain over to snow. Strong winds of 30 to 45 mph with gusts near 60 mph brought widespread blizzard conditions to all the area. Ice buildup from the freezing rain ranged from a tenth to as much as an inch for counties west of the Missouri River.<br><br>Snowfall amounts across the entire area generally ranged from 2 to 8 inches with a 15-inch amount recorded in southwest Corson County. Some of the snowfall amounts included: 3 inches at Eagle Butte, Blunt, Kennebec, Mission Ridge, and Onida; 4 inches at Pollock, Gettysburg, and Bowdle; 5 inches south of Harrold, Iona, and near McIntosh; 6 inches at Mobridge; 7 inches at Murdo; 8 inches at McLaughlin, and 15 inches southwest of Keldron. All 4,600 customers of the Moreau-Grand Electric company lost power due to the storm. The last time this occurred was during the winter of 1967-68. The monetary loss to this cooperative and other electric cooperatives for Jones, Stanley, Corson, and Dewey Counties was in the hundreds of thousands of dollars. There were over 100 line workers working countless hours with crews coming from as far away as Nebraska and Iowa to assist in the power recovery. Over 1,000 customers were without power for an extended period of time. Cell phone coverage was also knocked out for parts of the West River area due to downed towers.<br><br>The blizzard resulted in numerous schools, business, and road closures along with flight cancellations. Interstate-90 was shut down from Mitchell, South Dakota to the Wyoming border from Thursday the 6th until Friday evening of the 7th. Many semi-trucks and cars were stranded along the interstate with many people being rescued. Many travelers took shelter in Murdo, Chamberlain, and Pierre until the interstate reopened Friday evening. There were also several accidents across the area with a serious accident in Walworth county on Highway 83 near the Potter county line. In the early afternoon hours of Friday, the 7th, slippery roads, high winds, and low visibilities contributed to the rollover of a passenger van carrying seven students. The passenger van rolled several times causing serious injuries to three of the students. Also, a semi-truck rolled over on an icy and snowy Highway 45 south of Miller in the late afternoon hours of the 6th. The driver received minor injuries. The governor declared a state of emergency on the 7th, and President Bush declared South Dakota a disaster area. |
| April 25-26, 2008 | A strong low-pressure area brought widespread heavy snow of 6 to 20 inches to most of northeast South Dakota for much of the 25th and into the early morning hours of the 26th. The precipitation began as light freezing rain in the early morning across parts of the area before changing to all snow by mid-morning. As the low-pressure area intensified, snowfall rates and the north winds also increased. The heavy snow combined with the strong winds created widespread visibility problems along with large snowdrifts. Snowfall amounts included, 6 inches at Andover, Britton, Gann Valley, and 15 miles south of Miller, 8 inches at |

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| | Roy Lake, 9 inches at Clark, Big Stone City, Hillside Colony, and Sisseton, 10 inches 7 miles south of Bristol, and 11 inches at Hayti. Locations with a foot or more of snowfall included, 12 inches at Wilmot, Webster, and Waubay, 13 inches at Milbank, 15 inches at Castlewood, 16 inches near Victor, and near Summit, 17 inches at Clear Lake, 19 inches at Watertown, and 20 inches at Bryant. There were a number of automobiles that went into the ditch along with many other automobiles damaged in accidents. Many stranded motorists had to abandon their vehicles in the hardest hit areas. Travel was not advised across the entire area. A school bus slid into a ditch east of Castlewood with no injuries occurring. Interstate-29 was closed from 3 pm the 25th until 3 pm on the 26th from Brookings north to the North Dakota border. In addition, South Dakota State Highway 12 was closed from Webster to the Minnesota line from the afternoon of the 25th until the late morning of the 26th. Most counties affected by the storm opened emergency shelters when Interstate 29 was closed to house stranded motorists. Also, many schools were closed across the area. The very heavy snow set several records across the area. The 19 inches at Watertown broke its all-time 24-hour snowfall record of 16 inches. Both Victor and Clear Lake had their second highest snowfall ever recorded in a 24-hour period. Watertown, along with several other locations in northeast South Dakota, received near record or record snowfall for the month of April. In fact, Watertown's 29.5 inches of snow for the month of April was almost their seasonal normal snowfall. This event was also declared a disaster by the President. |
| March 1, 2007 | In southeast South Dakota, four to eight inches of snow was accompanied by sustained winds of over 30 mph at times with gusts over 40 mph. The combination of new snow, wind, and existing fresh snow cover resulted in a blizzard with widespread near zero visibilities. Drifting snow made travel extremely difficult to impossible. As a result, some who did attempt to travel became stuck or slid off roads. Schools and school activities were cancelled, and numerous businesses closed. |
| April 18-20, 2006 | **Severe Winter Storm (FEMA-1647-DR)**<br><br>The strongest storm of the 2005-2006 winter brought heavy, wet snow to northwestern South Dakota and the Black Hills and heavy rain across southwestern and south-central South Dakota. Reported snow totals included 10 to 24 inches in northwestern South Dakota, 16 to 30 inches in the Bear Lodge Mountains, 40 to 70 inches in the northern Black Hills, 74 inches in Lead, and 55 inches in Deadwood. Fifteen-foot drifts were reported on the plains of northwestern South Dakota.<br><br>Source: NWS Rapid City |
| November 27-29, 2005 | **Severe Winter Storm (FEMA-1620-DR)**<br><br>This storm brought snow and ice to the State. It was one of the worst ice storms in the State's history. Snowfall accumulations in central South Dakota ranged from 2 to 20 inches. Strong northwest winds of 30 to 50 mph with gusts to 70 mph caused widespread blizzard conditions. Visibilities were reduced to zero across the area with snowdrifts of 5 to 10 feet high in some places. Freezing rain occurred before the snow in some areas coating objects with up to three inches of ice and causing power outages. Some power lines were also brought down by snow and ice accumulation and high winds. Tens of thousands of households and businesses lost power from one day to up to two to three weeks in some rural areas. One electric cooperative said it was the worst damage they had in their 65 years of existence. Bon Homme Yankton Electric Association had 455 broken poles, 82 cross arms, and numerous line breaks. 509 customers were affected. The last line was turned on 8 days after the start of the storm. Consumers experienced roughly 118.1 hours or 4.9 days without power. Emergency repair and restoration costs were estimated at $352,323 with $282,538 in federal and state disaster relief funding. |

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| | Many roads, including Interstates 90 and 29 were closed due to the treacherous travel conditions. Several accidents occurred during the storm, killing two and injuring others. Many motorists were stranded. Several people had to be rescued. Air traffic was also brought to a halt across much of the area. Schools, businesses, government offices, and many other organizations were closed. Minor damage was caused to homes and vehicles by the strong winds and by windblown debris, mainly from trees. A 79-year old man died from exposure in Douglas County.<br>Source: NCEI and SHMT |
| April 2000 | **Winter Storm (FEMA-1330-DR)**<br>From April 19-20, a severe spring storm consisting of rain, heavy snow, and very high winds struck seven western counties of South Dakota. The storm's greatest impact was on the electrical power system. One to three feet of heavy, wet snow coupled with ice and high winds caused significant damage to three rural electric cooperatives, resulting in widespread power outages to homes and businesses. The power providers reported that over 1,500 power poles were damaged or destroyed. Eligible damage to public infrastructure was estimated at approximately $2,500,000. |
| April 1997 | An ice storm that affected Edmunds and McPherson Counties damaged 400 utility poles and caused 1,500 wire breaks. FEM Electric customers on 600 meters were without power for seven days. Business and economic impacts of this storm were estimated at $3,000,000 and emergency repair and restoration costs were estimated at $1,000,000. |
| January 1997 | **Severe Winter Storms/Blizzards (FEMA-1156-DR)**<br>All counties were declared disaster areas. Twice in a seven-day period in early January, cold Arctic air swept down and "froze" the State. The governor closed the interstates for public safety. More than 36,000 head of cattle perished. Roads were blocked or covered by 20-foot drifts of snow. Fifteen days after the storm ended, some roads were still blocked by snow. The Day County highway superintendent reported 20- and 40-foot vertical drifts blocking the highway. Livestock losses, damaged buildings, and feed shortages occurred in an area called the "red zone." This is an area of 4,722 cattle operations, 1,200 sheep operations, 1,000 hog farms, and 515 dairies along the northern third of the State west to east. The storm caused more than $30 million in damage/cleanup efforts. Three people died while trapped in vehicles along the highways. The snowmelt from this record-breaking storm was a major contributor to the flood disaster a few months later. |
| December, 1996 | Extreme cold struck portions of South Dakota. A Summit man died from exposure to the extreme cold after his vehicle became stuck in the snow. The man attempted to walk for help and was found about one mile from his car in the driveway of a home about a mile and a half west and one mile south of Summit. |
| November 13-26, 1996 | A slow-moving winter storm with severe snow and freezing rain entrenched itself over much of the State. The effects of the storm were felt primarily in the Black Hills and southeastern portions of the State. The storm was a result of a strong system of cold air, hovering close to the ground, with a system of warm air above. This combination made for rain, fog, and snow that quickly turned to damaging ice. The snow and ice formed and amassed on roadways, trees, electric transmission lines, and power poles. Some power lines were swollen by ice to five inches in diameter. The excessive weight and severe wind conditions snapped lines and flattened poles. Thousands of pole braces, crossarms, and anchors cracked under the heavy stress. Six rural electric cooperatives, affecting approximately 10,700 customers, experienced serious outages due to the loss of poles, braces, lines, crossarms, anchors, and substation failures. Customers were without power in subfreezing temperatures for several hours to several days. The force of the storm caused major delays on Interstates 90 and 29. Portions of |

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| | state and county highways and roads were closed for an extended period of time due to heavy ice and snow accumulation and extremely poor visibility. |
| October 22-24, 1995 | **Ice Storms (FEMA-1075-DR-SD)**<br><br>Between October 22 and 24, 1995, a severe autumn snow and ice storm caused widespread damage in South Dakota. Effects of this storm were felt first in the Black Hills. Portions of the hills received up to 22 inches of snow. As the storm moved across South Dakota, ice and 5 to 15 inches of wet snow covered trees and electric lines and poles. Winds associated with the storm caused lines to slap together and poles to fail, producing widespread power outages to large portions of rural South Dakota. Tree damage also led to significant damage to electrical utilities.<br><br>Thirteen rural electric cooperatives reported damage from this storm. The cooperatives lost nearly 9,500 poles and 170 transmission lines. Damage was estimated at $10 to $10.3 million to rural electric infrastructure only. Approximately 30,290 households were affected by the power outages. Crews from electric cooperatives in South and North Dakota, Minnesota, Iowa, and Nebraska assisted local cooperatives with line repairs.<br><br>The power outages also caused several rural water system pumping stations to go off-line, causing a loss of water utilities to members of rural water systems. The National Guard provided generators to power these pumping stations to restore water service.<br><br>This storm also forced major transportation delays as portions of Interstates 90 and 29 had to be closed because of the snow accumulation on the roadway and poor visibility. One of these interstate closings led Davison and Codington counties to initiate their sheltering plans for travelers who could not find rooms at local motels. The storm also caused numerous cancellations and delays in school openings because of travel conditions or the lack of power. Interstate traffic was restored by early October 24.<br><br>Twenty-eight counties were included in the disaster declaration: Aurora, Beadle, Bon Homme, Brookings, Brule, Buffalo, Charles Mix, Clark, Codington, Davison, Day, Deuel, Douglas, Grant, Gregory, Hamlin, Hanson, Hutchinson, Jerauld, Kingsbury, Lake, McCook, Marshall, Miner, Roberts, Sanborn, Spink, and Tripp Counties. |
| January–February 1995 | **Severe Winter Storms (FEMA-1045-DR)**<br><br>Damage to electric power lines in 21 counties was caused by an unusually foggy January weather. Continuous fog in many areas resulted in a heavy crust of ice forming on many of the power lines in central South Dakota. The fog-crust was reported to be three to five inches in diameter. The addition of high winds caused power poles to snap. Deep drifts of snow made it difficult for power company linemen to gain access to the damaged power lines, and in many areas, county snow removal equipment was required to provide access. According to reports, 13,435 households were without power for varying periods of time. The maximum time without power was 12 days. Early damage was estimated at more than $3.2 million. More than 1,700 power poles had to be replaced. |
| November–December 1983 | Weeks of subzero temperatures preceded the actual blizzard and set the stage for the deadly combination of cold, blizzard conditions, and loss of electrical power. A series of winter storms struck South Dakota in late November and throughout December. The impact was felt statewide, but it was particularly heavy on the Rosebud and Pine Ridge reservations. Cheyenne River, Lower Brule, and Crow Creek reservations were also affected, but to a lesser degree. Many of the Rosebud and Pine Ridge communities had propane fueled/heated homes. At the height of the storms, reservation roads were drifted closed and became impassible. A fuel shortage occurred when the weeks of subzero temperatures drained propane tanks faster than normal. Tribal governments opened community shelters for those who could make it to the shelters. As conditions worsened, fuel contractors could not start |

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| | their delivery vehicles and roads were increasingly impassible. County and tribal government snowplows were overwhelmed by the enormity of the task. One death resulted from these storms. |
| October 9, 1981 | The entire Black Hills area was virtually paralyzed by three to six feet of heavy snow and 40 to 70 mph winds. Roads were totally blocked, trees and power lines broken, and some homes sustained heavy damage. Not only were the northern hills residents isolated, but some were also without water and power for at least three days, causing food spoilage. |
| March 29, 1981 | A winter storm front created a tornado near Martin, which destroyed a mobile home and injured one occupant. By 3:00 a.m. on March 30, the storm was generating 50 to 80 mph winds and dumping up to 10 inches of heavy, wet snow in the northwest. Power lines and at least 1,500 poles in the northwest were snapped after being coated with one to six inches of ice. Strong winds also snapped power lines and poles in south central South Dakota. These winds overturned trucks and cars along Interstate 29. The winds also overturned a railroad tank car, spilling phosphoric acid. This accident forced the evacuation of part of Garretson. |
| January 1981 | A series of storms blocked the majority of roads in eastern South Dakota, overturned vehicles, and stranded hundreds of motorists. The severity of these storms caused four deaths in vehicles stalled in the deep snow. |
| 1977 | February, March, and November were especially active months for winter storms. Many rural roads were blocked with snow drifts six to eight feet high. Interstate 90 was often blocked and up to 100 cars were stranded. Six people died as a result of these storms. In addition to power outages reported in various part of the State, the March storm dropped over an inch of rain in the eastern part of the State and generated walnut size hail in Grant County. In November, a winter storm toppled a 1,400-foot television tower and derailed six freight cars. |
| January 1975 | Of the two blizzards in 1975, the one on January 11 and 12 was the worst. High winds exceeding 60 mph, subzero temperatures, and heavy snow combined to produce killer conditions. Several people died, and thousands of head of livestock perished in eastern South Dakota. |
| March 1969 | Heavy snowfall and high winds knocked out power in the Aberdeen area. Rural residents were hard hit as blocked roads prevented early power line repair. The Belle Fourche area also sustained loss of power and phone service as hundreds of poles were knocked down. |
| March 1966 | This storm moved into eastern South Dakota and remained stationary for 12 hours. Winds of 60 to 70 mph were common. Gettysburg had gusts up to 100 mph. The driving wet snow clung to the mouths of livestock and they suffocated. Cattle and sheep loss approached 100,000 animals with a value of nearly $20 million.<br><br>Many towns suffered physical damage from the storm. A total of 380 people in Pierre had to be evacuated as the result of a power failure. Many towns lost phone service, and some communities had windows shattered by high winds, allowing snow to drift into buildings. A 121-car train was completely stopped by snow drifts. This storm killed 10 people. |
| December 1965 | An ice storm destroyed an estimated 3,500 telephone poles in the Aberdeen area. Damage was nearly $650,000. Total damage to light and power systems approached $1 million. At the time, this was the worst ice storm experienced in 40 years. |
| January 1952 | The temperature dropped from 40°F to -8°F in a short period of time. The wet, driving snow clung to everything. Cattle were blinded and suffocated as snow covered their mouths and noses. Young country school children lost their way home and died of hypothermia. A few ranchers died when they tried to gather their livestock. Snow piled up to a point that people could walk along tops of power lines. In some isolated areas, people were snowed in for four months off and on throughout the winter. Planes were used to deliver mail, groceries, fuel, |

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| | and feed for livestock. Snow track vehicles were used to transport doctors to isolated farm areas. |
| January 1949 | A blizzard affected the entire State. Blizzard conditions existed for weeks rather than days. The general weather conditions were low temperatures (-2°F to -8°F), heavy snows (24 inches for the month), and winds from 40 to 73 mph. Towns and rural areas were completely isolated as the snow blocked up everything. Roads, railroad tracks, and buildings were buried under tons of snow. People were lost in the storm and many cattle were frozen. Airplanes were used to deliver food, fuel, and medicine to stranded people. Snow was very deep in western South Dakota. Pictures of the area showed drifts 35 feet high and several thousand feet long. |
| 1943 | A blizzard killed a large number of cattle. |
| 1927 | A blizzard killed a large number of cattle. |
| May 1905 | A blizzard hit western South Dakota counties in May. Cattle wandering around in the blizzard walked off the bluffs in the Badlands area and fell to their death. Estimated cattle loss exceeded 16,000. |
| January 12, 1888 | A blizzard was preceded by 10 days of cold, snowy weather, 8 to 10 inches of new snow, and a low temperature of -28°F. The weather warmed on January 11 and 12; it was foggy and about 32°F. The temperature dropped on the afternoon of January 12 to -20°F in five minutes. The wind blew so strongly that it knocked people off their feet. Many children, sent home from school, did not make it home. The blizzard was so withering that people lost their sense of direction and wandered about until they died of hypothermia (exposure). Thousands of head of livestock and wild animals perished. Many buildings were covered with snow or destroyed, and all transportation stopped. Although the storm lasted less than one day, an estimated 400 people died throughout the Dakotas, 174 of which were in South Dakota. |

## Probability of Future Occurrence

According to the NCEI Storm Events Database, there were 2,136 winter storms (snow and ice events) recorded in South Dakota between January 1993 and December 2021, and 499 extreme cold events from January 1994 to December 2021. On average, South Dakota experiences 76 winter storms and 18 extreme cold events each year. During the same time period, 20 deaths and 127 injuries were attributed to these events. This suggests that South Dakota can expect approximately 1.4 deaths and five injuries each year. Based on this information, the probability that at least one winter storm will occur in South Dakota in any given year is 100 percent.

The following figures compare the annualized frequency, or the estimate likelihood of future cold wave, ice storm and winter storm events by county between 1996 and 2019. The figures are based on data from the NRI developed by FEMA and the number of recorded cold wave and winter storm occurrences per year over the 23-year period of record from the NRI. Because cold wave and winter storm events can occur over several days or in a single day the event-basis was used to estimate annualized frequency. Ice storm used a similar method but used an estimated number of occurrences in event-days each year for a specified area over the period of record of 23 years. In the map legend of each figure below the estimated annualized frequency by county is described.

Based on the NRI analysis, in terms of cold wave Figure 3-39, counties in the northeastern portion of state have a higher probability of an event occurring compared the rest of the state. Counites with the highest probability include Edmunds, Brown, Marshall, Day, Roberts and Grant. In terms of ice storms Figure 3-40) the southeastern portion of the State has a higher probability of an ice event. The counties with the highest probability of an ice event include Minnehaha, Turner, Lincoln, and Union. The frequency of winter

storm events Figure 3-41 is more distributed across the State compared to cold wave and ice storm events, although Lawrence County, located in the Black Hills Region, stands out as having the highest frequency of winter storm event in the State.

This distribution of winter storm hazards corresponds to the areas of highest elevation (the Black Hills Region) and the areas with the greatest moisture content (the southeast corner of the State, where terrain is peppered with lakes and streams). Cold wave trends affect the northern and northeast counties more often.

**Figure 3-39 Annualized Frequency of Cold Wave Events by County 1996-2019**

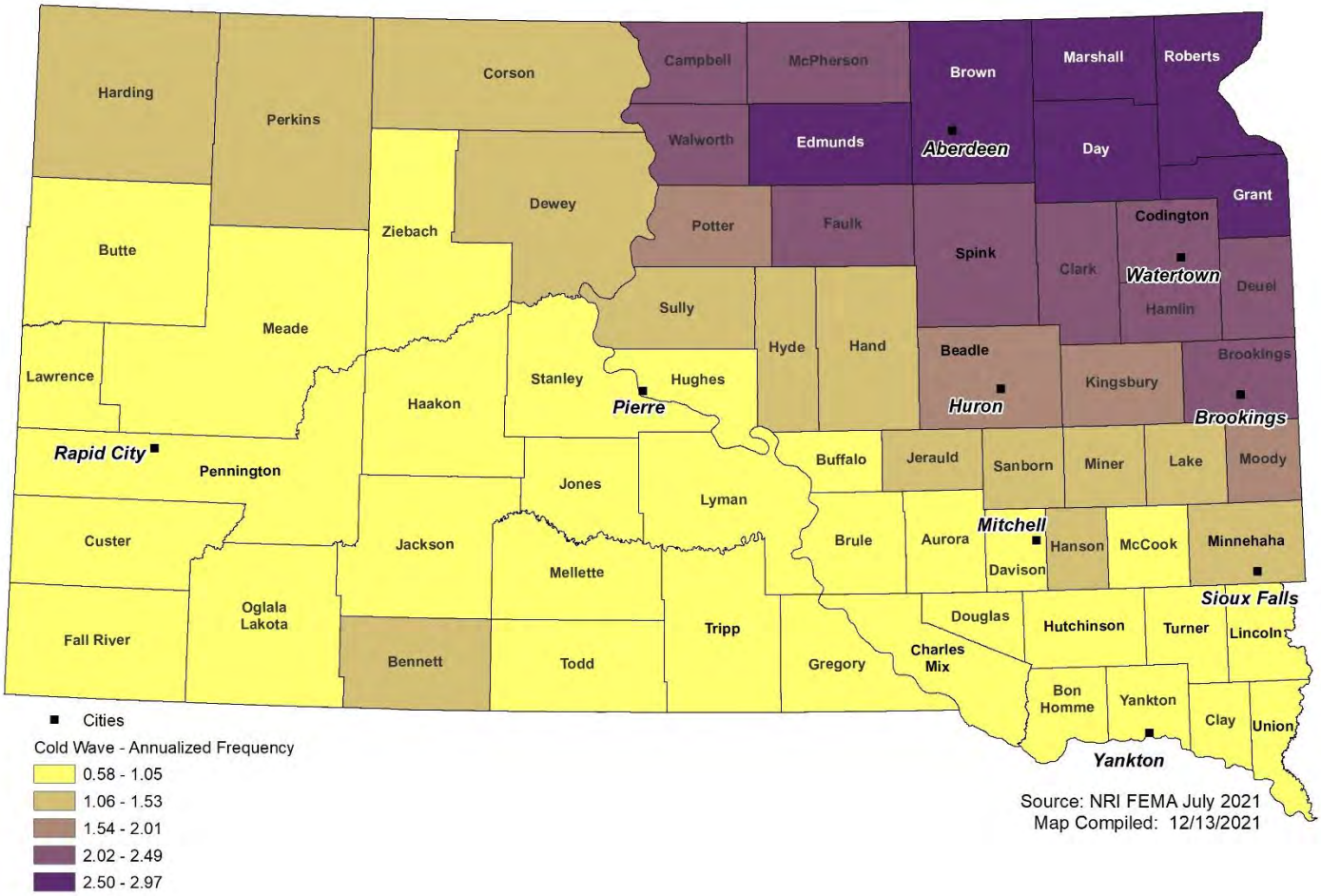


**Figure 3-40 Annualized Frequency of Ice Storm Events by County 1996-2019**

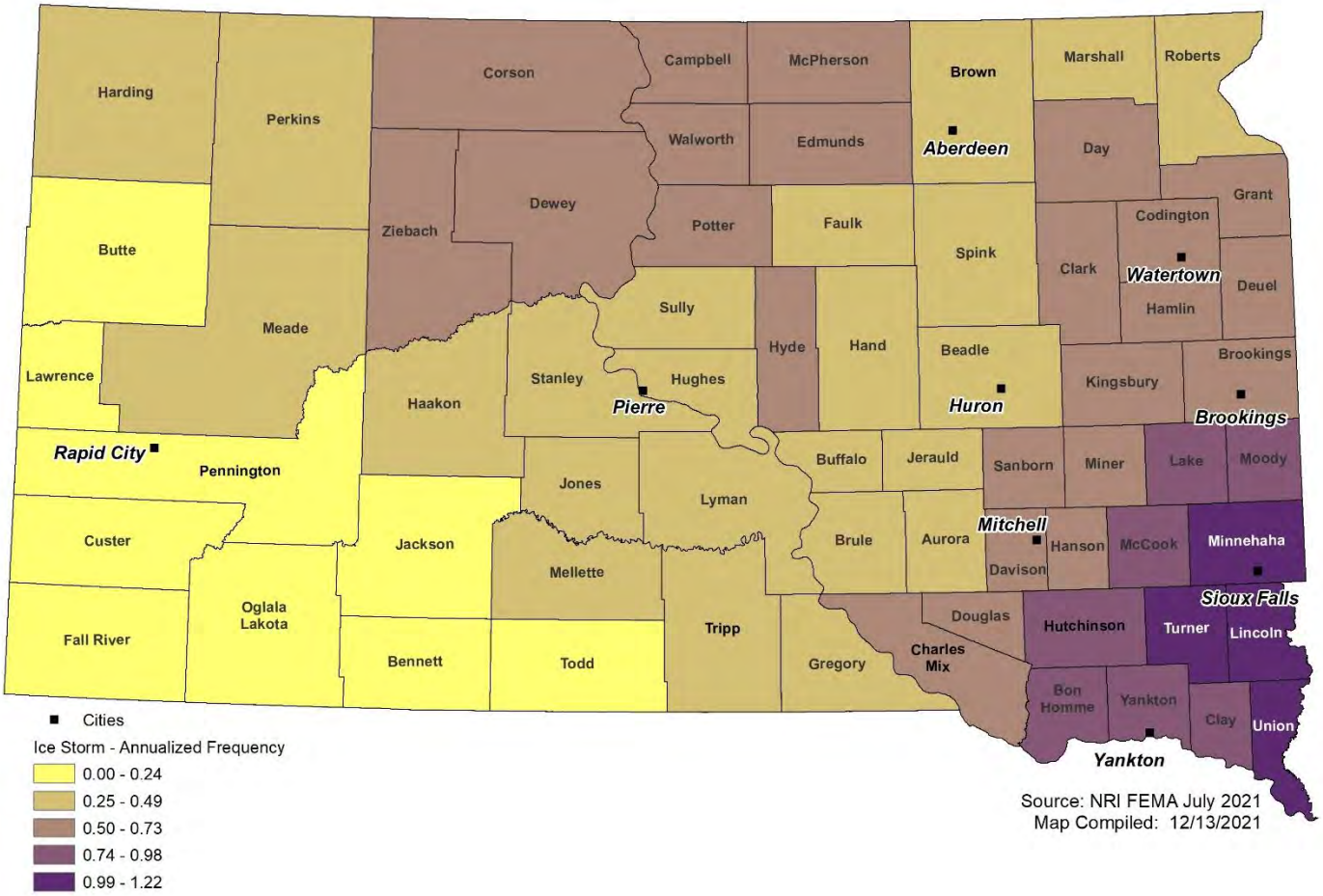
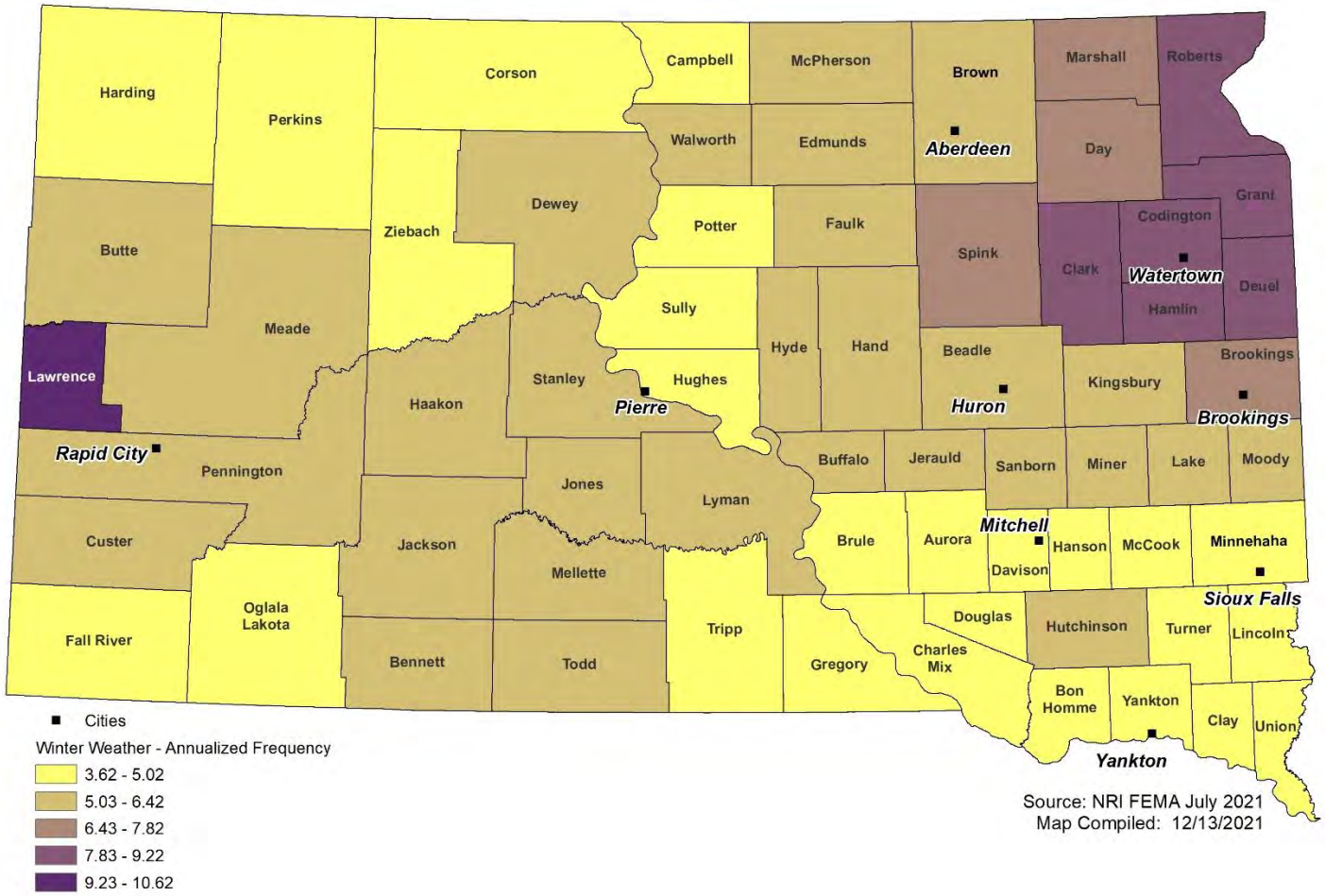


**Figure 3-41 Annualized Frequency of Winter Storm Events by County 1996-2019**




## Magnitude/Severity (Extent)

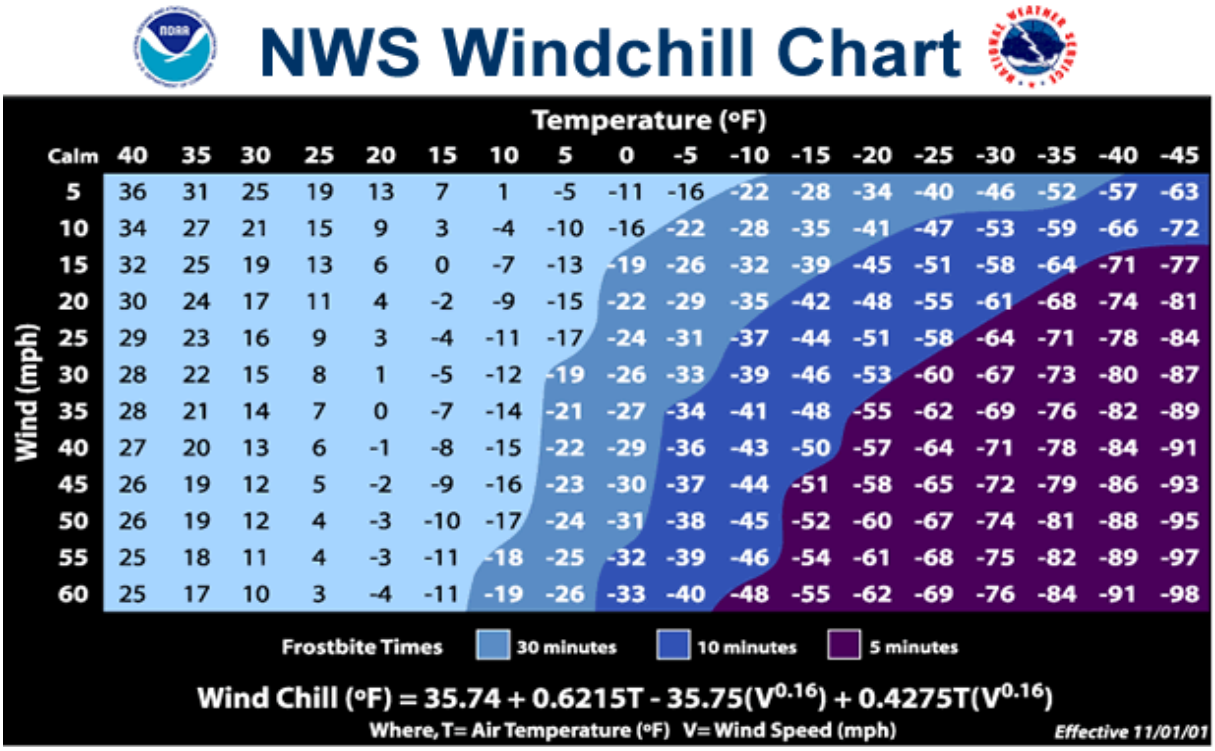
The extent rating of winter storms that cause issues in South Dakota includes storms forecasted to be Winter Storm Warnings or Blizzard Warnings. The NWS issues a Winter Storm Warning when conditions that can quickly become life threatening and are more serious than an inconvenience are imminent or already occurring. Heavy snows, or a combination of snow, freezing rain or extreme wind chill due to strong wind, may bring widespread or lengthy road closures and hazardous travel conditions, plus threaten temporary loss of community services such as power and water. Deep snow and additional strong wind chill or frostbite may be a threat to even the appropriately dressed individual or to even the strongest person exposed to the frigid weather for only a short period.

The most dangerous of all winter storms is the blizzard. A blizzard warning is issued when winds of 35 miles an hour will occur in combination with considerable falling and/or blowing snow for at least 3 hours. Visibilities will frequently be reduced to less than 1/4 mile and temperatures are usually 20 degrees Fahrenheit or lower. The blizzard marks the upper extent of severe winter storms that could be experienced in South Dakota.

In 2001, the NWS implemented an updated Wind Chill Temperature index (see Figure 3-42). This index was developed to describe the relative discomfort/danger resulting from the combination of wind and temperature. Wind chill is based on the rate of heat loss from exposed skin caused by wind and cold. As

the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

**Figure 3-42 National Weather Service Wind Chill Chart**



NWS Windchill Chart

| Wind (mph) | Temperature (°F) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Calm | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 | -10 | -15 | -20 | -25 | -30 | -35 | -40 | -45 |
| 5 | 36 | 31 | 25 | 19 | 13 | 7 | 1 | -5 | -11 | -16 | -22 | -28 | -34 | -40 | -46 | -52 | -57 | -63 |
| 10 | 34 | 27 | 21 | 15 | 9 | 3 | -4 | -10 | -16 | -22 | -28 | -35 | -41 | -47 | -53 | -59 | -66 | -72 |
| 15 | 32 | 25 | 19 | 13 | 6 | 0 | -7 | -13 | -19 | -26 | -32 | -39 | -45 | -51 | -58 | -64 | -71 | -77 |
| 20 | 30 | 24 | 17 | 11 | 4 | -2 | -9 | -15 | -22 | -29 | -35 | -42 | -48 | -55 | -61 | -68 | -74 | -81 |
| 25 | 29 | 23 | 16 | 9 | 3 | -4 | -11 | -17 | -24 | -31 | -37 | -44 | -51 | -58 | -64 | -71 | -78 | -84 |
| 30 | 28 | 22 | 15 | 8 | 1 | -5 | -12 | -19 | -26 | -33 | -39 | -46 | -53 | -60 | -67 | -73 | -80 | -87 |
| 35 | 28 | 21 | 14 | 7 | 0 | -7 | -14 | -21 | -27 | -34 | -41 | -48 | -55 | -62 | -69 | -76 | -82 | -89 |
| 40 | 27 | 20 | 13 | 6 | -1 | -8 | -15 | -22 | -29 | -36 | -43 | -50 | -57 | -64 | -71 | -78 | -84 | -91 |
| 45 | 26 | 19 | 12 | 5 | -2 | -9 | -16 | -23 | -30 | -37 | -44 | -51 | -58 | -65 | -72 | -79 | -86 | -93 |
| 50 | 26 | 19 | 12 | 4 | -3 | -10 | -17 | -24 | -31 | -38 | -45 | -52 | -60 | -67 | -74 | -81 | -88 | -95 |
| 55 | 25 | 18 | 11 | 4 | -3 | -11 | -18 | -25 | -32 | -39 | -46 | -54 | -61 | -68 | -75 | -82 | -89 | -97 |
| 60 | 25 | 17 | 10 | 3 | -4 | -11 | -19 | -26 | -33 | -40 | -48 | -55 | -62 | -69 | -76 | -84 | -91 | -98 |

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph) Effective 11/01/01

Source: NWS

Winter storms and blizzards can result in multiple injuries and illnesses; major or long-term property damage that threatens structural stability; and/or interruption of essential facilities and services for 24-72 hours. This can include property damage, local and regional power and phone outages, and closures of streets, highways, schools, businesses, and nonessential government operations. People can also become isolated from essential services in their homes and vehicles. A winter storm can escalate, creating life threatening situations when emergency response is limited by severe winter conditions. Other issues associated with severe winter weather include hypothermia and the threat of physical overexertion that may lead to heart attacks or strokes. Snow removal costs can impact budgets significantly. Heavy snowfall during winter can also lead to flooding or landslides during the spring if the area snowpack melts too quickly and contribute to high ground water tables and seepage into foundations. High snow loads also cause damage to buildings and roofs.

## Climate Change Considerations

The winter season is warming at a faster rate than any other season in the Northern Plains Region, and this is also true for South Dakota. Winter storms and blizzards, however, will continue to be a severe weather hazard in the State. Warmer winter temperatures could mean more ice and freezing rain events, which often impact electrical utilities and communication systems, but can also affect agricultural livestock and roads and transportation. A warmer winter climate could reduce energy consumption for heating in the long run, but there will still be some periods of exceptional cold temperatures.

The northern U.S. has experienced an increase in the frequency of large snowfall events, where other places in the country have been decreasing. Some analyses have shown an increase in winter storm

frequency and intensity, with storm tracks moving northward since 1950. There remains some uncertainty in projections for the coming decades, but the rising trend of extreme precipitation events in general (including winter season) will continue to be a hazard. According to the Fourth National Climate Assessment, rising temperatures in the Northern Great Plains have resulted in shorter snow seasons and rapid melting of winter snowpack. Changes in climate conditions will also make other atmospheric conditions to become less predictable. The polar vortex is the large areas of low pressure and cold air that is constrained by a strong polar just keeping it near North Pole. The increasing in temperature difference between the mid-latitude and polar regions, weakens and destabilizes the polar jet stream allowing it to dip into lower latitudes brining extreme polar cold into the continental United States. South Dakota experienced a polar vortex event in February 2021.

## Vulnerability Assessment

While all counties in South Dakota are vulnerable to winter storms, the more developed areas, represented by greater building values and higher population densities, will generally have greater costs for snow removal and functional downtime as a result of loss of utility services. The counties with greater developed areas may have the capacity to absorb those costs more than the rural areas.

In order to analyze the State's vulnerability to winter storms, the NRI was used as a tool. The NRI defines risk as the potential for negative impacts as a result of a natural hazard and determines a community's risk relative to other communities by examining the EAL and social vulnerability in a given community in relation to that community's resilience. This composite risk rating for cold wave, ice storms and winter storm is illustrated in Figure 3-43 through Figure 3-45 below

**Figure 3-43 NRI Cold Wave Risk Rating by County in South Dakota**

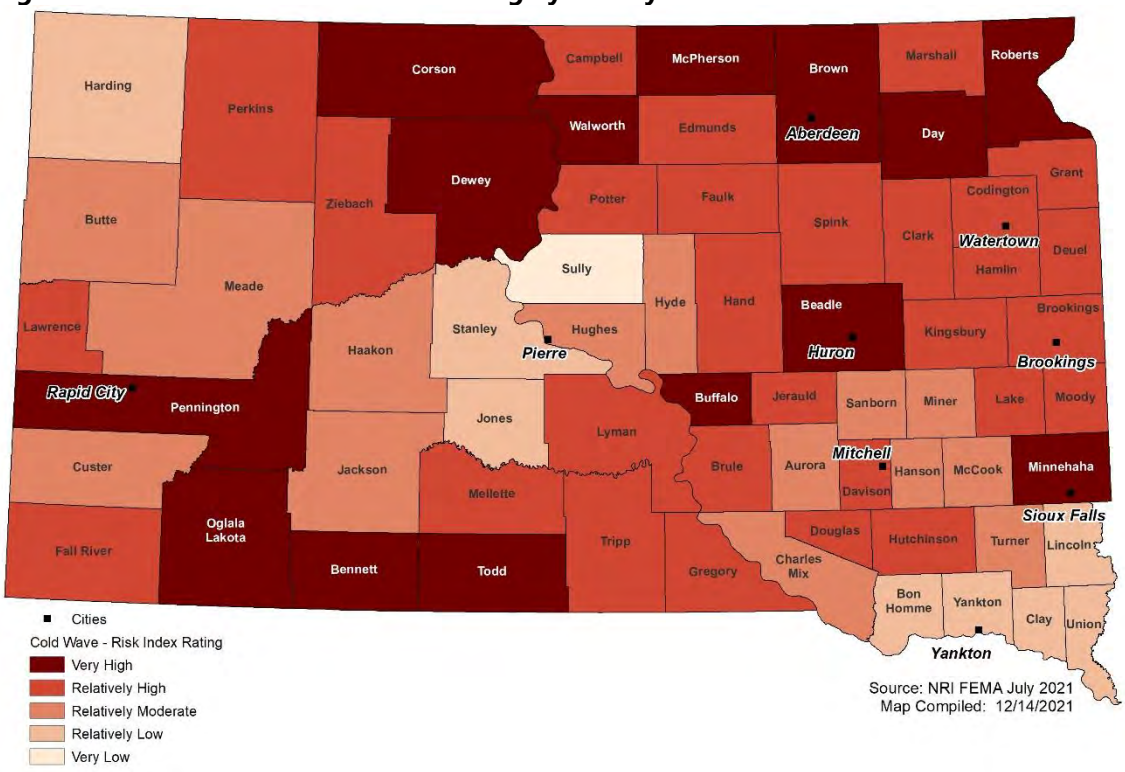


**Figure 3-44 NRI Ice Storm Risk Rating by County in South Dakota**

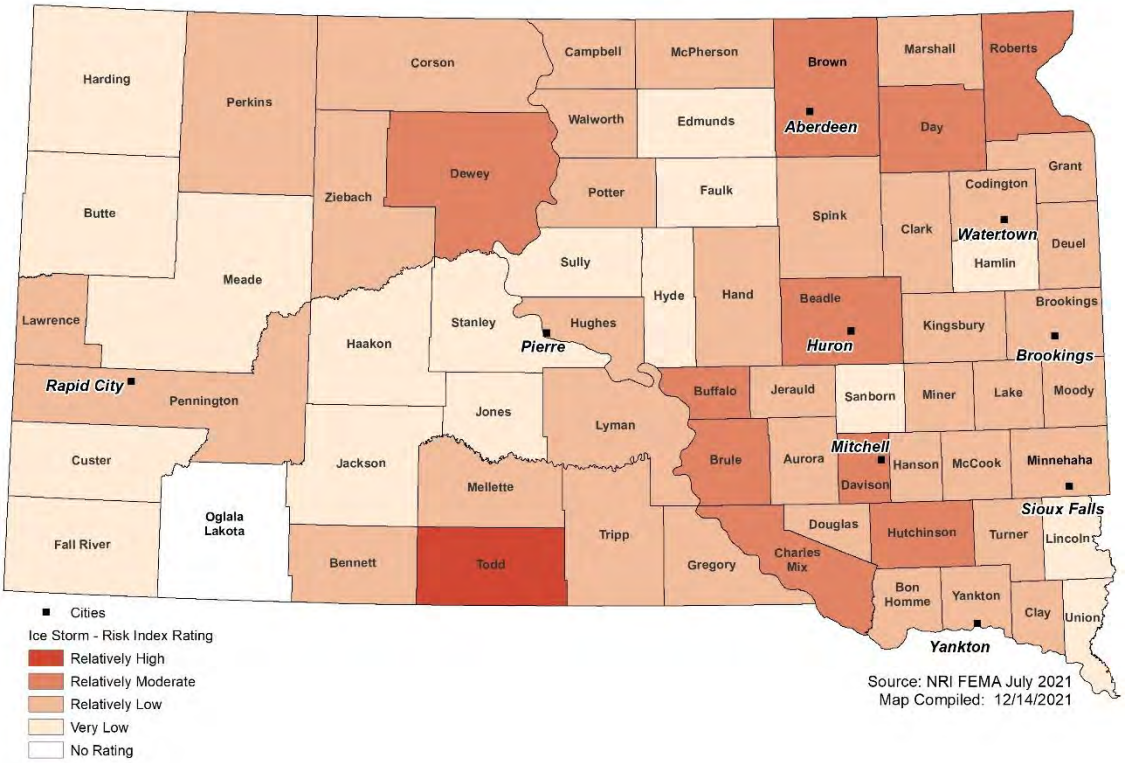
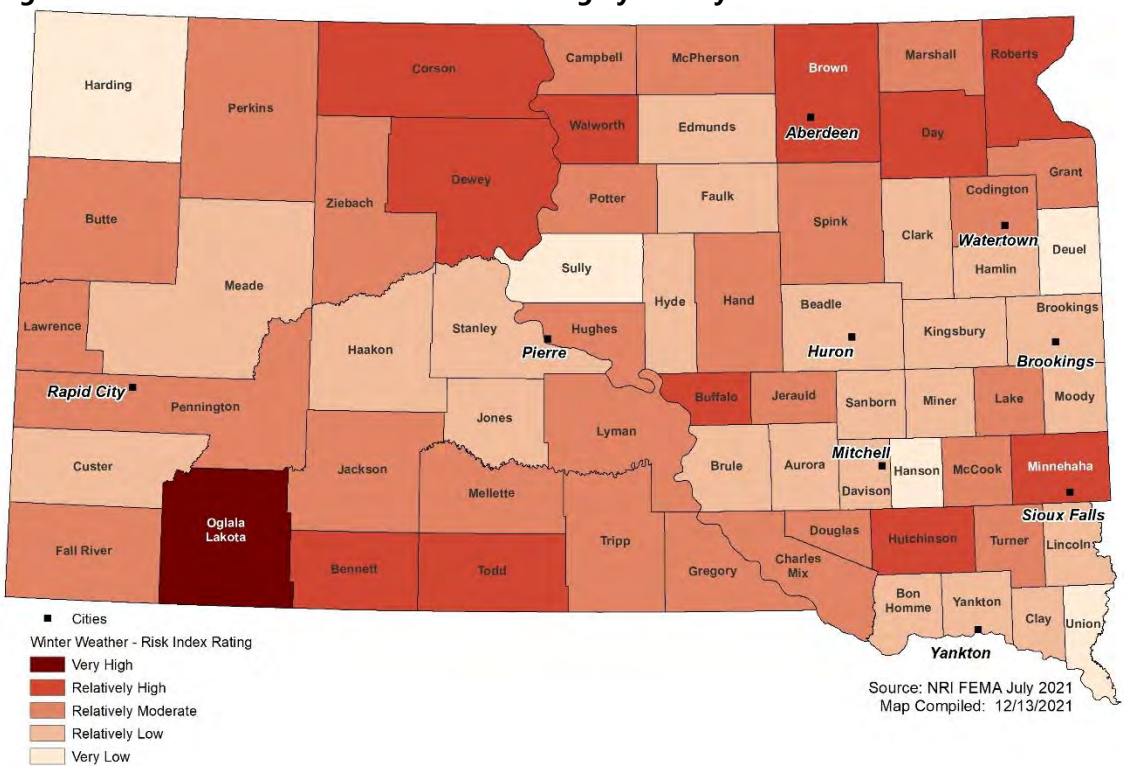



**Figure 3-45 NRI Winter Weather Risk Rating by County in South Dakota**



### *People*

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. As noted under Section 3.3.3 Summer Storm, statewide an estimated 9,922 Medicare Beneficiaries or 5% of total Beneficiaries (183,640) rely on electricity to live independently in their homes. 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.

According to the NCEI Storm Events Database South Dakota experiences an average of 76 winter storm events and 18 extreme cold events. Each year South Dakota can expect approximately 1.4 deaths and 127 injuries were attributed to winter storm and extreme cold events.

### *Property*

Property vulnerabilities to severe winter weather include damage caused by high winds, ice, or snowpack 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 snowpack is very heavy. This may create strains on structures, causing partial or entire collapses of walls, roofs, or windows and cause tree limbs to damage buildings and overhead utilities. This is a factor of 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.

Agricultural operations including crops and livestock are also highly vulnerable to severe winter storms.

To estimate potential losses to winter storms, historic loss data was analyzed. The NCEI data did not lend itself to county-by-county loss summaries, only a statewide summary, due to data tracking by forecast zones. According to the NCEI, there were 2,136 winter storms (snow and ice events) in South Dakota between January 1993 and December 2021, and 499 extreme cold events from January 1994 to December 2021. Total property damage for these events is estimated at $105 million dollars. This suggests that South Dakota averages 76 winter storms and $3.7 million in winter storm losses annually,

Figure 3-46 through Figure 3-48 shows the EAL rating due to cold wave ice storm and winter storm events for all South Dakota counties. Using data from the NRI tool, the EAL ratings are calculated using the annualized frequency and historic loss ratio for each county. With the exception of Charles Mix, Bon Homme, Yankton, Clay and Union Counties, the remaining counties in the State ranked within the relatively moderate to very high rating for expected annual losses in terms of cold wave events. Expected annual losses due to ice storms rates is relatively low to relatively moderate statewide. Brown and Minnehaha are the only counties that rate as very high expected annual losses due to winter storms, likely due to the larger populations in these areas and more development compared to the rural areas of the State.

**Figure 3-46 Expected Annual Losses due to Cold Wave Events by County**

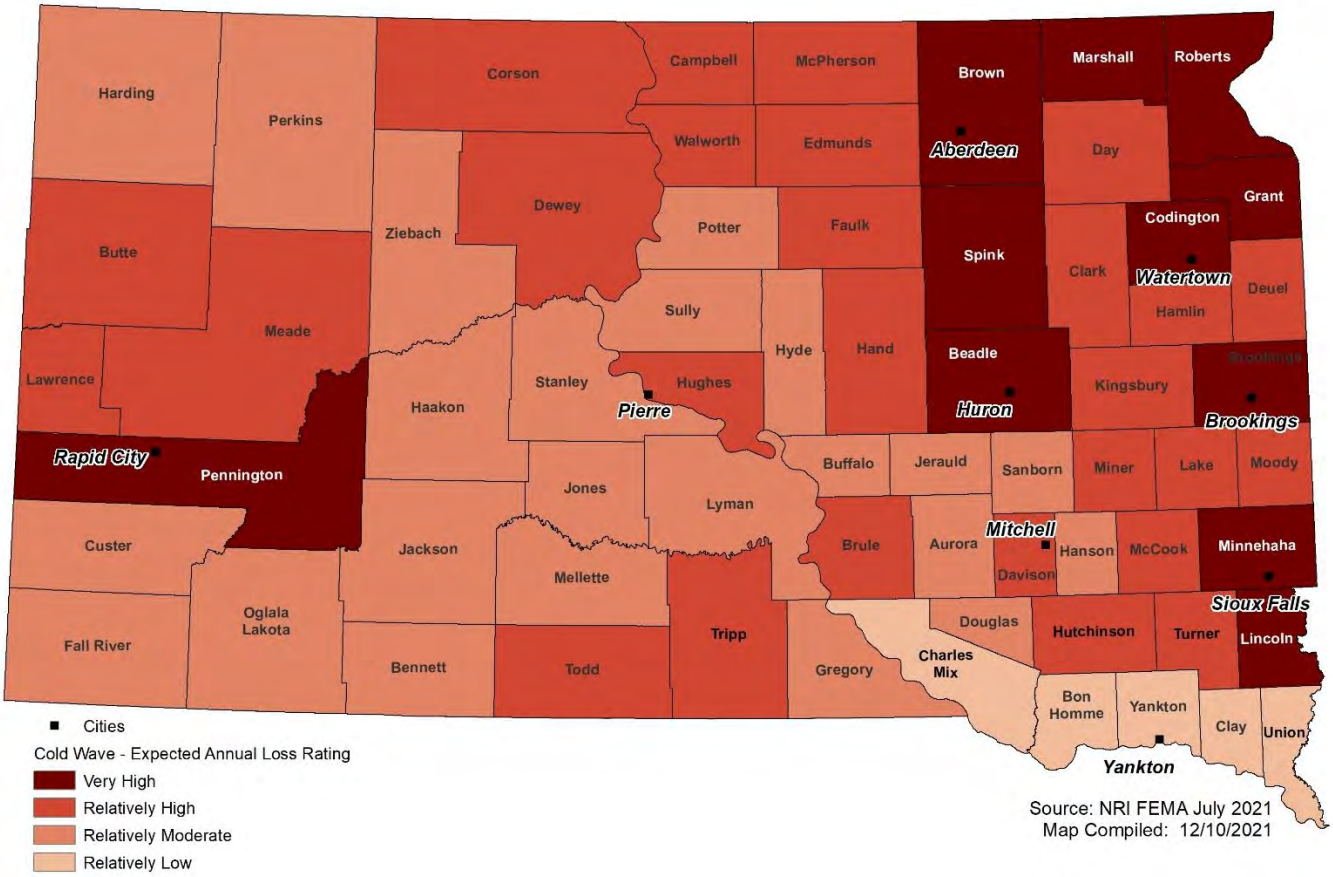


**Figure 3-47 Expected Annual Losses due to Ice Storm Events by County**

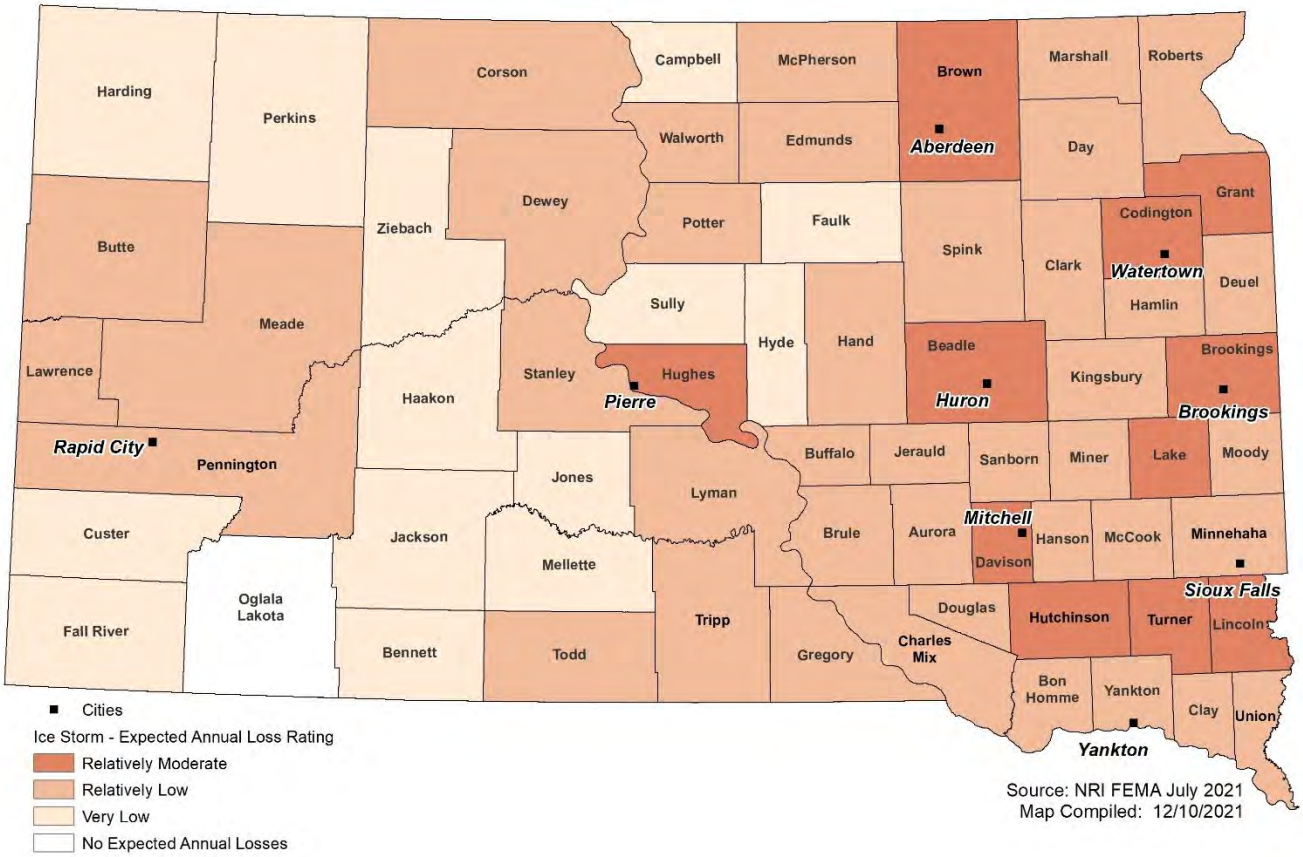
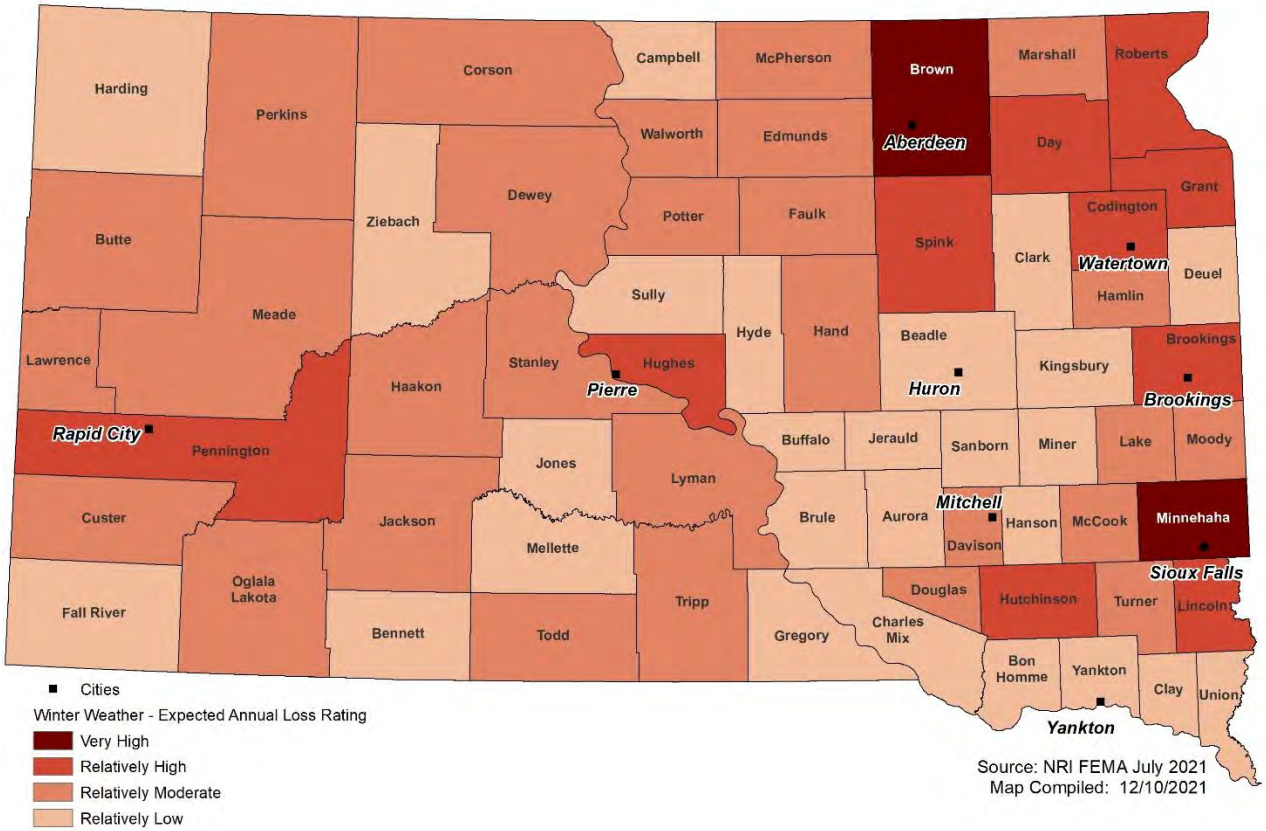


**Figure 3-48 Expected Annual Losses due to Winter Storm Events by County**




## *State Assets, Critical Facilities, and Infrastructure*

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. Ice storms or high winds in winter storms can cause extensive loss of overhead utility lines due to build up either on the lines or on adjacent trees that either collapse due to the weight or blow down onto the utility lines. Undergrounding of electric utility lines to increase power grid resiliency has been a priority of many rural electric cooperatives in South Dakota (see Rural Electric Cooperative section). Severe winter storms may even halt the operation of an area 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 State and local roadway system.

During the 2013 October blizzard, record amounts of snow developed on the SD Game Fish and Parks McNenny Fish Hatchery west of Spearfish. The excessive amounts caused the roof to fail and collapse in on itself. FEMA Public Assistance funding was used for the repairs.

## *Economy*

South Dakota's agricultural industry is also very susceptible to losses from winter weather and extreme cold. Data was obtained from the USDA RMA's indemnity reports for 2007 through 2021. The RMA identifies several causes of loss related to extreme cold and winter weather, including cold winter, freeze, and frost. South Dakota received $152,447,135 in indemnities and lost 1,596,749 acres from freeze, frost

and cold winter related events between 2007 and 2021. This averages out to $10,889,081 in winter weather-related indemnities each year.

### *Environment and Cultural Resources*

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

## Development Trends and Consequence Summary

Every county in the State is at moderate to high risk of winter storms. Despite this risk and high probability of future occurrences of a winter storm, the vulnerability to future winter storms is not likely to increase. The agricultural industry will also continue to be vulnerable to winter storms. Counties that are particularly dependent economically on crops or livestock will have a higher vulnerability to the effects of a winter storm event. Utility outages result in loss of service and direct damages and can increase risk of cold weather injuries.

All future development has the potential to be affected by severe winter storms. The vulnerability of community assets to severe winter storms is increasing through time as more people enter the certain areas of the State. Development pressures has been greatest in the southwest portion of the State which has experienced the greatest increase in housing unit development since 2010. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The adoption of the International Building Code which is equipped to deal with the impacts of severe weather events is one tools that can help counties deal with future growth and the associated impacts of severe weather.

**Table 3-37 Winter Storms Consequence Summary**

| Category | Narrative |
|---|---|
| Impact on the Public | Exposure risks to motorists, outdoor workers, homeless persons, general public; risk to persons with energy dependent medical needs and pre-existing medical conditions |
| Impact on the Economic Condition of the State | Potential loss of facilities or infrastructure function or accessibility and uninsured; impact to transportation sector and movement of goods, even if closures are not in the State itself; lost revenue to decreased business patronage or inability of workers to reach employment locations |
| Impact on the Environment | Tree and vegetation damage, crop damage; animal impacts |
| Impact on Property, Facilities, and Infrastructure | Buildings, equipment, and utility infrastructure are exposed to heavy snow and ice, sometimes complicated by strong winds; transportation system impacts; possibility of roof collapse; potential power loss and strain on energy systems; frozen pipes; limited access to or ability to maintain operations of public transportation or access to transportation hubs |
| Impact on the Public Confidence in Government | High expectations of government capabilities for reducing impact of snow and ice events related to transportation (roads, bridges, airports, rail); expectations for rapid power restoration |
| Impact on Responders | Exposure risks; adverse working conditions; buried fire hydrants |
| Impact on Continuity of Operations and Continued Delivery of Services | Potential loss of facilities or infrastructure function; potential loss of ability or accessibility to provide services; possible power interruption; transportation system impacts |
| Cascading Hazards | Wind, Floods |

### 3.3.5 Wildfire

#### Hazard Description

Wildfires are uncontrolled conflagrations that spread freely through the environment. Wildfires near populated areas pose threats, not only to natural resources, but also to human life and personal property. Natural causes, such as lightning, or human acts may ignite wildfires. Lightning remains a fixed element of the ecosystem, and human-caused fire risks continue to increase as more and more people move to and recreate in fire-prone wildland areas.

South Dakota has a history of damaging wildfires. The State's susceptibility to wildfire was recognized nationally in 1897 when, prompted by a series of large forest fires in 1893, President Grover Cleveland established the Black Hills Forest Reserve to protect the forests from fires (as well as wasteful lumbering practices).

Prior to 2010, years of drought along with extremely low percentages of normal snowpack in the Black Hills created the potential for catastrophic wildfires in South Dakota. 2015 was a dry year, thus wildfire risk returned. Compounding this situation is the impact of the mountain pine beetle on pine trees in South Dakota. The most common host is the Ponderosa Pine. This tree occurs on more than 1 million acres of forestland in South Dakota. When the beetle population is very low, only stressed or weakened trees, such as those struck by lightning or stressed by drought, are colonized. However, approximately every ten years the beetle population increases, and the beetles begin colonizing healthy as well as stressed trees. The South Dakota Department of Agriculture (SDDA) reported in 2012 that the mountain pine beetle population had reached epidemic proportions. SDDA published a Black Hills Regional Mountain Pine Beetle Strategy (2012) which proposed mitigation strategies for reducing the population to endemic levels over the course of several years. Between mountain pine beetles and dry conditions, there is great concern for wildfires in the wildland urban interface and also for agricultural and rural wildfires. Fires involving grass, prairie, or timber can cause mass destruction of property and vegetation.

South Dakota's semi-arid climate, highly flammable native vegetation, rugged terrain, and populated wildland urban interface up its wildfire make hazard.

**Topography** - The Black Hills are an outcropping of the Rocky Mountains, lying in an ellipse 100 miles long and 50 miles wide along the State's western edge. In the Black Hills, terrain varies from broad, open valleys; rolling topography; mountainous terrain up to 7,242 feet in elevation; and steep, narrow canyons.

**Fuels** - Fuels are generally conducive to high rates of spread, represented by National Fire Danger Rating System fuel models "G", "L," "K," and "C." Grass predominates in the broad valley bottoms. Ponderosa Pine grows on all aspects, and extensive pure forests of Ponderosa grow in the Black Hills. Mixed grass and timber stands occur in many areas depending on aspect. Fuel loading is lightest in the southern Black Hills and heaviest in the northern Black Hills.

**Weather** - During the summer months, temperatures are often in the 90s and low 100s with relative humidity in the teens. The average annual precipitation is approximately 17.5 inches. Some of this precipitation comes in association with thunderstorms that bring lightning during the fire season.

Lightning fires tend to burn more acreage than human-caused fires, in part, because 1) multiple lightning fire ignitions often occur at the same time; 2) lightning fires can occur throughout the protection area, while most human-caused fires occur in accessible areas; 3) people often detect and report human-caused fires quickly due to their proximity to inhabited areas; and 4) lightning producing thunderstorms typically occur during the hottest portion of the fire season, while many human-caused fires start during spring or fall.

**Conditions** - The Black Hills ecosystem is fire adapted, having evolved with fire and fire dependent plant species. The forests of the Black Hills are very different from pre-settlement times when frequent, low-intensity fires maintained a healthy forest structure. Ponderosa Pine is adapted to benefit from frequent, low-intensity fires started in summer by lightning. Historically, these fires killed smaller plants that competed with the pines for moisture and released nutrients from litter on the forest floor. These fires also prevented accumulation of fuels that feed severe fires, which can destroy the thick-bark defense of the trees.

Today, the forest contains many more trees per acre and much more undergrowth, needle litter and deadwood than it did historically. Under these circumstances, when wildfires occur under dry, warm, and windy conditions, they will frequently develop into uncontrollable crown fires that destroy the forest and any homes within it.

Mountain pine beetle attacks in Ponderosa Pine often coincide with abundant weak trees resulting from drought and overgrown conditions. These circumstances have been common throughout the Black Hills and have allowed a mountain pine beetle infestation to become epidemic. The Custer State Park area around Harney Peak, and the Norbeck Wildlife Preserve adjacent to Mount Rushmore has extremely high fuel loading due to mountain pine beetle outbreaks.

**Wildland Urban Interface** - Wildfires destroy hundreds of structures throughout the western United States every year. These fires can and will occur anywhere that humans and their development meet or intermix with wildland fuels. This wildland urban interface fire problem exists in every state, including South Dakota, and worsens each year. People continue to develop residential properties in fire-prone environments, increasingly exposing themselves and their personal property to the risks of wildfire. Fire and resource management professionals know that wildland urban interface development can draw the efforts of firefighters away from protecting the natural resources, whose stewardship they are charged with.

## Location

Early writings by explorers, trappers, and settlers often describe South Dakota as a sea of waving grass. The descriptions would not be valid today for the eastern half of the State. The more fertile and climatically desirable prairie of the eastern portion is now used for crop production. But the wild prairie still exists in the western part of the State. South Dakota's portion of the Great Plains now exists from the foothills of the Black Hills to the western boundary of the Missouri River. This amounts to nearly 35,000 square miles of land, which is used primarily for livestock grazing and some wheat and small grain cultivation. For most of the year, this area is at risk to wildfires because of the nature of the ground cover and the limited precipitation.

Although wildfires occur throughout the State, the grass and forestland areas west of the Missouri River represent the area most prone to large wildfires. This area remains vulnerable due to the large areas of continuous fuels and the extreme burning conditions that occur in the area. The area of the State known as the Black Hills has the highest potential for loss of lives and personal property from wildfire. After years of fire suppression, the landscape of the Black Hills has become a dense forest. High fuel loads, years of drought, and mountain pine beetle infestation have combined to make the area particularly susceptible to wildfire. Between 2000 and 2002, 10 percent of the Black Hills National Forest burned (see Past Events) (U.S. Forest Service, Spearfish, South Dakota, and the Northern Black Hills: Steps to Improve Community Preparedness for Wildfire).

The Black Hills National Forest encompasses 1,534,471 acres of land in South Dakota and Wyoming. Over one million acres of the forest are exclusively in South Dakota (Custer, Fall River, Lawrence, Meade, and

Pennington Counties). Of the one million acres, about 80 percent is federally controlled. The remaining 20 percent is controlled by the State and private citizens.

The land ownership pattern in the Black Hills includes a mix of private, Black Hills National Forest, State of South Dakota, Bureau of Land Management, and National Park Service lands. A "checkerboard" ownership pattern in the Black Hills National Forest produces a condition where private, residential structures are scattered throughout much of the National Forest. The U.S. Forest Service has reduced, through land exchanges, the number of individual property inholdings and the land area they cover within the Black Hills National Forest. However, the number of occupied developments on the remaining inholdings increases constantly. This rural residential growth continually and dramatically increases private property exposure within U.S. Forest Service's fire jurisdiction.

The State primarily maintains fire protection responsibility on private and state lands but protects a relatively large amount of federal land as well. The State of South Dakota Department of Public Safety Wildland Fire Division (SDWF) is the protecting agency (under contract) for all BLM lands in SD, approximately 250,000 acres. In addition, we provide mutual aid assistance to our federal wildland firefighting agencies throughout the State. Since a large portion of the State's fire protection area is private land, single family dwellings exist throughout the State's protection area. However, there are existing pockets with no dwellings due to the roughness of the terrain in some areas.

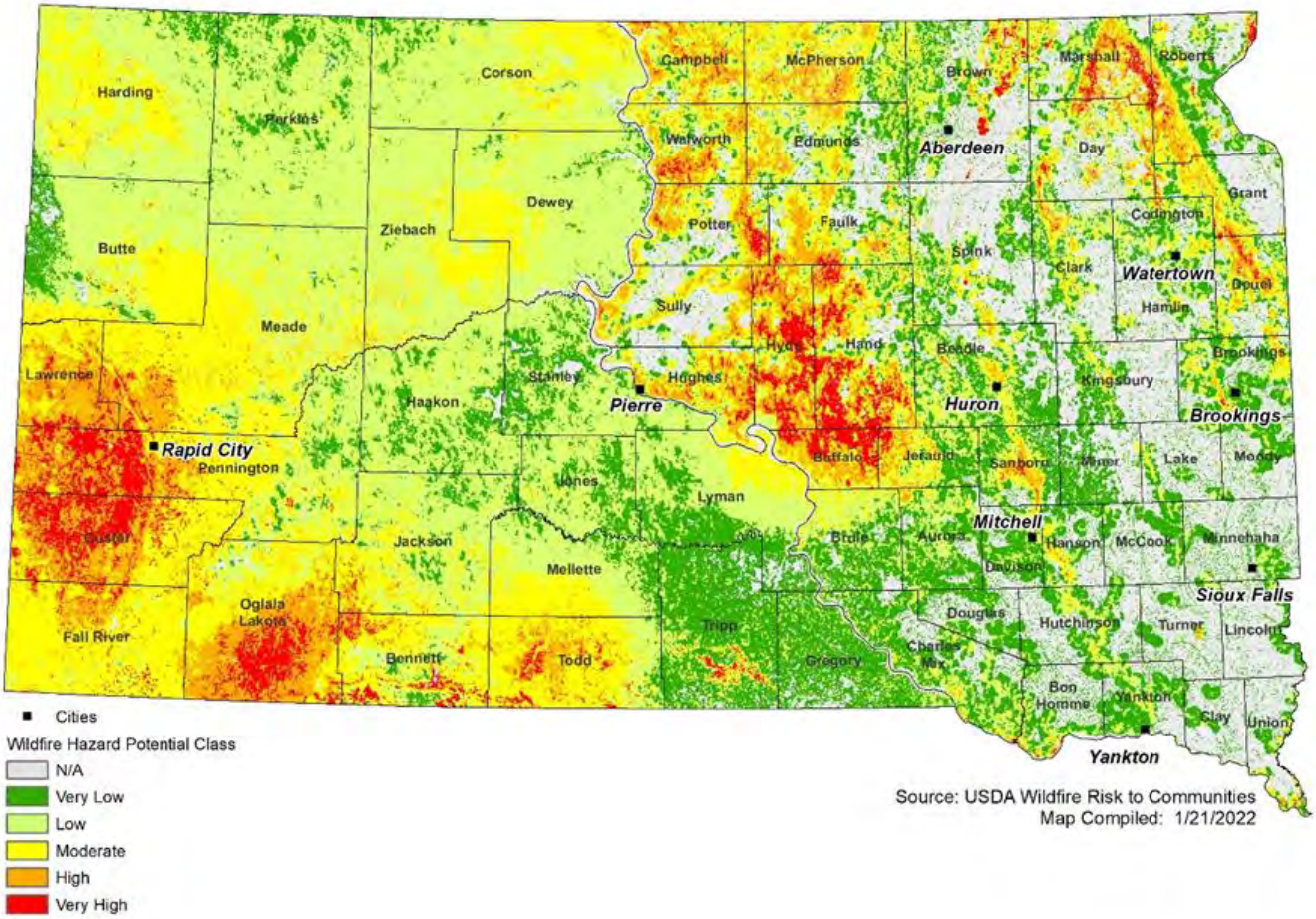
The greatest concentration of structures is located in and around the towns and cities in the Black Hills, including subdivisions within a few miles of the town and city limits. Rapid City and bedroom communities within a five-mile radius of the city represent the greatest concentration of structures located in the forested areas of the Black Hills. The population of new residents is growing, especially in Custer, Pennington, and Meade Counties, and there are far more individual property owners to deal with than in the past.

Many new residents are unfamiliar with the realities and responsibilities of living in a fire dependent ecosystem such as the Black Hills, are unaware of the natural role of fire, the concept of defensible space, and the capabilities of local government services. Many homeowners seem to value aesthetics more than safety and resist the concept of defensible space, believing that they will spoil the environment for which they came.

In addition to the Black Hills National Forest, there are fire-prone smaller forested areas on the Custer National Forest in Harding County, and BIA Trust and tribal lands on the Pine Ridge Reservation of Oglala Lakota County (unorganized), and the Rosebud reservation of Todd County (also unorganized). These three counties are in western South Dakota.

The USDA Wildfire Hazard Potential (WHP) map pictured below is an index that quantifies the relative potential for wildfire that may be difficult to control, used as a measure to help prioritize where fuel treatments may be needed. The 2020 version of the WHP is shown in the map below, using vegetation and landscape conditions from the LANDFIRE 2014 data set. As such, the data presented here reflect landscape conditions as of the end of 2014. This dataset represents best available data statewide, using data from a nationwide fire risk study (www.wildfirerisk.org) and a noted improvement over SILVIS datasets used in previous versions of this HIRA. The mapping reflects the higher risk areas in western and southwestern South Dakota (Pennington, Custer, Lawrence, Fall River, Oglala Lakota Counties). Also notable are pockets of very high potential in central South Dakota in Hyde, Hand and Buffalo Counties. As noted in Figure 3-49 below.

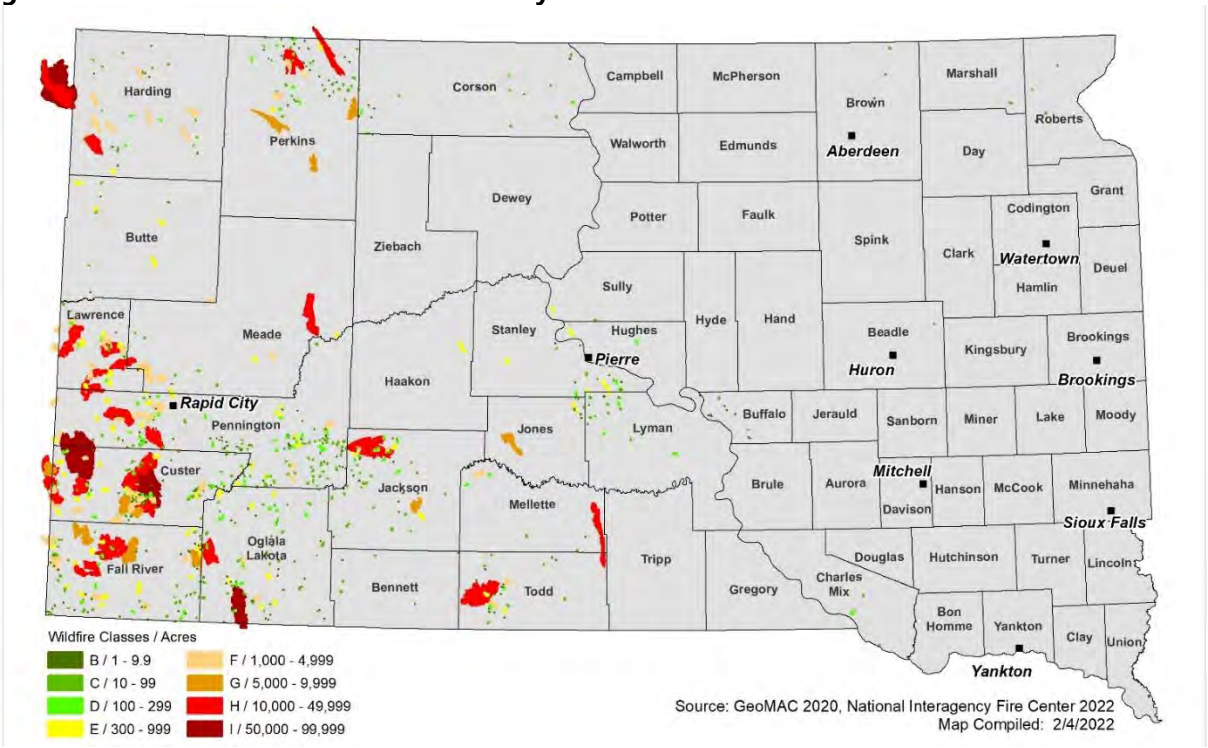
**Figure 3-49 South Dakota Wildfire Potential**




## Past Events

Past wildfire events have traditionally affected the western and southwestern portion of State. Wildfire burn footprints from 1800-2021 are depicted in Figure 3-50 South Dakota Wildfire History 1800-2021below.

**Figure 3-50 South Dakota Wildfire History 1800-2021**




The National Interagency Fire Center information indicates that lightning represents the single largest ignition source in its jurisdiction, causing 35 percent of fires and burning 41 percent of the acreage lost between 1996 and 2000. While debris burning caused slightly more fires, these fires burned only about one-third of the acreage lost to lightning-caused fires.

The table below contains information about wildfires in South Dakota between dating back to 1871. Most of the fire occurrence and corresponding acres burned in the Black Hills occur in Custer and Fall River Counties. Since 2012, the State of South Dakota has received six fire management assistance declarations. These events are summarized in Table 3-38.

One of the largest wildfires in South Dakota history is the Jasper Fire complex in August 2000, which is profiled in Table 3-38. Of these fires between 0.1 and 84,782 acres, 88% were human caused, 10% resulted from natural causes, and the causes of the remaining 2% were unknown. Between 1980 and 2015 191 fires burned 1,000 acres or more. Collectively these 191 fires burned a total of 1,058,056 acres. 121 (63%) of these fires occurred due to human causes, and the remaining 70 (37%) occurred due to natural causes. The location and cause distribution of the 191 events are depicted in the figures below. Most of the instances regarding wildfire events and hazards have occurred in the southwestern portion of South Dakota. With the largest events having taken place in counties like Custer, Fall River and Meade County.

**Table 3-38 South Dakota Wildfire Events**

| Date | Comments |
|---|---|
| October 4, 2021 | **The Auburn Fire (FEMA-5418-FM)**<br>The fire began on October 4, 2021 and lasted until October 10, 2021. The Auburn Wildfire burned an estimated 500 to 750 acres north of Rapid City. It started in Pennington County |

| Date | Comments |
|---|---|
| | and spread north into Meade County. There have been no reports of any structures destroyed at the current moment. |
| March 29, 2021 | **The Schroeder Fire (FEMA-5384-FM)**<br><br>The South Dakota Schroeder Fire began on March 29, 2021 and ended April 4, 2021. It burned 4 miles west of Rapid City, South Dakota, causing several neighborhoods in the Rapid City community to be evacuated. The Schroeder Fire burned a total of 2,195 acres, with no structural or loss of life reported. |
| August 11, 2018 | **The Vineyard Fire (FEMA-5272-FM)**<br><br>The fire began on August 11, 2018 east of the City of Hot Springs. The fire is estimated to have burned over 550 acres and came in close proximity to dense residential areas in Hot Springs. No injuries or structural damage had been recorded at the time of this plan update. The cause of the fire is still under investigation while the State Plan was being updated. |
| December 12, 2017 | **The Legion Lake Fire (FEMA-5229-FM)**<br><br>The Legion Lake Fire began on December 12, 2017 in Custer State Park and was fully contained by December 19, 2018. The fire was caused by a tree falling on a power line that caused sparks which ignited dormant vegetation that had been left from previous logging operations. The fire eventually moved out of the State Park, into Wind Cave National Park and onto private property burning 10,000 acres of private ranches. The Legion Lake Fire is the third-largest wildfire in the region's history burning 54,000 acres. |
| 2015 | **Sheep Draw Fire**<br><br>The Sheep Draw Fire in northwest South Dakota was estimated at 13,949 acres. One non-commercial structure was burned. No injuries reported. |
| 2013 | **Pautre Fire**<br><br>Planned to be a prescribed fire up to 210 acres on the Dakota Prairie National Grasslands, strong winds pushed the fire across a mowed fire line into tall grass and ultimately burned 10,679 acres. |
| 2012 | **Crookston Fire**<br><br>Driven by strong winds, the blaze started northeast of Kilgore and burned its way down to Crookston, Nebraska. The smoke was so thick firefighters closed the highway west of Valentine, Nebraska. |
| August 29, 2012 | **Wellnitz Fire (FEMA-5010-FM)**<br><br>The Wellnitz Fire began on August 29$^{th}$ due to lightning. The fire burned 77,159 acres across Oglala Lakota County (previously Shannon County), South Dakota and into Nebraska. Burned acreage in South Dakota alone was estimated at 28,478. The fire was 100% contained by September 7, 2012. |
| August 16, 2012 | A wildfire burned grassland in and near the Karl E. Mundt National Wildfire Refuge in southeastern Gregory County South Dakota on August 16$^{th}$. No structures were burned. The fire burned 146 acres, including 112 acres on the refuge and 34 acres of private land. |
| July 19, 2012 | **Myrtle Fire (FEMA-2996-FM)**<br><br>South Dakota received two fire management assistance declarations in 2012. The Myrtle Fire began on July 19$^{th}$, 2012 in Custer County due to human causes. The fire burned 10,080 acres and was 100% contained by July 24$^{th}$, 2012. |

| Date | Comments |
|---|---|
| January 9, 2012 | Unseasonably warm and dry weather, along with dry and dormant vegetation, provided a setting in which several fires that were started to burn trash and vegetation went out of control in Moody County. The largest was several miles northeast of Flandreau, where the burning of a tree pile spread to grassland. This fire burned about 120 acres, reaching to the eastern border of the county and State. Another fire just northwest of Flandreau, started to burn garbage, burned 4 acres of grassland. No indications of damage amounts were received, but no structures were reported to have burned. |
| October 4, 2011 | Several wildfires broke out in Gregory and Charles Mix Counties during the four-day period. Warm and dry weather, strong winds, and dry vegetation due to extended dry weather preceding this time contributed to the fires starting and spreading. The fires affected grassland and cropland, including baled hay. |
| 2011 | 740 fires burned 38,684.62 acres |
| 2010 | 609 fires burned 13,448.181 acres |
| August 27, 2010 | **Flynn Creek Fire** - Human-caused fire that burned 65 acres of U.S. Forest Service Southeast of Custer, SD |
| 2009 | 495 fires burned 11,372.499 acres |
| July 24, 2009 | **Duck Creek Fire** - Railroad caused fire that burned 342.95 acres on U.S. Forest Service Southwest of Hot Springs, SD |
| 2008 | 476 fires burned 7,088.953 acres |
| May 18, 2008 | **Freeland Well Fire** - Human-caused fire that burned 168 acres on U.S. Forest Service South of Custer, SD |
| 2007 | 808 fires burned 160,851.23 acres |
| July 2007 | **Boxelder Fire (FEMA-2716-FSA)**<br>At the time of the State's request, the fire had burned approximately 700 acres and had resulted in the evacuation of 100 residents from the town of Nemo in Lawrence County. |
| July 2007 | **Alabaugh Fire (FEMA-2710-FSA)**<br>This fire near Hot Springs in Fall River County was started by lightning on July 7 and was contained on July 12. It burned 10,324 acres. The fire killed one man and destroyed 33 homes. It also forced the evacuation of about 600 residents in about 300 homes. Fire suppression costs were estimated at $2.7 million. A state official said the blaze was the most intense wildfire ever recorded in the Black Hills.<br>Sources: InciWeb, Rapid City Journal, National Public Radio |
| 2006 | 1,388 fires burned 371,226.31 acres<br>Source: Steve Hasenohrl, South Dakota Chief Fire Management Officer |
| July 2006 | **East Ridge Fire (FEMA-2658-FSA)**<br>3,204 acres burned, $1,973,107 total outlay |
| 2005 | 781 fires burned 45,323.641 acres |
| July 2005 | **Skyline #2 Fire (FEMA-2569-FSA)**<br>42 acres burned, total outlay: $18,975 (FEMA share: $14,231) |

| Date | Comments |
|---|---|
| July 2005 | **Ricco Fire (FEMA-2565-FSA)**<br>3,939 acres burned in Meade County, started by lightning, total outlay: $573,581 (FEMA share: $428,064) |
| April 2005 | **Camp Five Fire (FEMA-2557-FSA)**<br>775 acres burned. Request for assistance withdrawn because event did not meet fire cost thresholds. |
| 2004 | 437 fires burned 15,517.87 acres |
| 2003 | 710 fires burned 111,999.37 acres |
| November 2003 | **Mill Road Fire (FEMA-2513-FSA)**<br>Total outlay: $62,852 (FEMA share: $45,685) |
| 2002 | 846 fires burned 179,287.9 acres |
| August 2002 | **Battle Creek Fire (FEMA-2458-FSA)**<br>On August 16, 2002, the Battle Creek Fire ignited on private land near Keystone. High temperatures, low relative humidity, and strong winds created conditions that led to intense fire behavior with long-range spotting. The fire burned actively for four days and burned 12,450 acres (9,120 acres of national forest system lands, 3,330 acres of private lands) before it was fully contained on August 25. Over 600 structures and the town of Keystone were threatened, but thanks to firefighters, losses were limited to three residences near Hayward.<br>Source: U.S. Forest Service, Battle Creek Fire Rapid Assessment (www.fs.fed.us/r2/blackhills/fire/history/battlecreek/index.shtml)<br>Total outlay: $1.8 million |
| June–July 2002 | **Grizzly Gulch Fire (FEMA-2434-FSA)**<br>This fire near Deadwood and Lead burned 10,801 acres and destroyed 7 homes and 20 other structures.<br>Source: Jerome Harvey, "Historic Wildfire in the Black Hills" (www.nfpa.org/assets/files/PDF/blackhills.pdf) |
| 2001 | 611 fires burned 124,401.74 acres |
| July–August 2001 | **Elk Mountain #2 Fire (FEMA-2369-FSA)**<br>This fire burned mostly in Wyoming but was complexed with the Roger's Shack fire which burned 11,896 acres in South Dakota in western Custer County. Two single family residential homes were lost.<br>Total outlay: $293,000 |
| August–September 2000 | **Flagpole Fire Complex (FEMA-2319-FSA) and Jasper Fire (FEMA-2324-FSA)**<br>The Flagpole fire complex started on August 11, 2000, in Fall River County in southwestern South Dakota. The wildfire was actually three different starts, the Flagpole Mountain, Green Canyon, and Chilson II fires in the southern hills area. The fires were attributed to lightning. The Flagpole Mountain fire burned in Ponderosa Pine; the Green Canyon fire burned in grass, scrub, and juniper. The terrain was extremely rocky and steep, making access and firefighting difficult.<br>Pushed by shifting winds, the Flagpole fire immediately threatened structures, including two homes, and destroyed one outbuilding. The Flagpole and Chilson II fires burned more than |

| Date | Comments |
|---|---|
| | 6,000 acres by the evening of August 12. The Flagpole fire threatened 30 homes on the north, south, and east sides of the fire and prompted officials to call for voluntary evacuations in the Shep's Canyon area, where there was only one access road. One residence was lost on the north side of the fire. The fires eventually burned 7,386 acres.<br><br>The Jasper Fire was located in Custer County in the Southwest Black Hills. It was the largest fire to occur in the Black Hills in at least a century. The fire started at about 2:30 p.m. on August 24, 2000 and was contained on September 8, 2000. The cause of the fire was arson.<br><br>The weather was very hot and dry, vegetation moisture was at record low levels, and atmospheric conditions were very unstable. The conditions caused extreme fire behavior and the fire spread rapidly, doubling in size every hour on the day it started. Almost immediately after ignition, the fire spread into the tops of the trees and blowing embers began causing spot fires ahead of the main fire. The fire created its own weather pattern as it burned. Lightning from the storm created by the fire was a big concern. The fire completely blackened some areas, leaving scorched, dead trees and ash-covered ground in its wake. Other areas experienced only a light ground burn. Large areas within the fire perimeter remained green, either lightly burned or completely undamaged.<br><br>Firefighting efforts continued for a month, and firefighters declared the fire controlled on the evening of September 25, 2000. The Jasper Fire burned 83,500 acres and was the largest fire in Black Hills history. It destroyed one summer cabin and three outbuildings, burned acreage at the Jewel Cave National Monument, and threatened more than 100 other structures and the communities of Custer and Hill City. Fire losses included approximately 244 million board feet of timber, 150 miles of range fence, 65 livestock water tanks, 20 miles of range water lines, 17 wildlife water developments, 59 wooden power line structures, and 2,738 feet of above ground telephone line.<br><br>Total outlay for both fires: $4.25 million |
| 2000 | 1,348 fires burned 354,357.13 acres |
| 1999 | 879 fires burned 161,972.42 acres |
| 1998 | 208 fires burned 6,843.96 acres |
| 1997 | 69 fires burned 1,353.65 acres. |
| March 28, 1997 | **Burdock Fire** - burned 350 acres on Private |
| 1996 | 69 fires burned 3,484.57 acres |
| February 10, 1996 | **East Gate Fire** - Powerline fire that burned 996 acres on Private |
| 1995 | 56 fires burned 1,588.97 acres |
| September 5, 1995 | **Indian Canyon Fire** - Lightning-caused fire on Private burned 1,504 acres |
| 1994 | 201 fires burned 2,663 acres [includes Stagebarn Canyon]. |
| August 15, 1994 | **Stagebarn Canyon Fire (FEMA-2109-FSA)**<br><br>Stagebarn Canyon near Indian Hills subdivision northwest of Rapid City. Fire started by lightning. 112 acres burned; cost in excess of $159,000. |
| 1993 | 44 fires burned 678 acres. |
| 1992 | 958 fires burned 20,367 acres. |

| Date | Comments |
|---|---|
| 1991 | 815 fires burned 43,782 acres. |
| September 1990 | **Swedlund Fire (Cicero Peak fire) (FEMA-2076-FSA)**<br>Burned 14,518 acres, approximately 5,000 acres in Custer State Park. Caused by logging equipment. |
| 1990 | 860 fires burned 11,725 acres. |
| 1989 | 911 fires burned 14,779 acres. |
| 1988 | 1,171 fires burned 69,512 acres. |
| July 5, 1988 | **Galena Fire** – 16,788 acres burned in Custer State Park. Started by lightning and required the evacuation of the City of Keystone during the height of tourist season. |
| Jul 25, 1988 | **Westberry Trail Fire (FEMA-2068-FSA)**<br>Suspected arson fire and was located in a subdivision on the western edge of Rapid City. Burned 14 homes and 3,980 acres. |
| June 20, 1988 | The Short Pines Fire in Harding County started by lightning burned over 5,274 acres of School and Public state land and one 105-acre fire started by a powerline in Rapid City on Skyline Drive destroyed one single family residence. |
| Jul 20, 1987 | **Battle Mountain Fire (FEMA-2061-FSA)**<br>Started by lightning in the game production area, two miles from Hot Springs. Burned 2,200 acres. |
| 1987 | 1,638 fires burned 52,277 acres. |
| 1986 | 478 fires burned 3,572 acres. |
| July 12, 1985 | **Flint Hill Fire (FEMA-2057-FSA)**<br>Lightning-caused fire that burned 23,000 acres west of Edgemont. |
| July 12, 1985 | **Seven Sisters Fire (FEMA-2056-FSA)**<br>Lightning cause fire that burned 9,300 acres south of Hot Springs. |
| 1985 | 1,229 fires burned 110,669 acres. |
| 1984 | 651 fires burned 28,230 acres. |
| 1983 | 950 fires burned 18,613 acres. |
| 1982 | 403 fires burned 6,886 acres. |
| 1981 | 1,556 fires burned 24,537 acres. |
| 1980 | 1,349 fires burned 42,077 acres. |
| 1979 | 485 fires burned 14,214 acres. |
| 1978 | 479 fires burned 48,290 acres. |
| 1977 | 535 fires burned 6,952 acres. |
| 1976 | 582 fires burned 9,130 acres. |
| July 1975 | Custer State Park (FEMA-2017-FSA) |
| 1975 | 851 fires burned 30,671 acres |

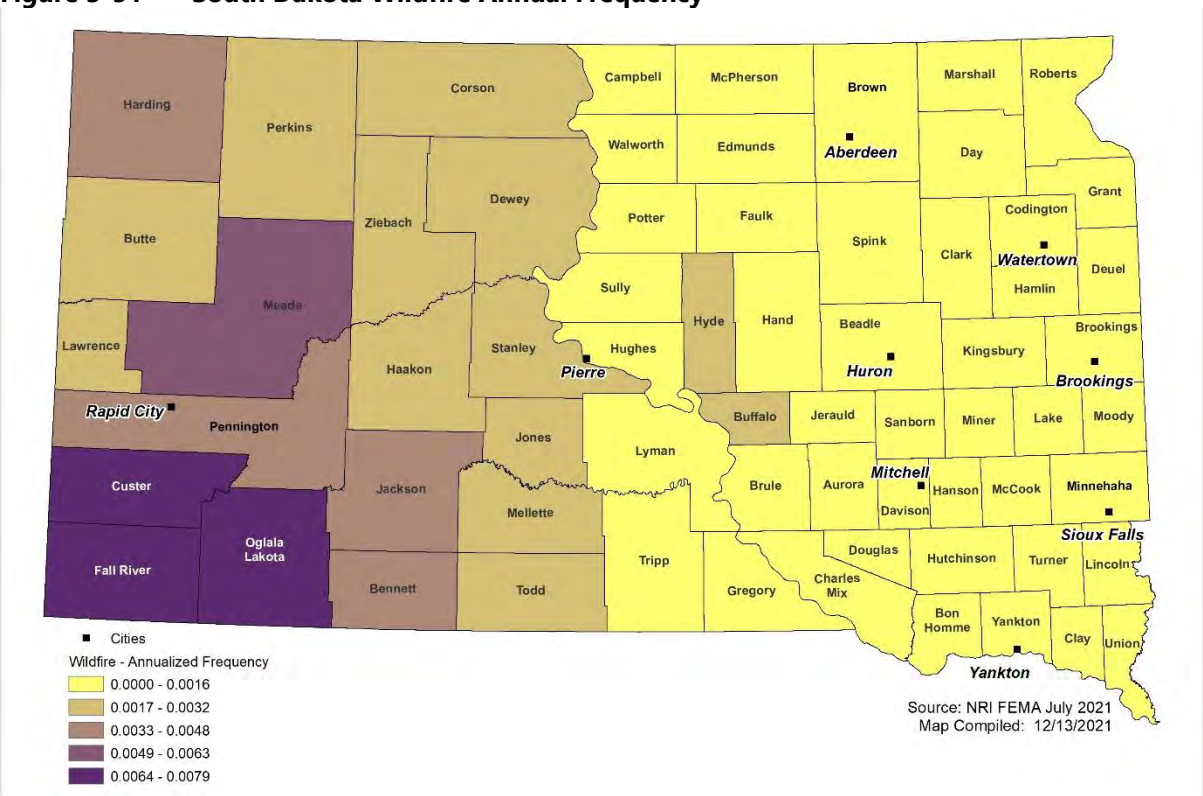
| Date | Comments |
|---|---|
| July 1974 | **Argle & Booms Canyon (FEMA-2016-FSA)**<br>Lightning-caused fire that burned 4,356 acres north of Hot Springs. |
| 1974 | 1,022 fires burned 38,864 acres. |
| 1973 | 704 fires burned 36,252 acres. |
| 1972 | 452 fires burned 13,638 acres. |
| 1971 | 815 fires burned 20,890 acres. |
| 1970 | 477 fires burned 6196 acres. |
| 1969 | 211 fires burned 3254 acres. |
| November 21, 1962 | Burned an area that stretched from Harrold to Highmore (20 miles long) and consumed 30,000 acres of hay and cropland. No loss of life. |
| August 30, 1960 | Two simultaneous lightning strikes south of Hot Springs started the Green Canyon fire (6,389 acres) and the Wildcat fire (10, 454 acres). |
| September 8, 1959 | This human-caused fire nearly destroyed the town of Deadwood. The fire burned 4,500 acres (1,971 federal, 2,560 private) around the town and did more than $1 million (1959 dollars) in damage. More than 60 structures (businesses, residences, utilities, etc.) were destroyed and damage to infrastructure was severe. Nearly 4,000 people were evacuated from the town in less than 30 minutes.<br>Source: Jerome Harvey, "Historic Wildfire in the Black Hills" (www.nfpa.org/assets/files/PDF/blackhills.pdf) |
| August 23, 1949 | Human-caused forest fire started by Nemo. Burned out to the hogback area by Tilford. Burned 6,630 acres and required both the SDNG and Rapid City Air Base to provide over 1000 personnel to the Black Hills NF to suppress the fire. (Source: Big Elk fire file, SDWF agency historical archives) |
| September 5, 1947 | Three human-caused fires burned into one conflagration that burned an estimated 320,000 acres in Hyde, Sully, Potter, Faulk and Hughes Counties in one day. Estimated $2,000,000 damage to improvements (1947 dollars). Considerable damage to range and farmland, (Source: SDWF agency historical archives and *"75 Years of Sully County History*" published by the *Onida Watchman).* |
| July 10, 1939 | **McVey Fire by Hill City South Dakota** - Cause is still unclear. Burned 21, 857 acres. Almost burned over the town of Hill City. One firefighter was killed by a lightning strike during mop-up. 45 miles of fire line was constructed by over 1775 men at the height of the blaze. (Source*: Sawmills of the Black Hills*, by M. Linde and SDWF agency archives). |
| 1931 | **Rochford Burn** - Arson set forest fire. Burned approximately 20,900 acres in western Pennington County in the high elevation limestone country of the Black Hills National Forest, 12 structures were lost. (Source: SDWF Agency historical archives) |
| 1899 | **The Iron Creek fire** - Burned for most of August south of Spearfish. By the time winter snows arrived, it had burned 38,400 acres of timber on the Black Hills National Forest and numerous mining claims |
| March 1879 | This fire burned for at least one week in an area from Brookings County to Union County. The path was over 100 miles long and 20 miles wide |

| Date | Comments |
|---|---|
| October 1871 | During the week of the Great Chicago fire, a large wildland fire occurred along the Missouri River burning from Springfield to Yankton, burning many structures and farms. |

## Probability of Future Occurrence

The western and southwestern portions of South Dakota are more vulnerable to wildfires, but some counties have a higher risk than others. In addition, the vulnerability can vary slightly based on the seriousness of wildfires. As referenced in Figure 3-51 below**,** Pennington, Custer and Oglala Lakota Counties have a higher probability of occurrence, based on the best available NRI data.

**Figure 3-51 South Dakota Wildfire Annual Frequency**




## Magnitude/Severity (Extent)

The magnitude of wildfires is typically measured by how many acres they burn, the intensity of the burn, and the potential for property losses. Typically, wildfires in the wildland urban interface result in a complete loss of the structure and contents. Wildfires often result in massive evacuations can also cause multiple deaths and injuries. The counties with the greatest vulnerability to wildfire hazards are those in the Black Hills Region.

## Climate Change Considerations

Wildfire conditions across South Dakota and the western United States in general are likely to worsen in the future due to climate change. This is due to increasing temperatures, an increase in annual precipitation, and drought as a regular occurrence. The increase in temperatures can dry out fuels more rapidly. The increase in moisture can provide favorable conditions for fuel (vegetation) growth. The trend towards larger precipitation events with drought as a common occurrence provides multiple windows of

opportunity for the fuels to dry out and burn, particularly fine fuels like grasses. South Dakota has already had large fires in every month of the year, and so it is possible that the State will have a true 12-month fire season. As a case in point the Legion Lake Fire on December 12, 2019 was the third-largest wildfire in the Black Hills Region's history, burning 54,000 acres.

The U.S. Forest Service released a study titled "Wildland Fire and Climate Change" detailing the effect climate change will likely have on atmospheric patterns that affect fire weather. These changes could result in fire patterns that will in turn impact carbon cycling, forest structure, and species composition. The study explains that with a doubled $CO_2$ environment, there is potential for an increase in lightning activity, a higher frequency of surface pressure and associated circulation patterns conducive to surface drying, and fire weather conditions in general. These findings suggest that these factors and higher summer temperatures will likely increase the annual window of high fire risk by 10-30%. Predictions past 2040 are largely speculative given the current rate of increase in fossil fuel emissions, but there will certainly be in increase in the potential for drought and the number of days in a year with flammable fuels. The above variables will extend fire seasons and area burned in ecoregions where fire extent is linked to fuel conditions. More intense wildfires can produce highly erodible soils that can lead to increased sediment loading in reservoirs and streams, damaging water infrastructure and degrading water quality. This can also result in increased flood and debris flow risk in affected watersheds for many years following a destructive fire.

## Vulnerability Assessment

The southwestern portion of South Dakota has the highest risk index rating according to FEMA's NRI data listed below in. To assist with the evaluation of past events, the NRI has developed the Risk Index Rating as a method of identifying and quantifying risk. As noted below, two counties in South Dakota have a relatively high risk of a wildfire occurring.

These counties are Oglala Lakota and Todd counties. With counties such as Fall River, Custer, Pennington, and Bennett being in the same portion of the State and having a moderate chance of a wildfire occurring. This can be attributed to environmental factors such as climate change and drought.

**Figure 3-52 South Dakota Wildfire Expected Annual Loss Rating**

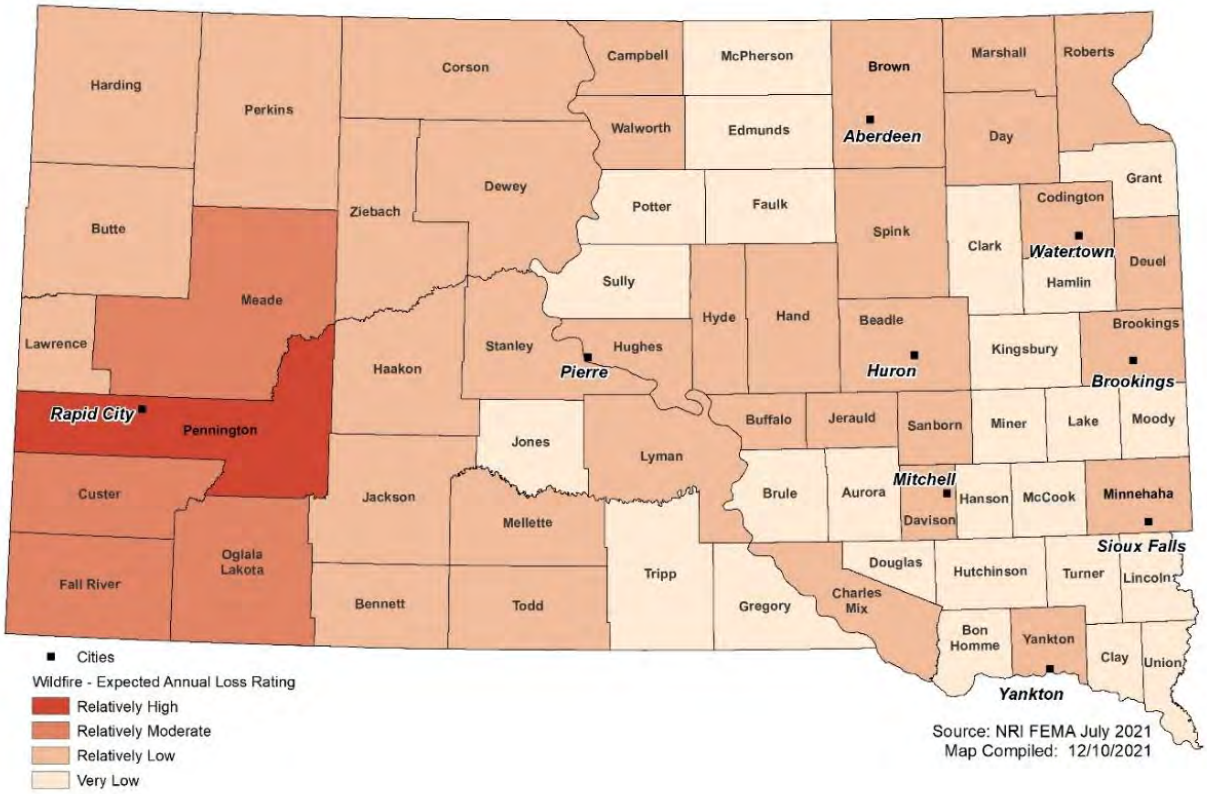



**Table 3-39 South Dakota State Building Wildfire Risk by State Agency**

| State Agency | Very High | High |
|---|---|---|
| Bureau of Information and Telecommunications | 1 | 10 |
| Dept of Ag & Natural Resources | 0 | 1 |
| Dept of Corrections | 0 | 4 |
| Dept of Game, Fish & Parks | 4 | 13 |
| Dept of Health | 0 | 3 |
| Dept of Labor | 0 | 1 |
| Dept of Military | 0 | 35 |
| Dept of Public Safety | 4 | 3 |
| Dept of Transportation | 4 | 31 |
| Unified Judicial System | 1 | 0 |
| **Total** | **14** | **101** |

Source: Wood Analysis based on USDA WHP data, State of South Dakota

Drought can create conditions for more numerous and intense fires that quickly overwhelm local and state capacities for fire suppression. Generally, large wildfires make up a small portion of total fire occurrences in any given year but account for the greatest portion of suppression costs. Expenses can also be driven up by atypically large numbers of moderate or small fires that drain resources. Table 3-40 summarizes South Dakota's fire suppression costs from 1994 to 2018. State fire suppression costs totaled $54,956,928 in that 24 year timespan. This averages as $2,289,872 annually per year and does not include losses to structures, forests, utilities, etc. Note that the amount of financial support was not known for every event. Within that 24-year time period, the highest suppression costs occurred in 2002, 2006, 2007, and 2012; each of these years coincided with a drought. The fire suppression costs for these years was orders of magnitude greater than that of wet years, such as 2010. In addition, in response to the drought

year 2006, the South Dakota Legislature passed a law that was enacted to allow the use of the State Fire Suppression Fund to pay for responding and managing large wildfire activity in the prairie regions of the State. This can drive up fire fund expenditures in future years. (Source, SDCL 41-20A-8.)

**Table 3-40 State Fire Suppression Costs by Year, 1994-2018**

| Year | State Fire Suppression Costs |
|---|---|
| 2018 | $943,237 |
| 2017 | $3,055,336 |
| 2016 | $3,004,592 |
| 2015 | $1,196,440 |
| 2014 | $454,641 |
| 2013 | $893,262 |
| 2012* | $8,493,171 |
| 2011 | $1,789,511 |
| 2010 | $801,405 |
| 2009 | $525,343 |
| 2008 | $938,134 |
| 2007* | $7,686,640 |
| 2006* | $6,026,422 |
| 2005 | $2,127,925 |
| 2004 | $1,009,829 |
| 2003 | $1,599,697 |
| 2002* | $9,444,193 |
| 2001 | $2,025,028 |
| 2000 | $1,510,648 |
| 1999 | $191,441 |
| 1998 | $135,301 |
| 1997 | $149,239 |
| 1996 | $307,694 |
| 1995 | $258,766 |
| 1994 | $389,033 |
| **Total** | **$54,956,928** |

Source: SDWF, 2018; *Drought year

### *People*

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 indirect impacts from wildfires on people are related to dense smoke from fires within the region. Wildfires in the past three years have decreased the air quality throughout the entire western United States. Dense smoke poses a risk to both people with compromised health as well as those considered healthy. A study from the University of California San Diego found that wildfire smoke is more harmful to respiratory health in humans than pollution from cars (NPR 2021). Studies have also shown an increase in ambulance calls, hospital visits and an increase of people experiencing respiratory or cardiac emergencies (NPR 2020).

Pennington County is the second most populous county in South Dakota and also has areas of WUI zones. Due to this Pennington has one of the highest wildfire risks in the State. When factoring in social vulnerability, Oglala Lakota County may have a harder time recovering from extensive wildfires due to low income levels.

### *Property*

The potential impacts of wildfire on property include crop loss, injury and death of livestock and pets, and damage to infrastructure, homes and other buildings located throughout the wildfire risk area, with greatest potential impact on property, buildings and infrastructure located within high and very high hazard zones including the WUI, and buildings and infrastructure located within forested lands, to include national forests and parks. Pennington County where Rapid City is located along with the surrounding counties of Meade, Custer, Fall River and Oglala Lakota all have the highest annual loss rating.

### *State Assets, Critical Facilities, and Infrastructure*

Wildfire impacts to critical facilities can include structural damage or destruction and risk to persons located within facilities. Disruption of transportation, shipping, and evacuation operations, and interruption of facility operations and critical functions.

Pennington County also has the highest amount of state buildings susceptible to wildfire damages. With 101 total buildings being subject to wildfire hazards. Four of which are considered to have a very high as noted in Table 3-41 below. Custer County also has ten buildings in what is a very high wildfire hazard area based on analysis using USDA GIS data.

**Table 3-41 South Dakota State Building Wildfire Risk**

| State Building's by County | State Buildings Wildfire Hazard Area | Very High | High | Moderate |
|---|---|---|---|---|
| Pennington | 101 | 4 | 51 | 46 |
| Fall River | 49 | 0 | 1 | 48 |
| Hughes | 33 | 0 | 4 | 29 |
| Lawrence | 21 | 0 | 8 | 13 |
| Custer | 29 | 10 | 16 | 3 |

USDA, Wildfire Information, January 2022

A similar GIS overlay analysis was performed to identify trends in vulnerabilities to critical facilities/lifelines. The results are captured in the table below. Trends indicate a high number of public school and fire station facilities potentially at risk to wildfires.

**Table 3-42 Critical Facilities/Lifelines at Risk to Wildfire Hazards by Hazard Ranking**

| Critical Facility | Very High | High | Moderate | Low | Very Low | Total |
|---|---|---|---|---|---|---|
| Aviation | 1 | 22 | 30 | 51 | 43 | **147** |
| Bridge | 167 | 443 | 841 | 1,235 | 1,433 | **4,119** |
| Bridge Scour | 8 | 20 | 40 | 51 | 51 | **170** |
| College/University | - | 3 | 4 | 1 | 8 | **16** |
| Courthouse | 1 | 2 | 8 | 19 | 19 | **49** |
| EMS Station | 3 | 21 | 38 | 56 | 55 | **173** |
| Fire Station | 5 | 33 | 72 | 82 | 80 | **272** |
| Hospital | - | 6 | 12 | 16 | 15 | **49** |
| Local EOC | 1 | 4 | 12 | 22 | 26 | **65** |
| Local Law Enforcement | 1 | 7 | 28 | 40 | 41 | **117** |
| Power Plant | 3 | 7 | 7 | 13 | 16 | **46** |
| Prison | 2 | 1 | 10 | 10 | 14 | **37** |
| Private School | 3 | 6 | 9 | 7 | 9 | **34** |
| Public School | 2 | 41 | 84 | 141 | 131 | **399** |
| RMP Facility | - | 4 | 12 | 26 | 47 | **89** |

| Critical Facility | Very High | High | Moderate | Low | Very Low | Total |
|---|---|---|---|---|---|---|
| State EOC | - | - | 1 | - | - | **1** |
| TRI Facility | 1 | 8 | 27 | 38 | 85 | **159** |
| Wastewater Facility | 7 | 23 | 36 | 41 | 54 | **161** |
| Water Facility | - | - | 1 | 2 | 2 | **5** |
| Weather Radar Station | - | - | - | 1 | 1 | **2** |
| **Total** | **205** | **651** | **1,272** | **1,852** | **2,130** | **6,110** |

Source: State of South Dakota OEM, HIFLD, South Dakota OpenData, USDA Wildfire Risk to Communities, Wood GIS analysis

Fire suppression may also require increased cost to local and state government for water acquisition and delivery, especially during periods of drought when water resources are scarce. Drought can create conditions for more numerous and intense fires that quickly overwhelm local and state capacities for fire suppression. Generally, large wildfires make up a small portion of total fire occurrences in any given year but account for the greatest portion of suppression costs. Expenses can also be driven up by atypically large numbers of moderate or small fires that drain resources. Table 3-40 summarizes South Dakota's fire suppression costs from 1994 to 2018. State fire suppression costs have totaled $54,956,928 in the past 24 years. This averages as $2,289,872 annually per year and does not include losses to structures, forests, utilities, etc. Note that the amount of financial support was not known for every event. Within that 24-year period, the highest suppression costs occurred in 2002, 2006, 2007, and 2012; each of these years coincided with a drought. The fire suppression costs for these years were orders of magnitude greater than that of wet years, such as 2010. In addition, in response to the drought year 2006, the South Dakota Legislature passed a law that was enacted to allow the use of the State Fire Suppression Fund to pay for responding and managing large wildfire activity in the prairie regions of the State. This can drive up fire fund expenditures in future years. (Source, SDCL 41-20A-8.)

### *Economy*

The economic impacts of wildfire include loss of property, direct agricultural sector job loss, secondary economic losses to businesses in or near wildland resources like parks and national forests, and loss of public access to recreational resources. Tourism in South Dakota plays a major economic role, with the presence of State and National Park's and other outdoor recreational opportunities. Damage to these assets or disruption of access to them can have far reaching negative impacts to the local economy. Mt. Rushmore is in Pennington County. Pennington has the highest annual loss rating in the entire state. The mountain carving for another national monument is being constructed in Custer County, which also has a relatively moderate loss rating.

Counties in the Black Hills Region that are at a higher risk of wildfire exposure than counties east of the Missouri River have felt these development pressures. Pennington, Custer, and Meade Counties have seen an increase in the development of subdivisions and residential properties within the WUI in their jurisdictional boundaries as well as surrounding communities. In addition to the increased growth in the WUI, climate change is expected to increase the fire risk for the State by 10-30%, because of increased temperatures, increased likelihood of drought events, as well as the increased risk to beetle and insect infestations. Due to these factors, future vulnerability to wildfire events is likely to increase. The implementation of mitigation projects such as educating homeowners on how to protect their property, or the implementation of development standards and regulations related to wildfire mitigation, will help the State's population and infrastructure be better protected when a wildfire event does occur.

### *Environment and Cultural Resources*

Wildfire with South Dakota and the surrounding regions of the United States are more apt to increase in the coming years due to climate change. This is due to increasing temperatures, an increase in annual droughts, and extreme heat. The increase in temperatures can make for more rapid wildfires.
The tourism and outdoor industries are also prone to wildfires. If portions of South Dakota are subject to or at risk of wildfires, then these industries could suffer and create further losses. Wildfires as a hazard in South Dakota can be assisted by using tools such as prescribed fires. Prescribed fires use science to account for each individual fire and is created and formulated in advance. These type of fires designs, scale, objectives, different type of fuels and the environmental conditions also. Utilizing prescribed fires can help foster diverse ecological environments for plants, animals and the endangered within species in South Dakota.

## Development Trends and Consequence Summary

Many counties have experienced an increase in population and resulting development pressures. Counties in the Black Hills Region that are at a higher risk of wildfire exposure have experienced some development pressures, potentially increasing vulnerability. Pennington, Custer, and Meade Counties have seen an increase in the development of subdivisions and residential properties within the WUI in their jurisdictional boundaries as well as surrounding communities. In addition to the increased growth in the WUI, climate change is expected to increase the fire risk for the State by 10-30%, because of increased temperatures, increased likelihood of drought events, as well as the increased risk to beetle and insect infestations. Due to these factors, future vulnerability to wildfire events is likely to increase. The implementation of mitigation projects such as educating homeowners on how to protect their property, or the implementation of development standards and regulations related to wildfire mitigation, will help the State's population and infrastructure be better protected when a wildfire event does occur.

**Table -43 Wildfire Consequence Table**

| Category | Narrative |
|---|---|
| Impact on the Public | Staff, recreationists, campers, property owners in remote areas or the WUI areas, and persons with breathing difficulties may at risk to injury or death; secondary impacts may negatively affect water quality and downstream water users |
| Impact on the Economic Condition of the State | Potential loss of facilities or infrastructure; potential impact to tourism and land development activities depending on severity of the fire season and location of fire events. Depending on nature of area where fire occurs, many home-based businesses will be impacted due to evacuation, lack of utility service, or through destruction of property. State fire suppression and management costs average $2M annually |
| Impact on the Environment | Significant impact related to loss of forest or grasslands, impacts to water quality; erosion and sedimentation may affect critical infrastructure and natural waterways. Loss of ground vegetation may encourage landslides, mudslides, or other geologic movement of land. Dead or damaged trees are at risk of falling |
| Impact on Property, Facilities, and Infrastructure | Vulnerabilities in WUI areas include critical infrastructure, facilities, properties, equipment, vehicles, and communications and utility infrastructure |
| Impact on the Public Confidence in Government | Ability to respond and recover may be questioned and challenged if planning, response, and recovery is not timely and effective. Coordinated warning and evacuation is essential |
| Impact on Responders | Exposure exists to response personnel performing routine duties when event occurs; fire event - related duties may cause significant danger to response personnel including evacuation, suppression, law enforcement, and damage assessment. Local, state and federal fire management personnel involved in firefighting at risk to injury and death |

| Category | Narrative |
|---|---|
| Impact on Continuity of Operations and Continued Delivery of Services | Potential loss of facilities or infrastructure function or accessibility or ability to provide services. Power interruption is likely if not adequately equipped with back-up generation |
| Cascading Hazards | Landslides, Floods |

## 3.3.6 Drought

### Hazard Description

According to the NWS, "Drought is a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people. It is a normal, recurrent feature of climate that occurs in virtually all climate zones, from very wet to very dry. Human factors, such as water demand and water management, can exacerbate the impact that drought has on a region." Four common types of drought are defined below.

- **Meteorological** drought is most often described in terms of dryness and the duration of the dry period. Other types of drought typically begin with a meteorological drought.
- **Hydrological** drought usually occurs as a result of precipitation shortfalls that negatively impact water supply.
- **Agricultural** drought links impacts on agriculture to meteorological or hydrological drought with a focus on precipitation shortages, soil water deficits, reduced water levels needed for irrigation, etc.
- **Socioeconomic** drought refers to the situation that occurs when physical water shortages begin to affect people.
- **Flash** drought refers to relatively short period of warm surface temperature and anomalously low and rapid decreasing soil moisture. It is related to the rate of rapid drought intensification rather than duration of drought conditions.

South Dakota is vulnerable to the social, economic, and environmental impacts of drought. Specifically, drought in South Dakota means limited water availability for people, agriculture, and recreation. The demand for water for multiple uses also impacts water availability. Rural water systems designed largely to supply water for people are now also being used for cattle and to fight wildfires, taxing the limits of the systems. These problems are only expected to get worse in the years to come as populations grow.

Drought in South Dakota is often accompanied by periods of extreme heat. According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. According to the NWS, among natural hazards, only the cold of winter - not lightning, hurricanes, tornadoes, floods, or earthquakes - takes a greater toll. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the heat wave of 1980, more than 1,250 people died.

Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating or a chemical (salt) imbalance caused by too much sweating. When heat gain exceeds the level the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise, and heat-related illness may develop. Elderly persons, small children, those with chronic illnesses, those on certain medications or drugs, and persons with weight and alcohol problems are particularly susceptible to heat reactions, especially during heat waves in areas where moderate climate usually prevails. The chart below illustrates the relationship of temperature and humidity to heat disorders.

**Figure 3-53 National Weather Service Heat Index**

**NOAA's National Weather Service**

**Heat Index**

**Temperature (°F)**

| Relative Humidity (%) | 80 | 82 | 84 | 86 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 118 | 110 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 80 | 81 | 83 | 85 | 88 | 91 | 94 | 97 | 101 | 105 | 109 | 114 | 119 | 124 | 130 | 136 |
| 45 | 80 | 82 | 84 | 87 | 89 | 93 | 96 | 100 | 104 | 109 | 114 | 119 | 124 | 130 | 137 | |
| 50 | 81 | 83 | 85 | 88 | 91 | 95 | 99 | 103 | 108 | 113 | 118 | 124 | 131 | 137 | | |
| 55 | 81 | 84 | 86 | 89 | 93 | 97 | 101 | 106 | 112 | 117 | 124 | 130 | 137 | | | |
| 60 | 82 | 84 | 88 | 91 | 95 | 100 | 105 | 110 | 116 | 123 | 129 | 137 | | | | |
| 65 | 82 | 85 | 89 | 93 | 98 | 103 | 108 | 114 | 121 | 126 | 130 | | | | | |
| 70 | 83 | 86 | 90 | 95 | 100 | 105 | 112 | 119 | 126 | 134 | | | | | | |
| 75 | 84 | 88 | 92 | 97 | 103 | 109 | 116 | 124 | 132 | | | | | | | |
| 80 | 84 | 89 | 94 | 100 | 106 | 113 | 121 | 129 | | | | | | | | |
| 85 | 85 | 90 | 96 | 102 | 110 | 117 | 126 | 135 | | | | | | | | |
| 90 | 86 | 91 | 98 | 105 | 113 | 122 | 131 | | | | | | | | | |
| 95 | 86 | 93 | 100 | 108 | 117 | 127 | | | | | | | | | | |
| 100 | 87 | 95 | 103 | 112 | 121 | 132 | | | | | | | | | | |

**Likelihood of Heat Disorders with Prolonged Exposure or Streuous Activity**

Caution | Extreme Caution | Danger | Extreme Danger

Source: NWS

Note: Heat Index (HI) values were devised for shady, light wind conditions. Exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

The NWS has in place a system to initiate alert procedures (advisories or warnings) when the Heat Index (HI) is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for the issuance of excessive heat alerts is when the maximum daytime high is expected to equal or exceed 105°F and a nighttime minimum high of 80°F or above is expected for two or more consecutive days. Heat alerts are issued by a county when any locations within the county is expected to reach these criteria.

## Location

No portion of the State of South Dakota is immune to drought conditions. The effects of drought vary based on where in the State it occurs, when it happens, and how long the drought persists. For example, a drought in East River (defined as the eastern half of the State east of the Missouri River) can greatly affect agricultural crops. A long-term drought is not needed to affect agricultural yields. Droughts of just a few weeks, also known as "flash drought", during critical periods of plant development can have disastrous effects on agriculture production. Droughts that occur in the Black Hills during winter months may affect winter sports related tourism and recreation. Droughts that occur in the western part of the State may increase the threat of wildfire. In summary, drought is one of the few hazards with the potential to directly or indirectly impact the entire population of the State, be it from water restrictions, higher water and food prices, reduced air or water quality, or restricted access to recreational areas (McKee and Doesken, 1999).

## Magnitude/Severity

The impacts drought can have on modern society are often underrated. Drought impacts in the planning area can be wide-reaching: economic, environmental, and societal. Droughts cause obvious and severe impacts on agricultural areas by destroying existing crops and prolonging unsuitable growing conditions which hinders efforts to recover agricultural losses. This causes secondary financial impacts first on the farmers, who have no crops to sell, and then on the consumers, who must pay higher prices for scarce produce. Increased demand for a decreased water supply raises water costs, which also drives up the overall costs to both farm producers and consumers. The State may see an increase in dry fuels and associated wildfires, and some loss of tourism/recreation revenue. Water supply issues for municipal, industrial, and domestic needs will be a concern. Lawn and tree impacts in urban areas could result from water restrictions. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding. It also increases the wildfire hazard and even landslide hazard.

Urban areas are also impacted by rising water costs, which may impact personal property and personal water usage bills. Recreational uses which are water-dependent may increase significantly in price or decrease in availability, particularly those which are based in reservoirs or lakes, as the water levels may be too low to sustain safe recreation. Finally, the increased risk of wildfires impacts the State. While the hazard of fire itself is profiled separately, drought conditions increase the likelihood that wildfires will occur, either naturally or due to human causes.

The United States Drought Monitor measures drought in five categories, from D0 (Abnormally Dry) to D4 (exceptional drought). Each condition is defined in Figure 3-54; the State of South Dakota is vulnerable to all levels of drought. Droughts are subject to global climate and precipitation trends, and wet and dry periods can persist for years.

**Figure 3-54 U.S. Drought Monitor Drought Severity Classifications**

| | | | Ranges | | | | |
|---|---|---|---|---|---|---|---|
| Category | Description | Possible Impacts | Palmer Drought Severity Index (PDSI) | CPC Soil Moisture Model (Percentiles) | USGS Weekly Streamflow (Percentiles) | Standardized Precipitation Index (SPI) | Objective Drought Indicator Blends (Percentiles) |
| D0 | Abnormally Dry | Going into drought:<br>• short-term dryness slowing planting, growth of crops or pastures<br>Coming out of drought:<br>• some lingering water deficits<br>• pastures or crops not fully recovered | -1.0 to -1.9 | 21 to 30 | 21 to 30 | -0.5 to -0.7 | 21 to 30 |
| D1 | Moderate Drought | • Some damage to crops, pastures<br>• Streams, reservoirs, or wells low, some water shortages developing or imminent<br>• Voluntary water-use restrictions requested | -2.0 to -2.9 | 11 to 20 | 11 to 20 | -0.8 to -1.2 | 11 to 20 |
| D2 | Severe Drought | • Crop or pasture losses likely<br>• Water shortages common<br>• Water restrictions imposed | -3.0 to -3.9 | 6 to 10 | 6 to 10 | -1.3 to -1.5 | 6 to 10 |
| D3 | Extreme Drought | • Major crop/pasture losses<br>• Widespread water shortages or restrictions | -4.0 to -4.9 | 3 to 5 | 3 to 5 | -1.6 to -1.9 | 3 to 5 |
| D4 | Exceptional Drought | • Exceptional and widespread crop/pasture losses<br>• Shortages of water in reservoirs, streams, and wells creating water emergencies | -5.0 or less | 0 to 2 | 0 to 2 | -2.0 or less | 0 to 2 |

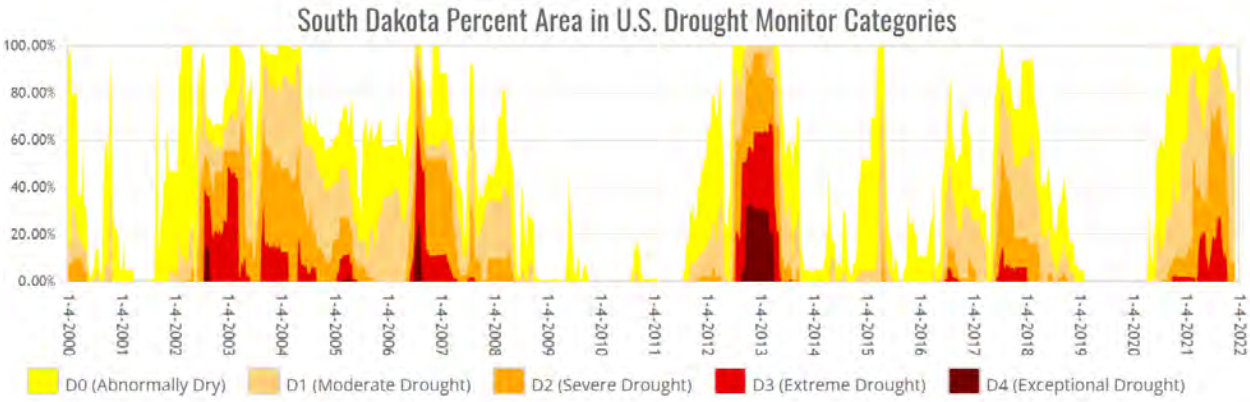
Source: U.S. Drought Monitor

The most significant impacts associated with drought are those related to water intensive activities such as wildfire protection, commerce, tourism/recreation, municipal usage, and wildlife preservation. Considering the significant presence of agricultural activities in the State, South Dakota can be expected to experience crop losses and livestock feeding expenses and deaths.

## Past Events

The U.S. Drought Monitor maintains weekly records of drought. Per these records, during the 1,145-week period from January 2000 through December 2021, all or portions of the State's 14 counties spent at least 700 weeks (61% of the time period) in some level of drought, defined as Abnormally Dry (D0) or worse conditions. All or portions of the State's 11 counties spent more than 150 weeks (13% of the time period) in Extreme Drought (D3) or worse conditions. Figure 3-55 illustrates the severity and duration of drought conditions during this time. The most significant droughts on record during this period were between 2002-2003, 2006 – 2007 and 2012-2013. During the 2006 – 2007 and 2012 – 2013 drought events, over 60% of the State was in extreme drought.

**Figure 3-55 U.S. Drought Monitor Drought Intensity, State of South Dakota, 2000-2021**




Historical drought information for South Dakota is difficult to find. An article in the Proceedings of the South Dakota Academy of Science suggests that South Dakota has seen droughts worse than the 1930's Dust Bowl. The article is based on a study of tree core data conducted to learn more about historical drought in South Dakota. The results of the study are illustrated in Table 3-44.

**Table 3-44 Duration and Magnitude Estimates of 15 Dry and 15 Wet Spells in South Dakota**

| | Dry Periods | | | Wet Periods | | |
|---|---|---|---|---|---|---|
| Rank | Years | No. Years | % Of Max | Years | No. Years | % Of Max |
| 1 | 1531-1551* | 21 | 100.0 | 1429-1448* | 20 | 100.0 |
| 2 | 1325-1344* | 20 | 90.8 | 1284-1297* | 14 | 80.3 |
| 3 | 1859-1873 | 15 | 82.5 | 1559-1574* | 16 | 66.0 |
| 4 | 1397-1411* | 15 | 73.0 | 1609-1617 | 9 | 53.6 |
| 5 | 1710-1725 | 16 | 65.8 | 1762-1769 | 8 | 35.7 |
| 6 | 1780-1791 | 12 | 51.3 | 1882-1892 | 11 | 31.5 |
| 7 | 1933-1942 | 10 | 50.0 | 1683-1695 | 12 | 30.0 |
| 8 | 1753-1761 | 9 | 43.5 | 1792-1806 | 15 | 28.1 |
| 9 | 1660-1668 | 9 | 44.7 | 1903-1910 | 8 | 27.2 |
| 10 | 1580-1598* | 9 | 32.2 | 1962-1969 | 8 | 26.1 |
| 11 | 1852-1857 | 6 | 29.7 | 1773-1779 | 7 | 24.4 |
| 12 | 1956-1961 | 6 | 29.6 | 1832-1842 | 11 | 21.1 |
| 13 | 1467-1472* | 6 | 27.0 | 1726-1733 | 8 | 21.0 |
| 14 | 1377-1388* | 12 | 26.3 | 1943-1947 | 5 | 20.6 |
| 15 | 1637-1640 | 4 | 24.8 | 1641-1645 | 5 | 19.5 |

Source: Bunkers, M.J., L.R. Johnson, J.R. Miller, and C.H. Sieg. 1999. Old Black Hills Ponderosa Pines Tell a Story. *Proceedings of the South Dakota Academy of Science*, Vol. 78.

Note: *Sample size <5 trees and is likely not adequate to reliably infer precipitation patterns.

Another source of data on previous drought occurrences is the National Drought Mitigation Center (NDMC), located at the University of Nebraska in Lincoln, which provides a clearinghouse for information on the effects of drought based on reports from media, observers, impact records, and other sources.

According to the NDMC's Drought Impact Reporter, during the 20-year period from January 2002 through November 2021, 104 drought impacts were recorded for the State of South Dakota. Most of the impacts, 70, were classified as "agriculture." Other impacts include "relief, response & restrictions" (32), "plants and wildlife" (14), "society and public health" (12), "fire" (9), "water supply and quality" (7), "business and industry" (3), and "tourism and recreation" (3). These categories are described as follows:

- **Agriculture** - Drought effects associated with agriculture, farming, aquaculture, horticulture, forestry, or ranching. Examples of drought-induced agricultural impacts include damage to crop quality; income loss for farmers due to reduced crop yields; reduced productivity of cropland; insect infestation; plant disease; increased irrigation costs; cost of new or supplemental water resource development (wells, dams, pipelines) for agriculture; reduced productivity of rangeland; forced reduction of foundation stock; closure/limitation of public lands to grazing; high cost or unavailability of water for livestock, Christmas tree farms, forestry, raising domesticated horses, bees, fish, shellfish or horticulture.
- **Relief, Response, and Restrictions** - This category refers to drought effects associated with disaster declarations, aid programs, requests for disaster declaration or aid, water restrictions, or fire restrictions. Examples include disaster declarations, aid programs, USDA Secretarial Disaster Declarations, Small Business Association Disaster Declarations, government relief and response programs, state-level water shortage or water emergency declarations, county level declarations, a declared "state of emergency," requests for declarations or aid, non-profit organization-based relief, water restrictions, fire restrictions, NWS Red Flag Warnings, and declaration of drought watches or warnings.
- **Plants & Wildlife** - Drought effects associated with unmanaged plants and wildlife, both aquatic and terrestrial, include loss of biodiversity of plants or wildlife; loss of trees from rural or urban landscapes, shelterbelts, or wooded conservation areas; reduction and degradation of fish and wildlife habitat; lack of feed and drinking water; greater mortality due to increased contact with agricultural producers, as animals seek food from farms and producers are less tolerant of the intrusion; disease; increased vulnerability to predation (from species concentrated near water); migration and concentration (loss of wildlife in some areas and too much wildlife in others); increased stress on endangered species; salinity levels affecting wildlife; wildlife encroaching into urban areas; and loss of wetlands.
- **Society & Public Health** - Drought effects associated with human, public and social health include health-related problems related to reduced water quantity and/or quality, such as increased concentration of contaminants; loss of human life (e.g. from heat stress, suicide); increased respiratory ailments; increased disease caused by wildland fire concentrations; increased human disease caused by changes in insect carrier populations; population migration (rural to urban areas, migrants into the United States); loss of aesthetic values; change in daily activities (non-recreational, like putting a bucket in the shower to catch water); elevated stress levels; meetings to discuss drought; communities creating drought plans; lawmakers altering penalties for violation of water restrictions; demand for higher water rates; cultural/historical discoveries form low water levels; prayer meetings; cancellations of fundraising events; cancellation/alteration of festivals or holiday traditions; stockpiling water; public service announcements and drought information websites; protests; and conflicts within the community due to competition for water.
- **Fire** - Drought often contributes to forest, range, rural, or urban fires, fire danger, and burning restrictions. Specific impacts include enacting or easing burning restrictions, fireworks bans,

increased fire risk, occurrence of fire (number of acres burned, number of wildland fires compared to average, people displaced, etc.), state of emergency during periods of high fire danger, closure of roads or land due to fire occurrence or risk, and expenses to state and county governments of paying firefighters overtime and paying equipment (helicopter) costs.

- **Water Supply & Quality** - Drought effects associated with water supply and water quality include dry wells, voluntary and mandatory water restrictions, changes in water rates, easing of water restrictions, increases in requests for new well permits, changes in water use due to water restrictions, greater water demand, decreases in water allocation or allotments, installation or alteration of water pumps or water intakes, changes to allowable water contaminants, water line damage or repairs due to drought stress, drinking water turbidity, change in water color or odor, declaration of drought watches or warnings, and mitigation activities.
- **Business & Industry** - This category tracks drought's effects on non-agriculture and non-tourism businesses, such as lawn care, recreational vehicles or gear dealers, and plant nurseries. Typical impacts include reduction or loss of demand for goods or services, reduction in employment, variation in number of calls for service, late opening or early closure for the season, bankruptcy, permanent store closure, and other economic impacts.
- **Tourism & Recreation** - Drought effects associated with recreational activities and tourism include closure of state hiking trails and hunting areas due to fire danger; water access or navigation problems for recreation; bans on recreational activities; reduced license, permit, or ticket sales (e.g. hunting, fishing, ski lifts, etc.); losses related to curtailed activities (e.g. bird watching, hunting and fishing, boating, etc.); reduced park visitation; and cancellation or postponement of sporting events.

In addition, NCEI reported 395 drought events affecting 50 counties and/or zones in South Dakota since 2015. A total of $30.288 million was recorded for these events. No casualties were recorded for these events. Table 3-45 summarizes some of the most severe droughts in the State since 1889.

**Table 3-45 South Dakota Droughts: 1889-2021**

| Date | Comments |
|---|---|
| November 2020 – August 2021 | Starting from November 2020, a lack of significant precipitation as the agricultural season ended maintained severe to extreme drought conditions. The drought condition persisted through December and January, during which frozen ground provided little means for drought conditions to change, despite 100-175 percent of normal precipitation. Severe drought conditions developed in late February 2021, across much of north central and parts of central South Dakota. Precipitation departures since October 1st, 2020, had been from three-quarters of an inch to two and a quarter inches below normal or only 25 to 50 percent of normal. Severe to extreme drought conditions continued throughout April, especially over north central South Dakota. Through May and June 2021, severe to extreme drought conditions continued across north central South Dakota extending towards the James Valley and into parts of central South Dakota. Severe to extreme drought conditions expanded across the area through the month of June due to much above average temperatures and much below average rainfall. Statewide, South Dakota recorded its 4th warmest and its driest June since record keeping began in 1895. Severe to extreme drought conditions continued from June into July across most of the area. Drought conditions were still prevailing across the State in August, although some improvement in drought conditions were observed by the month's end across portions of Minnehaha and Lincoln Counties. |
| October 2017 | The severe drought across much of central and north central South Dakota at the beginning of October diminished and became confined to just western Corson and extreme northwestern Dewey Counties by the end of October |

| Date | Comments |
|---|---|
| September 2017 | Severe drought continued across most of central and north central South Dakota throughout much of September west of the James River Valley. There was some improvement towards the end of September. Periodic episodes of precipitation across the region had prevented widespread worsening of the drought conditions. The severe drought had begun across the region in early June. Several counties still had burn bans in place. Crops and pastureland continued to suffer from the long-term dryness. The spring and winter wheat production was at its lowest in years and more than 60 percent below long-term norms. |
| August 2017 | Drought conditions improved some in August as a changing weather pattern had brought cooler conditions along with more frequent episodes of showers and thunderstorms. The average monthly temperatures across the drought region were from 3 to 5 degrees below normal. Monthly rainfall amounts were from 3 to 6 inches, ranging from one to nearly four inches above normal.<br><br>There was a decrease in the area coverage of severe drought along with almost the elimination of the extreme drought region across north central South Dakota. In fact, the drought conditions jumped two categories from the 1st to the 31st from extreme to moderate drought over part of north central South Dakota. Due to the above normal rainfall, there was some improvement with the crops and pastureland across the region. Although, stock water supplies were still running short.<br><br>Most of the counties across the region had lifted their burn bans by the end of August. There was also an increase in the number of sick or dead livestock due to nitrate poisoning from the drinking water. Stream flows were also up to at or above normal due to the heavier rainfall by the end of the month along with better topsoil and subsoil moisture. The drought continued into September. |
| June 2017 | Governor Daugaard activates the Drought Task Force and on June 8, 2017, declares a drought emergency for the State. The 2017 drought is reported to have led to diminished crop production in the State and to have lasted into January 2018. |
| July 2016 | Governor Daugaard activated the Drought Task Force due to the moderate and severe drought conditions in western portions of the State and extreme conditions in northeastern South Dakota. By August 2016 over 50% of the State was in moderate drought. |
| January-June 2013 | Drought conditions continued over all southeast South Dakota in January. Precipitation was below to well below normal, although with the low midwinter normals, even greater precipitation would have been unlikely to change the dry soil conditions. There was little noted in the way of new effects of the drought, with the dry conditions giving a poor outlook for the spring and summer, including poor germination of the winter wheat crop during the dry fall. Water restrictions continued to be few during the winter because of the low water usage, but the area was becoming more vulnerable to even marginally weather if it developed in the spring and summer. Drought was generally listed as continued severe to extreme for the area. |
| October 2012 | Drought conditions continued over all southeast South Dakota in October with well below normal rainfall keeping soil and vegetation dry. Rainfall for the month was below normal everywhere, and less than half of normal in much of the area. Harvest of drought affected crops was completed, but there was no estimation available on how much yields were reduced. Winter wheat was planted on time, but the lack of moisture greatly hampered germination. Water restrictions were generally eased, with water use dropping off with the fall season. Drought was generally listed as continued severe to extreme for the area. |
| September 2012 | Drought conditions continued over all southeast South Dakota with well below normal rainfall keeping soil and vegetation dry. Rainfall for the month varied from around half to less |

| Date | Comments |
|---|---|
| | than a quarter of normal. Stress on crops that prevailed over the growing season became more evident with the start of harvest, although the amount of the reduced yields was still uncertain. Local governments continued to use water use restrictions in an effort to prevent serious water supply problems. Drought was generally listed as continued severe to extreme for the area. |
| August 2012 | Drought conditions continued over all the area with below normal rainfall keeping soil conditions dry. Stress on crops continued even though August was less hot than July, with temperatures averaging only a little above normal. Crop damage was quite evident, though the amount of reduced yields and other damage which might become evident at harvest was uncertain. While reported water supply problems were not extreme, many local governments had water use restrictions in place. Drought was generally listed as severe to extreme for the area and was being compared to the worst of the dust bowl years, though not yet over as long a time period. |
| July – August 2012 | Drought conditions became established over much of the State with long-term dry climate and soil conditions combining with much below normal rainfall during the month. Stress on crops increased and was continuous with no significant relief during the dry month. Hot weather added to the stress as it contributed to high evaporation. Crop damage in the form of reduced yields became certain, but the long remaining time to harvest and the unknown rainfall before that time made even rough damage estimates impossible. Severe general long-term non-agricultural water supply problems were not observed, but the continued long-term dry conditions raised fears of this for the future. Cattle sell-offs were also occurring across the region. Range and pasture conditions were poor to very poor with fire danger remaining a big issue. The severe drought continued into August. |
| June 2012 | Long-term dry climate and soil conditions combined with well below normal rainfall to make the dry conditions more acute and short-term. This resulted in stress on crops developing during the month, mainly south of Interstate 90. After an abnormally dry fall and winter, short-term drought fears had been temporarily forestalled by spring rains. The rains had fallen shortly after an unusually early planning brought on by very warm late winter and early spring weather. However, the return to dry weather in June compounded the effects of the long-term dry conditions. |
| January –March 2012 | The severe drought conditions from December continued across part of northeast South Dakota including the counties of Deuel, Codington, and Hamlin throughout March. The severe drought conditions would continue into February. |
| 2007 | Drought continued in some areas of South Dakota. The July 24, 2007, Drought Monitor for South Dakota (Figure 3-54 U.S. Drought Monitor Drought Severity Classifications) showed that drought encompassed most of the State. Most of Fall River County was experiencing severe drought conditions that also reached north into southern Custer County. |
| 2006 | Fifty-six counties designated primary natural disaster areas by the USDA. The other 10 were contiguous to primary natural disaster areas and thus also eligible for assistance. For many areas, this was their seventh consecutive year of drought. The NWS cooperative observer 8 miles north northwest of Usta in Perkins County recorded a maximum temperature of 120 degrees on July 15th, which tied the previous all-time record high in South Dakota, first set on July 5th, 1936, in Gann Valley. A woman died of heat exhaustion while hiking in the Badlands National Park on July 16th. |
| 2005 | Fifteen counties designated primary natural disaster areas by the USDA.<br><br>Twenty-nine were contiguous to primary natural disaster areas and thus also eligible for assistance. |

| Date | Comments |
|---|---|
| | In 2005, the Missouri River basin had experienced five consecutive years of below normal runoff. System storage was at a record low due to the combined impact of the drought and water allocation decisions made during the drought. Impacts included reduced hydropower production, loss of fish production, unusable boat ramps, and irrigation water supply problems.<br>Source: South Dakota Engineer Society |
| 2004 | Thirty-four counties designated primary natural disaster areas by the USDA. Eighteen were contiguous to primary natural disaster areas and thus also eligible for assistance. |
| 2003 | Forty-three counties designated primary natural disaster areas by the USDA. Twenty were contiguous to primary natural disaster areas (in South Dakota or neighboring states) and thus also eligible for assistance. |
| 2002 | Many areas in South Dakota were devastated by drought in 2002.<br>After a dry winter and spring, below normal rainfall for June brought severe drought conditions to the area. Much of the rainfall for June was below 50 percent of normal with much of the area receiving 20 to 40 percent of the normal rainfall. Some locations were at 10 to 15 percent of normal rainfall. Central and north central South Dakota were the hardest hit with the drought conditions. As a result of the severe dryness, a lot of grazing land and stock ponds dried up, and ranchers had to buy additional feed for their animals, transport them to healthier pastureland for grazing, or sell their herds prematurely. Crops suffered with much having to be cut up for hay or replanted. Water levels on lakes and rivers were also way down. Burn bans and voluntary or mandatory water restrictions were implemented across much of the area. All counties were declared drought disasters. |
| May/July 1992 | Twenty-eight counties declared by governor as drought disaster areas: Aurora, Bon Homme, Buffalo, Butte, Campbell, Charles Mix, Corson, Dewey, Douglas, Edmunds, Haakon, Hand, Harding, Hughes, Hyde, Jackson, Jerauld, Jones, Lawrence, Lyman, Meade, Perkins, Stanley, Sully, Todd, Tripp, Walworth, and Ziebach. |
| 1988 | Statewide. Regional impact varied. |
| 1985–1987 | Western half of state during 1985; continued in Black Hills during 1986 and 1987. Rated as a 10- to 25-year event |
| 1980–1982 | Statewide. Rated as a 10- to 25-year event. Most severe in 1981. |
| 1973–1977 | Statewide, except Black Hills. Rated as a 10- to 25-year event. Most severe in 1976. Includes drought emergency declaration (FEMA-3015-EM) in 1976 |
| 1954–1962 | Statewide. Rated as a 25-year event. Regional variations. Most severe in 1956 and 1959, except in the Black Hills where it was most severe in 1961. |
| 1929–1942 | Statewide. Rated as greater than a 25-year event. Dust Bowl years. Regional impact varied a little. Most severe in 1931, 1933, 1934, and 1936. Included in this period was a “plague” of grasshoppers |
| 1910–1914 | Western half of state. Regional impact varied. Most severe in 1911. |
| 1889–1905 | Statewide. Regional impact varied. Most severe between 1894 and 1896 and 1898 and 1901. |

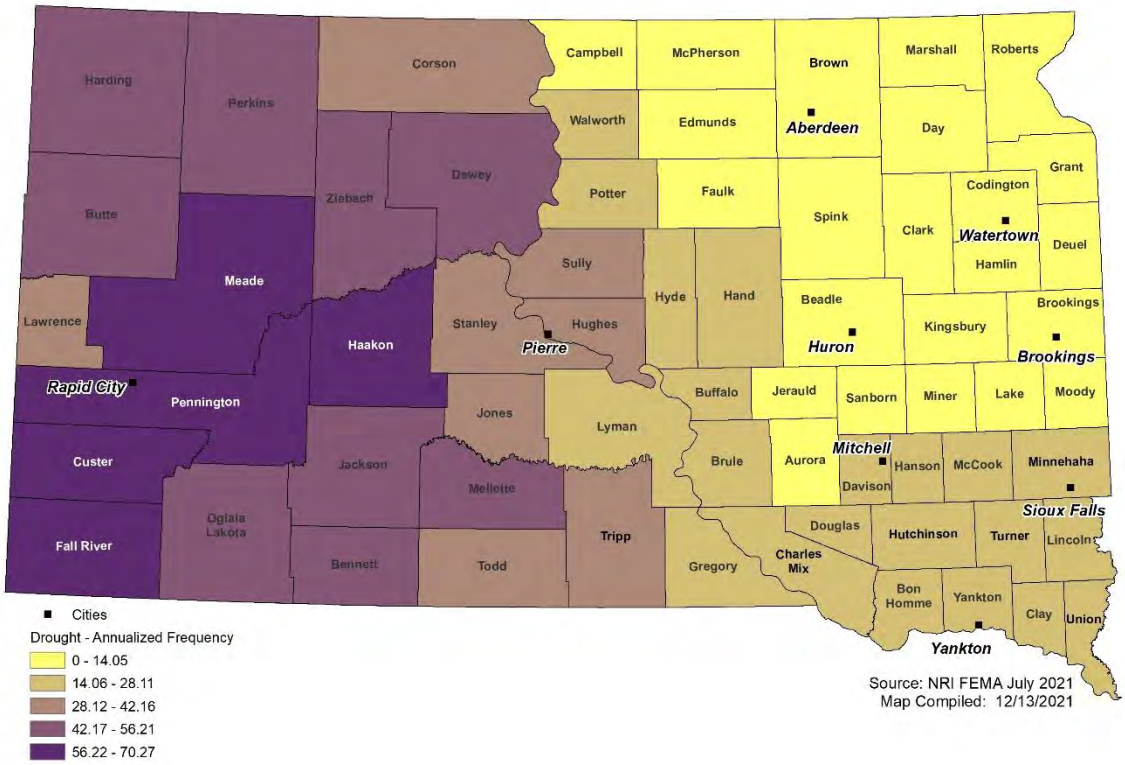
Source: NCEI

## Probability of Future Occurrence

According to the South Dakota Drought Mitigation Plan that was released in November 2015, most of South Dakota has experienced severe or extreme drought between 15% and 19.9% of the time over a 100-year period. Figure 3-56 shows the annualized frequency of drought by county, based on the NRI. The trend follows the general average precipitation trends, with the western portion of the State receiving much less than eastern half, and more prone to drought conditions. Based on paleoclimatic techniques such as tree ring research, which spans a period of roughly 400 years, multi-year droughts as significant as the 1930's drought or worse occur on average every 57 years. Based on historical records (10 in the past 118 years, counting the 2002-2007 dry spell and other multi- year events as one event) notable droughts have occurred somewhere in the State on average about every 12 years, which is equivalent of an 8% chance any given year. Climate change could increase the frequency of drought in South Dakota in the future.

As shown in Figure 3-55 U.S. Drought Monitor Drought Intensity, State of South Dakota, 2000-2021, during 11 out of the 22 years' period, portions and sometimes more than 60% of the State experienced extreme drought or worse conditions, which means the portions or more areas of the State have a 50% chance to experience extreme drought or worse conditions in any given year.

**Figure 3-56 Annualized Frequency of Drought Events by County**




## Climate Change Considerations

The Fourth National Climate Assessment provides an in depth look at climate change impacts on the U.S on a regional basis, which was released in November 2018. Chapter 22: Northern Great Plains summarized the impacts of climate change on the overall drought and heat conditions for the Northern Great Plains region, which includes the states of Montana, Wyoming, North Dakota, South Dakota and Nebraska. Climate model projections paint a clear picture of a warmer future in the Northern Great Plains, with conditions becoming consistently warmer in two to three decades and temperatures rising steadily

towards the middle of the century. This warming is projected to occur in conjunction with less snowpack and a mix of increases and reductions in the average annual water availability. Precipitation and streamflow projections show only modest changes, but many areas within the region are already subject to a high degree of year-to-year variability—both wet and dry years. Low-probability, but high-severity and high-impact, events are the result of large variability, including both extreme flood events like in 2011 and drought events like in 2012. This interannual variability implies greater uncertainty about future climate and about the potential for future flooding and drought. Temperature increases of 2°– 4°F projected by 2050 for the Northern Great Plains under the lower scenario (RCP4.5) are expected to result in an increase in the occurrence of both drought and heat waves; these projected trends would be greater under the higher scenario (RCP8.5).

Also, the 2017 Climate Science Special Report, which provided information for the preparation of the Fourth National Climate Assessment, points to increasing mean temperatures in the Great Plains. This will lead to increased evaporation and drought frequency, which will compound water scarcity problems. In parts of the region, this will constrain development, stress natural resources, and increase competition for water among communities, agriculture, energy production, and ecological needs. Changing extremes in precipitation are projected across all seasons, including higher likelihoods of both increasing heavy rain and snow events and more intense droughts.

South Dakota will remain vulnerable to periodic drought, due to at least two primary factors. First, much of the agricultural area in South Dakota relies on rain (in other words, is not irrigated). Dry periods during the warm season can have devastating effects on crops grown in the State and on grass, hay and pastures. This critical sector of the State economy is very susceptible to drought impacts. Second, for water supply systems that rely on the Missouri River, such as many rural water systems both east and west of the river, changes in high elevation snowpack accumulation and earlier runoff in the northern Rockies may alter water availability and flow through the Missouri River system. because much of the projected increase in precipitation is expected to occur in the cooler months while increasing temperatures will result in additional evapotranspiration.

In regard to temperatures and extreme heat, warmer and more extreme temperatures can exacerbate drought impacts and result in consequences regardless of drought. According to the National Climate Assessment, for an average of seven days per year, maximum temperatures reach about 95ºF in the Northern Plains. These high temperatures are projected to occur much more frequently, even under a scenario of substantial reductions in heat-trapping gas (also called greenhouse gas) emissions, with days over 100ºF projected to double in number in the Northern Great Plains region by mid-century. These increases in extreme heat will have many negative consequences, including increases in surface water losses, heat stress, and demand for air conditioning. Additionally, summertime increases in humidity and a rising trend in minimum (overnight) temperatures are increasing heat stress risk to humans and animals. The animal agriculture (livestock) sector of South Dakota can be very susceptible to warm, humid nights and create stress on the physical health of animals.

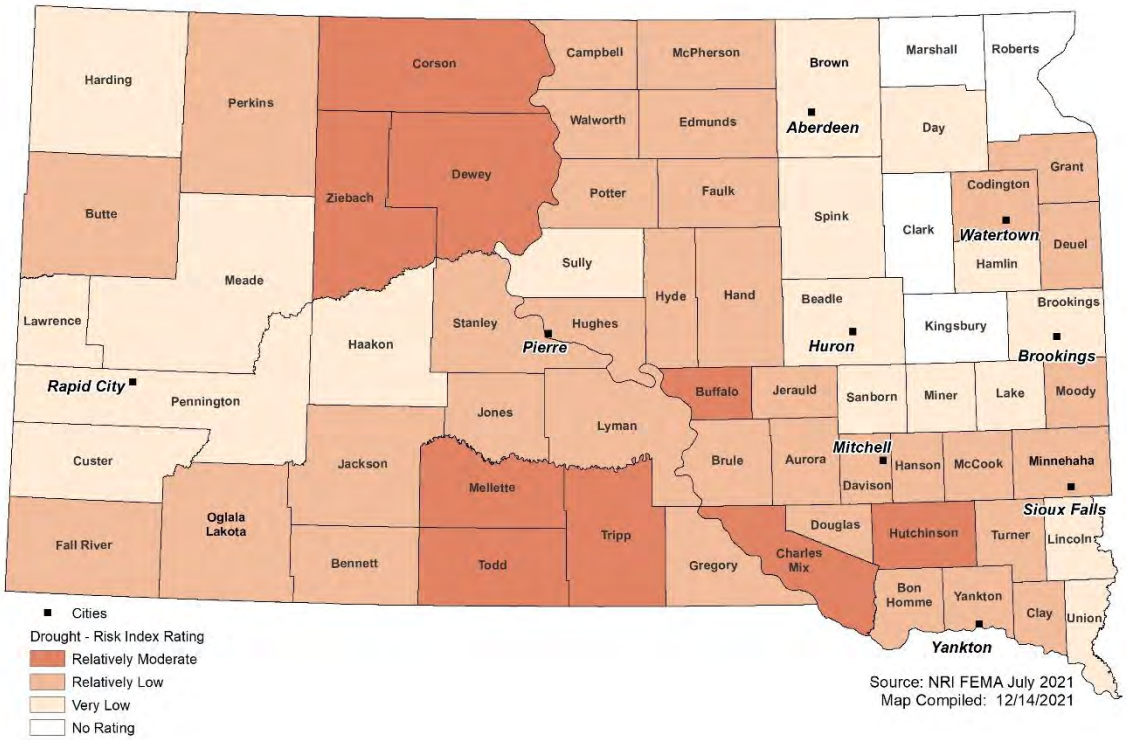
## Vulnerability Assessment

While all 66 counties in the State of South Dakota are vulnerable to drought hazard, none has high or very high-risk rating for drought events. Figure 3-57 illustrates the relative risk of South Dakota counties to drought hazard based on data in the NRI.

The NRI calculates the risk rating for drought by considering multiple parameters, including EAL value, social vulnerability score and community resilience score. EAL value, in particular, takes into account agriculture (crop and livestock) value exposed to drought occurrences, annualized frequency for drought events, as well as historical loss ratio for drought events. The agriculture value exposed to drought is

based on the value derived from USDA 2017 Census of Agriculture and CropScape data. The historical loss ratio is calculated based on SHELDUS data, which compiles data from the monthly Storm Data publication produced by NOAA's NCEI. NRI also utilizes data from NDMC's US Drought Monitor.

**Figure 3-57 NRI Drought Risk Rating by County in South Dakota**




## *People*

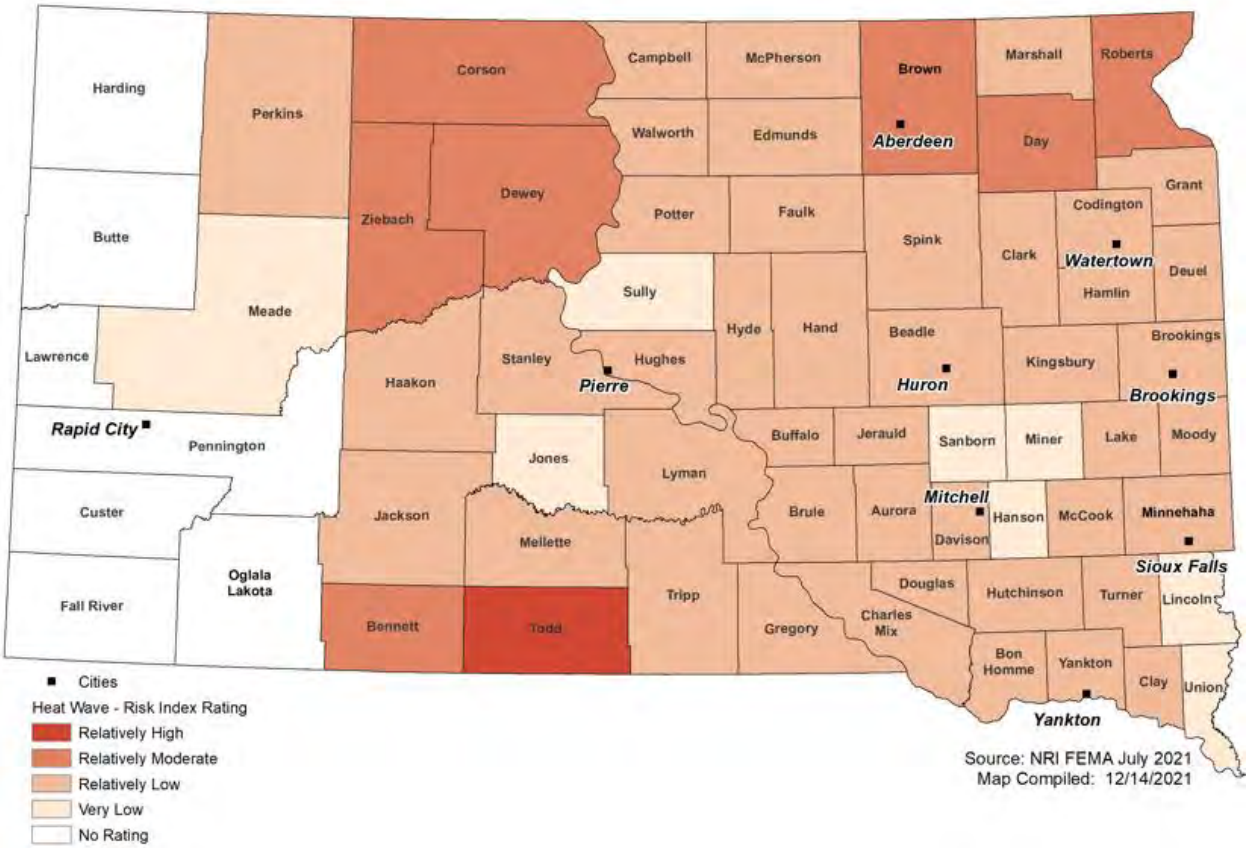
The historical and potential impacts of drought on populations include agricultural and recreation/tourism sector job loss, secondary economic losses to local businesses and public recreational resources, increased cost to local and state government for large-scale water acquisition and delivery, and water rationing and water wells running dry for individuals and families. Other public health issues can include impaired drinking water quality, increased incidence of mosquito-borne illness, an increase in wildlife-human confrontations and respiratory complications as a result of declined air quality in times of drought.

Drought may cause health problems related to low water flows and poor water quality; it may also cause health problems due to an excess of dust and poor air quality. According to the Centers for Disease Control, viruses, protozoa, and bacteria can pollute both groundwater and surface water when rainfall decreases. Acute respiratory and gastrointestinal illnesses are more easily spread from person to person, bacteria can more easily contaminate and cause infectious diseases, and recreational waters can become infected with pathogens that thrive in the shallow warm waters that exist during drought conditions. Generally, drought may require conservation of water resources, which could mean that water use is restricted to critical uses; this could impact how people use water on a daily basis. Those who are young, old, and suffering from chronic diseases could be especially vulnerable to the impacts of drought.

Refer to the 2015 South Dakota Drought Mitigation Plan for more details on vulnerability assessment for drought on people and the overall socioeconomic sector.

Heat waves that are sometimes associated with drought can directly impact human health. Risk associated with heat waves based on the NRI is shown in the figure below.

**Figure 3-58 NRI Heat Wave Risk Rating by County in South Dakota**

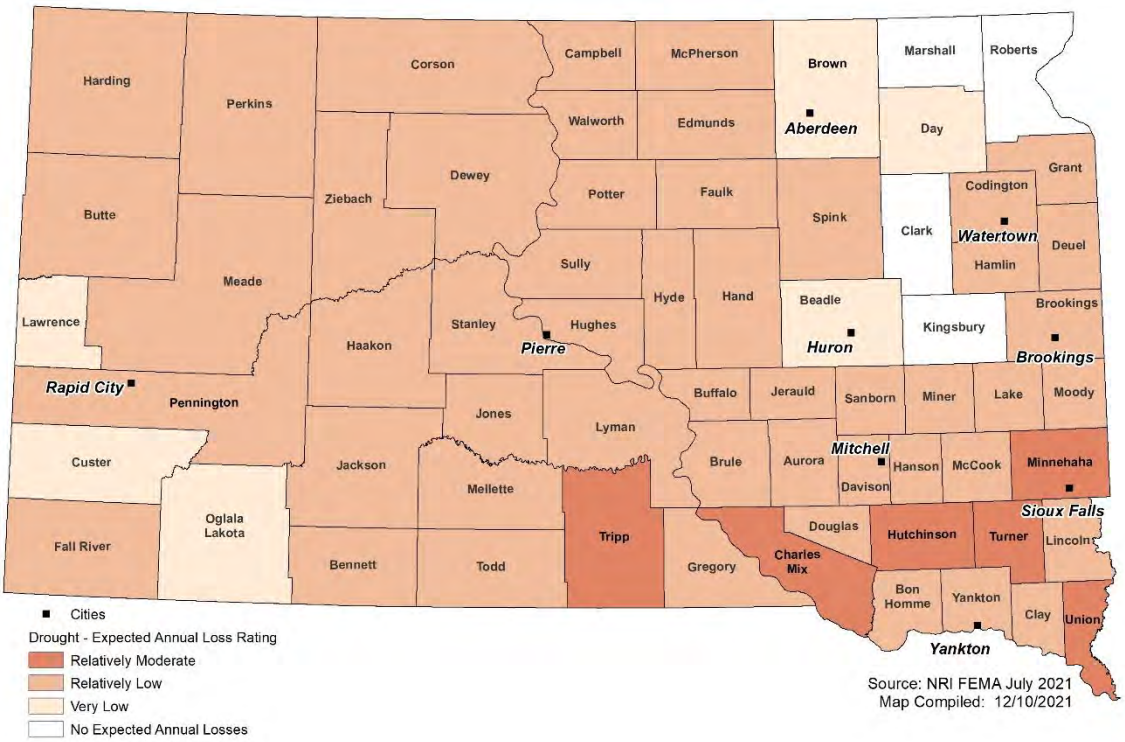



### *Property*

Drought does not typically have a direct impact on buildings, although an increase in expanding or collapsing soils could affect building foundations. Developed areas may experience damages to landscaping if water use restrictions are put in place, however these losses are not considered significant. Drought can affect soil shrinking and swelling cycles and can result in cracked foundations and infrastructure damage.

Figure 3-59 illustrates the relative risk of EAL rating due to drought for South Dakota counties based on data in the NRI. None has high or very high-risk EAL rating. As mentioned above, the EAL calculation takes into account agriculture value exposed to drought, annualized frequency for drought, and historical loss for drought. The EAL rating is thus heavily based on agricultural impacts.

**Figure 3-59 NRI Expected Annual Loss Rating for Drought in South Dakota**




## *State Assets, Critical Facilities and Infrastructure*

In terms of state assets, state parks in South Dakota are likely to suffer the greatest impacts from drought, particularly those that provide water-based recreational activities. Direct losses to the State can include lost revenue from park access fees. Other sources of state revenue that can be impacted by drought include hunting and fishing license sales. The SD Game Fish and Parks (GFP) annual budget is reduced due to a decrease in hunting, fishing, and boating license sales. This is discussed further in the 2015 South Dakota Drought Mitigation Plan, though currently the GFP does not track license sales in a way that makes the sales data easy to access or analyze patterns in drought years vs non-drought years. Tracking these data would allow for an economic analysis of drought impacts to the GFP. Based on an account in the Drought Impact Reporter the South Dakota Game, Fish, and Parks Department noted that the State lost approximately $1 million in pheasant hunter license fees during the 2005 drought. The drought conditions reduced pheasant populations and, corresponding, pheasant hunter numbers across the State.

Drought conditions rarely affect existing buildings, infrastructure, and critical infrastructure. However, severe to exceptional droughts can have significant consequences for water supply (drinking water and agriculture uses), water quality, firefighting, navigation, recreation and other critical facilities. Additionally, a higher demand on the water system infrastructure can lead to disruption of service due to line breakage. Possible losses to infrastructure also include the loss of potable water. Available data does not support a more detailed vulnerability and loss estimation for drought impacts on non-state critical facilities. One example is power plants that generate hydroelectric power from dams on the Missouri River could be vulnerable to drought-reduced reservoir levels.

The effect on local government infrastructure is the same as for the general public, and a drought may interrupt the normal operation of government in some places. For example, facilities dependent on wells may lose water supply.

### *Economy*

Drought impacts to the local or regional economy can be difficult to quantify but can be extensive and long lasting depending on the circumstances during, and after a severe drought event. If water resources are limited, effects would be more severe for industries that rely on large amounts of water and any prolonged drought would intensify these impacts. Sectors critical to the economy such as commerce, distribution, agriculture, tourism, related environmental resources, municipal and industrial water supply, key city assets, energy generation, and even socioeconomic aspects can be affected due to lack of, or even reduced quality of water resources.

Drought takes a particularly heavy toll on agriculture due to crop losses from lack of moisture. Farmers often protect themselves from the effects of drought by insuring all or a portion of their crop against drought losses. This is done through multi-peril crop insurance, which is underwritten by the RMA. The RMA, part of the USDA, maintains a database of crop insurance claims. Table 3-46 shows the crop losses due to drought in one of the most recent and severe periods of statewide drought, which occurred in 2012. Drought-related crop losses that year totaled $294,625,661. Data for 2002 and 2018 is compared to that of 2012, while all three are significantly dry years in South Dakota. In 2012 drought-related crop losses totaled $838,876,036, nearly three times as much as the losses in 2002, and over 33 times as much as the losses in 2018. The drought in 2012 was particularly worse for some counties, notably Hutchinson, Bon Homme, Charles Mix, Lincoln, and McCook. In 2013, the drought-related crop losses totaled $232,648,444. In 2014, the losses totaled $20,902,831 and in 2015, the losses totaled $48,005,987. The 2012 drought is still the last significant drought year with available data at the time of the 2022 HIRA update, while there is ongoing drought in the State during 2021 and 2022.

**Table 3-46 South Dakota Crop Loss Due to Drought: 2002, 2012 and 2018**

| County | 2002 Indemnities ($) | 2012 Indemnities ($) | 2018 Indemnities ($) |
|---|---|---|---|
| Aurora | $9,981,468 | $20,312,297 | $17,944 |
| Beadle | $16,888,079 | $15,920,978 | $75,547 |
| Bennett | $3,031,438 | $2,547,781 | $452,317 |
| Bon Homme | $6,868,510 | $53,074,783 | $231,878 |
| Brookings | $387,848 | $4,652,860 | $86,658 |
| Brown | $3,492,269 | $3,867,983 | $1,211,001 |
| Brule | $10,078,871 | $11,189,445 | $77,061 |
| Buffalo | $3,093,701 | $5,442,786 | $26,534 |
| Butte | $570,113 | $568,080 | $72,594 |
| Campbell | $3,352,881 | $1,639,784 | $440,231 |
| Charles Mix | $14,953,511 | $52,741,118 | $73,451 |
| Clark | $4,452,317 | $6,613,557 | $448,256 |
| Clay | $1,250,351 | $37,583,767 | $1,027,786 |
| Codington | $1,394,286 | $6,544,813 | $418,464 |
| Corson | $4,422,324 | $3,837,987 | $1,084,173 |
| Custer | $309,970 | $617,713 | $421,601 |
| Davison | $7,885,578 | $25,309,304 | $200,729 |
| Day | $979,621 | $2,046,009 | $301,942 |
| Deuel | $371,275 | $3,268,970 | $184,154 |
| Dewey | $2,612,684 | $1,718,676 | $407,325 |
| Douglas | $5,463,319 | $32,805,118 | $14,369 |
| Edmunds | $5,121,562 | $3,333,600 | $963,345 |
| Fall River | $319,562 | $1,659,373 | $867,392 |
| Faulk | $3,245,911 | $3,244,005 | $24,943 |
| Grant | $218,744 | $3,096,120 | $665,014 |

| County | 2002 Indemnities ($) | 2012 Indemnities ($) | 2018 Indemnities ($) |
|---|---|---|---|
| Gregory | $4,700,874 | $13,427,341 | $136,750 |
| Haakon | $4,439,525 | $5,317,145 | $443,221 |
| Hamlin | $347,794 | $5,296,778 | $90,110 |
| Hand | $12,896,771 | $7,447,056 | $3,471 |
| Hanson | $3,298,202 | $26,245,752 | $155,279 |
| Harding | $3,402,141 | $1,841,929 | $659,682 |
| Hughes | $9,941,061 | $5,915,209 | $180,563 |
| Hutchinson | $9,758,512 | $94,572,548 | $645,118 |
| Hyde | $8,411,019 | $4,555,116 | $28,894 |
| Jackson | $2,546,546 | $1,749,899 | $335,997 |
| Jerauld | $5,164,721 | $3,543,515 | $42,350 |
| Jones | $2,182,334 | $2,660,595 | $40,874 |
| Kingsbury | $4,896,508 | $4,912,931 | $89,748 |
| Lake | $1,167,346 | $3,646,413 | $112,215 |
| Lawrence | $19,545 | $83,794 | $9,072 |
| Lincoln | $139,801 | $55,931,547 | $1,287,250 |
| Lyman | $9,304,102 | $9,970,739 | $600,595 |
| McCook | $624,002 | $45,295,473 | $91,284 |
| McPherson | $4,624,314 | $4,338,115 | $372,712 |
| Marshall | $476,464 | $1,021,099 | $1,363,712 |
| Meade | $4,288,087 | $4,512,961 | $1,009,011 |
| Mellette | $1,187,891 | $1,459,244 | $210,054 |
| Miner | $3,799,930 | $6,899,052 | $68,251 |
| Minnehaha | $576,527 | $29,759,062 | $1,048,505 |
| Moody | $311,254 | $2,742,224 | $210,384 |
| Oglala Lakota | $1,188,991 | $1,157,968 | $424,217 |
| Pennington | $3,261,621 | $3,339,429 | $1,476,641 |
| Perkins | $8,077,696 | $3,292,653 | $506,923 |
| Potter | $13,821,626 | $3,994,871 | $102,966 |
| Roberts | $80,479 | $880,552 | $491,032 |
| Sanborn | $3,651,509 | $5,650,254 | $127,382 |
| Spink | $10,169,572 | $8,827,121 | $318,462 |
| Stanley | $4,749,540 | $1,951,946 | $100,258 |
| Sully | $18,609,676 | $8,206,428 | $40,962 |
| Todd | $978,776 | $1,580,025 | $27,876 |
| Tripp | $7,241,518 | $15,736,702 | $174,139 |
| Turner | $1,379,258 | $56,652,120 | $711,393 |
| Union | $131,241 | $28,868,718 | $634,841 |
| Walworth | $5,895,543 | $781,254 | $277,892 |
| Yankton | $3,498,560 | $49,536,920 | $785,405 |
| Ziebach | $2,638,591 | $1,636,631 | $173,704 |
| Total | $294,625,661.00 | $838,876,036 | $25,403,898 |

Source: RMA Cause of Loss Historical Data Files

Data on indemnity payouts for crop loss due to drought and high heat for 2015, 2018 and 2020 was also obtained from the RMA. In 2015, the State received $50,972,413 for crop loss due to drought and $320,331 due to heat, for a total of $51,292,744. In 2018, the State received $104,679,444 for crop loss due to drought and $6,055,591 due to heat, for a total of $ 110,735,035. This contrasts with the indemnity payments in 2020. The State did not experience severe drought conditions in 2020 when compared to

2015 and especially 2018. In 2020, the State received $25,403,898 for crop losses from drought and $1,438,379 for heat, for a total of $26,842,277.

Moreover, average annualized losses were calculated based on RMA historical crop indemnity data. The 2007-2020 indemnities related to drought were added together and then divided by 14 (for the 14-year time period from 2007 to 2020). Over that 14-year period, insured crop losses in South Dakota due to drought have averaged $137.55 million annually.

Furthermore, refer to Figure 3-59 that shows the EAL Rating by County in South Dakota based on data from NRI. In addition, the 2015 South Dakota Drought Mitigation Plan also contains more details on drought hazard's impact on agriculture and economy. To conclude, severe drought years can have a devastating financial impact on South Dakota's agricultural industry.

### *Environment and Cultural Resources*

Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes, and vegetation. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

Drought can also increase risk of wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. A drought may also increase the speed at which dead and fallen trees dry out and become more potent fuel sources for wildfires. Drought conditions can also cause soil to compact, decreasing its ability to absorb water, making an area more susceptible to flash flooding and erosion.

While drought's direct impacts on cultural resources may be minimal compared to other hazards' direct impacts, drought's damage to plants, the degradation of the landscape, and increased erosion can deflate or remove cultural resources entirely from their original locations, severely impacting the integrity of the resources. As an example, based on input from the SHMT In 2021, the USDA Farm Service Agency (FSA) allowed most of the counties in South Dakota to apply for funding through the Emergency Conservation Program (ECP) to mitigate the effects of drought and/or wildfire. The State Historic Preservation Office alone received 765 ECP projects for consultation under Section 106 of the National Historic Preservation Act.

Additionally, lower water levels, particularly in man-made reservoirs, exposes previously inundated cultural resources, creating exponential increases in the looting of archaeological sites and cultural resources.

## Development Trends and Consequence Summary

Development trends are not anticipated to affect drought vulnerability. A summary of the myriad consequences of drought is captured in the table below.

**Table 3-47 Drought Consequence Table**

| Category | Narrative |
|---|---|
| Impact on the Public | Health impacts from low water quality; reduced air quality; increased risk of infectious diseases/contamination; water supply disruptions and reduced water quality could impact service delivery; air quality from blowing dust could have detrimental health impacts |
| Impact on the Economic Condition of the State | Agricultural economies are adversely affected if drought results in widespread loss of crop or yield reductions or livestock impacts. Agricultural supply and support industries can also be affected. Food costs increase due to higher costs or lack of production; reduced tourism and recreation revenue for activities reliant on precipitation (i.e. water sport industries, fishing, hunting). Local economy and finances dependent on consistent water supply or precipitation may be adversely affected for duration of drought |
| Impact on the Environment | Disruptions in wildlife and habitat, including increased animal mortality; decreased land quality; low stream flows; increased water contamination. May cause disruptions in wildlife habitat, resulting in an increasing interface with people, or reducing numbers of animals if forage becomes too sparse. Land quality can be negatively impacted by overgrazing during drought. Water quality can become degraded to the point of causing localized fish kills. Low stream flows and higher water temperatures will have negative impacts on riparian habitats and aquatic species |
| Impact on Property, Facilities, and Infrastructure | Infrastructure can be damaged by excessively dry expansive soil as it contracts; dams and ditches can experience structural damage due to decreased pore water pressure, damage caused by high sediment loads when pulling water from the bottom of reservoirs, and damage caused by debris flows and flooding following wildfires. Water treatment facilities may be stressed. Reduced hydroelectric power generation |
| Cascading Hazards | Wildfire, Flood, expansive soil issues |

### 3.3.7 Tornado

#### Hazard Description

The NWS defines a tornado as a violently rotating column of air extending from a thunderstorm to the ground. The most violent tornadoes are capable of tremendous destruction with wind speeds of 250 mph or more. Damage paths can be in excess of one-mile wide and 50 miles long. In an average year, about 1,000 tornadoes are reported across the United States, resulting in approximately 80 deaths and more than 1,500 injuries.

Though climate data is available to explain a predisposition to tornadoes, there is no accurate way of predicting when or where a tornado may occur. Tornado systems have been linked to the development of temperature and wind flow patterns in the atmosphere, which can cause moisture, instability, lift, and wind shear. Expert predictions of these conditions begin first by modeling in the long-term and relying on critical analysis of satellite data, weather stations, balloon packages, airplanes, wind profilers, and radar-derived winds to pinpoint storm activity for the short-term.

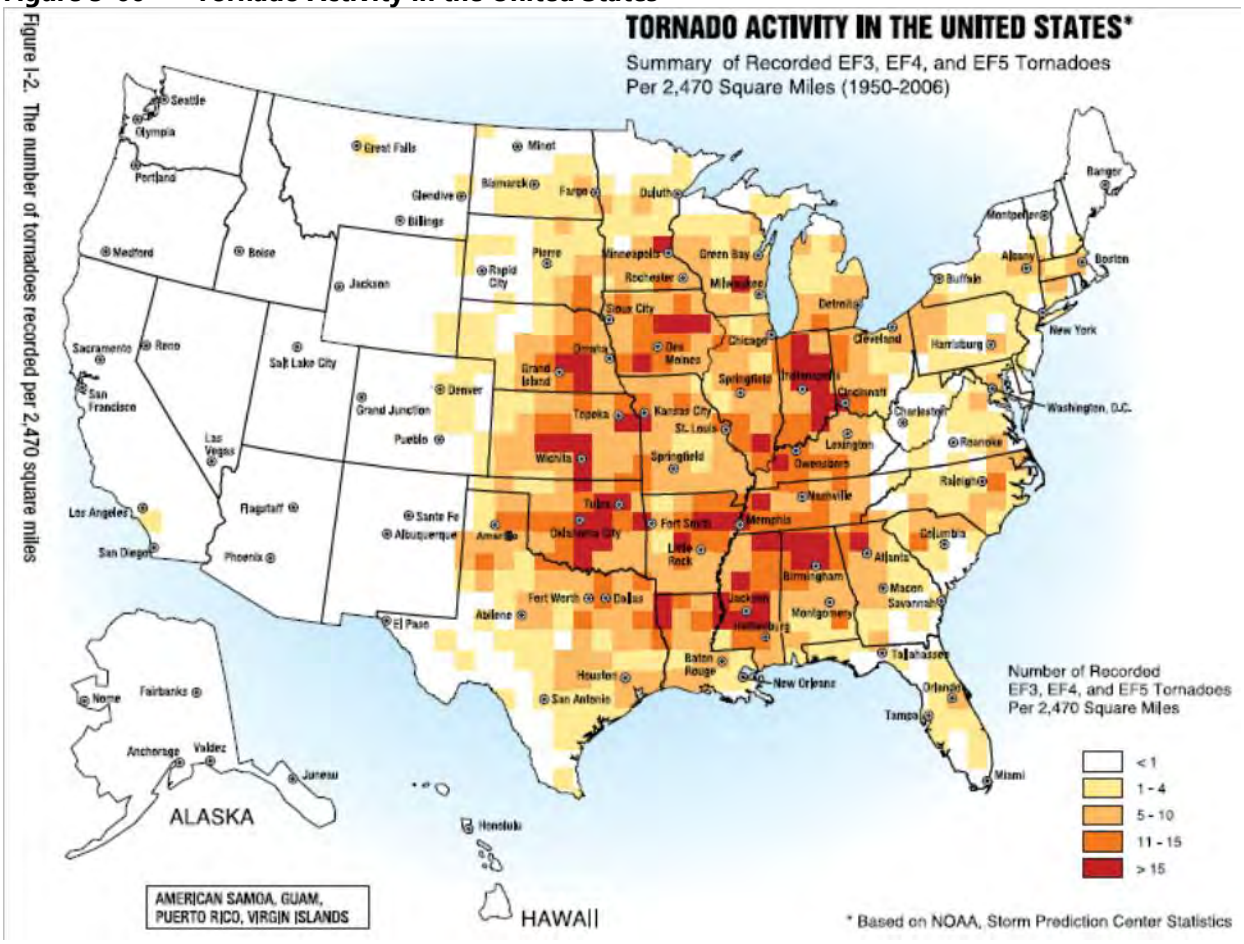
Tornadoes typically occur in South Dakota in May, June, and July, but they can occur in any month. The greatest period of tornado activity (about 82 percent of occurrence) is from 11 a.m. to midnight. Within this time frame, most tornadoes occur between 4 pm and 6 pm.

#### Location

Tornado disasters are often associated with Tornado Alley (the area from the Gulf to the Northern Great Plains that has high tornado incidence). South Dakota sits in the northern region of Tornado Alley and is susceptible to the specific conditions to which the formation of tornadoes has been attributed: warm Gulf air coming in contact with cool Canadian air fronts and dry air systems from the Rocky Mountains. The intersection of these three systems produces thunderstorm conditions that can spawn tornadoes. According to NOAA, tornadoes can occur at any location and from a wide variety of conditions. Western South Dakota, though not in the Tornado Alley, is still vulnerable to tornadoes of different strengths.

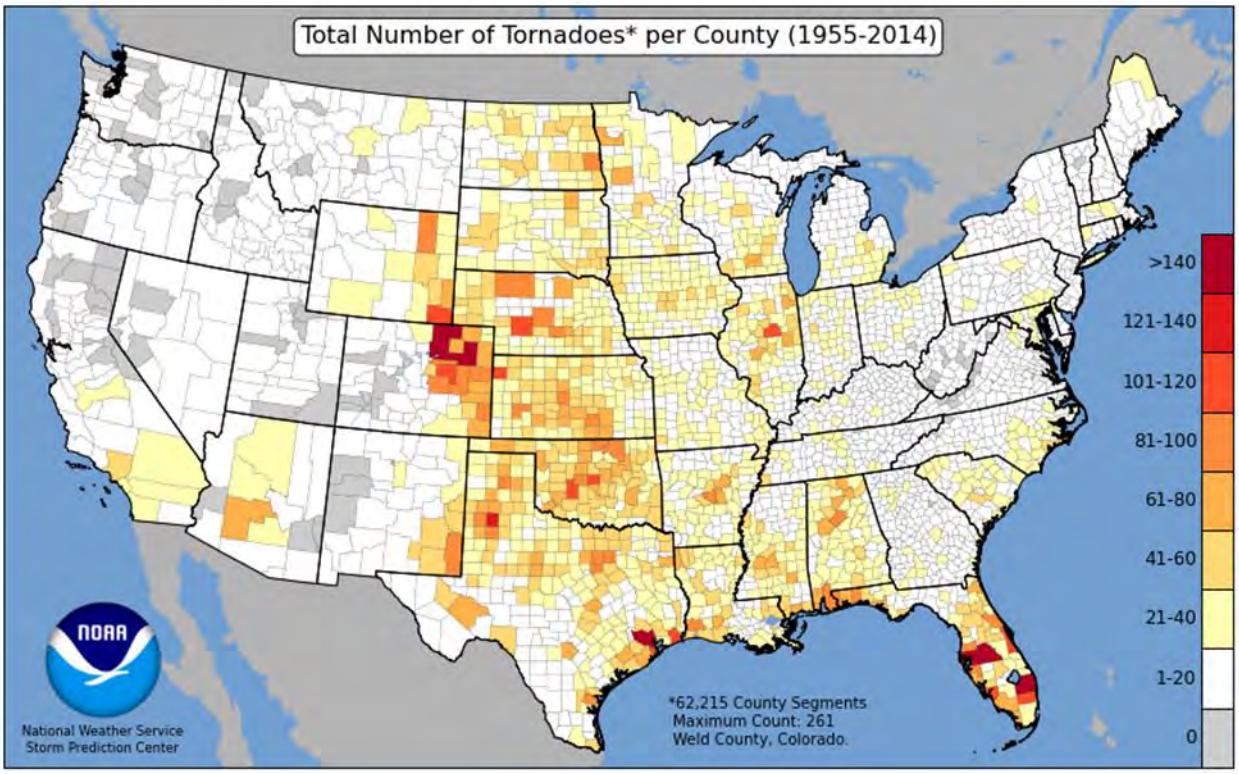
Figure 3-60 illustrates the number of F3, F4, and F5 tornadoes recorded in the United States per 2,470 square miles between 1950 and 2006. Figure 3-61 illustrates the total number of tornadoes per county from 1955 to 2014. By noting the South Dakota data from these two maps and matching them up to the Wind Zone table (Table 3-52) in the Windstorm section, it appears that approximately 90 percent of South Dakota has a high tornado risk and 10 percent has a moderate tornado risk. A very small area in the northwest corner of the State has a low tornado risk.

**Figure 3-60 Tornado Activity in the United States**




Source: Taking Shelter from the Storm (FEMA 2008)

**Figure 3-61 Total Number of Tornadoes per County, 1955-2014**




Source: NOAA

## Past Events

According to the NCEI Storm Events Database, there were 726 tornadoes in South Dakota between 1950 and 2021 rated as an F1 or higher. Tornadoes reported in the database are in segments. One tornado can have multiple segments as the NCEI counts a new segment when county boundaries are crossed. So, the number of past occurrences is really a reflection of the number of past tornado segments. Total property damage for these events is estimated at $706,258,000. There were 27 deaths and 466 injuries in this time period. This number increases to 29 deaths and 466 injuries if all tornado events, including those smaller than an F1, are recorded. This suggests that South Dakota averages 10 tornadoes of F1 intensity or greater, $972,907 in damages, and seven injuries each year.

Figure 3-62 shows tornado paths of individual tornadoes where data was available.

**Figure 3-62 Tornado Paths in South Dakota 1955-2019**

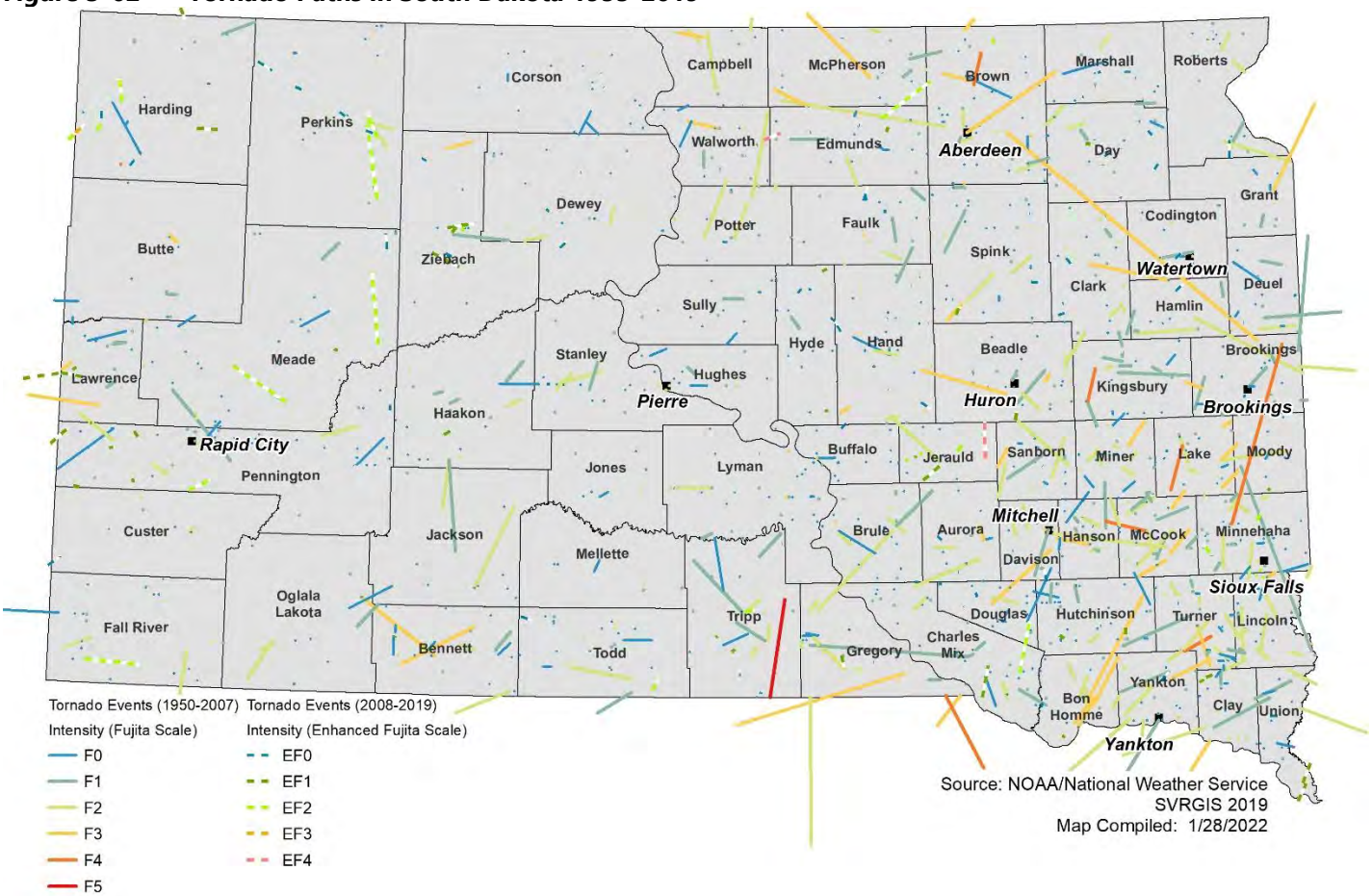



**Table 3-48 South Dakota Tornadoes**

| Date | Comments |
|---|---|
| August 29, 2021 | Based on Sentinel satellite imagery, the tornado spun up in Turner County around 2 miles west southwest of Lennox in a field southwest of the intersection of 464th Avenue and 279th Street. The tornado tracked east-northeast for around one-half mile and crossed into Lincoln County just south of the intersection of 279th Street and 464th Avenue. After another half mile, the tornado uprooted seven large cottonwood trees and damaged numerous others at the Lenkota Country Club. The tornado continued into the western portions of Lennox north of the city park, with a majority of damage to large trees between 4th and 5th Avenue as the path turned more eastward and eventually a bit southeastward. The most significant damage occurred as the tornado approached State Highway 17, with a trampoline deposited high in a gnarled tree along South Cherry Street, and the complete destruction of a shed just east of Highway 17. The tornado lifted about a quarter mile east of Highway 17, just east of Lennox. Areas south of the path experienced strong rear-flank winds. While in Turner County, the tornado was rated EFU, while in Lincoln County it was rated EF1. The average path width for the tornado was 100 yards. Property damage costs are a rough estimate. Damage was estimated to be $75,000 according to the NCEI database. |
| August 30, 2020 | The tornado initially touched down in the pastureland east of South Dakota Highway 45, roughly 0.8 miles south of 184th Street. It continued to track north for roughly 0.6 miles, damaging a tree grove and fence line. The track then turned west northwest and crossed South Dakota Highway 45, roughly 0.2 miles south of 184th street. A southbound RV pulling an enclosed trailer was struck. The trailer detached from the RV and the RV was lofted and rolled |

| Date | Comments |
|---|---|
| | roughly 200 yards into a corn field on the west side of South Dakota Highway 45. The driver was pronounced dead at the scene. The tornado track continued west northwest through the corn field for an estimated 0.4 miles. The tornado was at its peak width and intensity at this point. Corn was completely flattened in some areas with a distinct convergent pattern. As the tornado weakened and roped out the path took a southwest turn and persisted for roughly another 0.6 miles before coming to an end in the corn field. |
| August 28, 2020 | A tornado formed just southwest of the intersection of 203rd Street and 428th Avenue. During a brief touchdown and eastward travel, damage was limited to crops, marked by ground scour noted on high-resolution satellite data. The tornado lifted around a quarter mile east of 428th Avenue. Crop damage is an estimate from insured losses. Information provided by the USDA. |
| July 6, 2020 | A long-lived supercell thunderstorm tracked east-southeast from Wyoming across parts of the northern Black Hills and west central South Dakota, including the Rapid City area. The storm produced hail as large as baseball size as it moved through Rapid City, with gusty winds as well. Significant damage to vehicles and property occurred in western and southern portions of Rapid City. The storm also produced an EF2 tornado over the northern Black Hills, where it snapped and uprooted large Ponderosa Pine trees. |
| July 4, 2020 | A tornado touched down 3 miles north northwest of Wetonka causing significant damage to the Grassland Hutterite Colony. A large machine shop lost the roof and wall. A large, empty, anchored grain bin was completely removed from its base and the adjacent feed mill was significantly damaged. A 400 foot by 80-foot turkey barn was completely destroyed along with a smaller outbuilding. Debris from these two buildings was scattered in many directions. A trailer was flipped, freight storage unit rotated, and two other outbuildings had complete loss of roof panels. Roof and siding damage occurred to many of the residential buildings. Tree and crop damage had also occurred. The tornado tracked over 2 miles southeast, crossing Mcpherson County Highway 23 and ending about one mile north northeast of Wetonka. Debris from the Grassland Colony was dispersed along the entire track of the tornado. |
| September 10, 2019 | A frontal boundary provided focus for convective development across south central South Dakota during the very late afternoon and early evening as a strong impulse moved in the southwest flow aloft. Initial discrete cells produced spotty hail and damaging wind, with MLCAPE values around 1500-2000 J/kg and 45-55 knots of deep layer shear. As cells spread eastward and developed into a line, the increase in low-level jet during the evening quickly increased the 0-3 km shear to 35-40 knots. Three QLCS tornadoes occurred within the city limits of Sioux Falls. In addition to the tornadoes, widespread wind damage to trees and spottier damage to residences were reported across much of the city. A total of nine people were injured in the storms around Sioux Falls. Repeated cells resulted in flash flooding by later evening and into the overnight hours. |
| August 6, 2019 | A tornado developed and touched down in the heart of town near Washington and 7th streets, causing damage to several trees at the touchdown point. Shortly after, the tornado severely damaged several structures while tracking south, including leveling several buildings at the lumber yard, destroying the civic center, and causing significant damage to the school. The start of the school year was delayed by two weeks due to extent of the damage. Two people were (directly) injured by debris when a garage collapsed on them while moving vehicles to safety. Numerous power transmission poles and lines were removed by the tornado. Around 2 miles south southeast of Burke, the tornado struck a residence causing severe damage to the roof. Shortly thereafter, the tornado lifted before reaching the intersection of 295th Street and 345th Avenue after traveling a bit less than 4 miles. The path width reached a maximum of 75 yards within the city of Burke. Up to 3000 trees were damaged by the tornado in and near Burke. Property damage costs are rough estimates. |

| Date | Comments |
|---|---|
| July 18, 2019 | A brief land spout occurred during the initial phase of scattered thunderstorms which developed rapidly along a weak convergence boundary. The brief land spout touched down in a cornfield near the intersection of 467th Avenue and 258th Street in Crooks. The tornado traveled generally toward the east-southeast just on the north side of 258th Street, striking a farm outbuilding and removing several metal roofs panels at the very end of its track. |
| July 17, 2019 | A tornado spun up around two miles north of Tripp, touching down just east of a railroad line east of State Highway 37 and north of 285th Street. The tornado tracked to the southeast, where it impacted a farmstead, causing significant damage to two barns and destroying a small outbuilding. The tornado continued across 411th Ave. where it removed the second story of a poorly constructed residence. Fortunately, the residents were not home at the time. After a mile on the ground, a third farmstead was struck tearing metal roofing from a barn. At this point, the tornado veered a bit more southward, finally lifting just after crossing U.S. Highway 18 near 412th Avenue. |
| June 28, 2018 | A tornadic thunderstorm tracked east-northeast from Montana across Harding County during the evening. The storm produced several tornadoes, including four in Harding County. The largest of the tornadoes was rated EF-3 and caused significant damage at a couple of ranches. Each event is described below:<br><br>The tornado started south of Capitol, Montana and crossed the state line into South Dakota approximately ten miles south southwest of Camp Crook. The tornado produced considerable tree and structural damage west of South Camp Crook Road. It also lifted and destroyed some farm machinery, including a five-ton tractor that was found a few miles northwest in Montana. East of Camp Crook Road, a large farm outbuilding was destroyed, and its foundation was extracted from the ground and broken apart. The tornado was rated an EF-3 with peak wind speeds estimated around 136 mph.<br><br>The tornado developed just south of SD Highway 20 near mile marker 17, where it snapped power poles and trees near a house. A farm outbuilding was also severely damaged, with most of its exterior walls collapsed. Based on video evidence, the tornado then continued northward across rural areas northwest of Buffalo and crossed Clanton Road before dissipating. The tornado was rated an EF-2 with peak wind speeds estimated near 115 mph.<br><br>Based on eyewitness reports and video evidence, the tornado developed east of the first tornado near Johnson Draw and continued northeastward to near Waterhole Creek before dissipating. A home on Holcomb Place was damaged. The tornado was rated an EF2 with peak wind speeds were estimated near 120 mph. |
| June 13, 2016 | A severe thunderstorm developed over the eastern slopes of the central Black Hills and tracked northeastward onto the plains. The storm produced large hail and eventually formed into a line of storms with strong wind gusts as it moved across the plains. An EF2 tornado developed as the storm moved north of Hermosa; Numerous pine trees were snapped along Murphy Road where the tornado initially formed. Several power poles were snapped where it crossed Highway 79. Several homes were badly damaged, and many outbuildings were destroyed as the tornado passed through the Spring Creek Acres subdivision. The property damage is estimated at $100,000 |
| May 22, 2016 | An EF2 tornado developed over southeastern Todd County and moved northeastward for about ten minutes. The tornado did not damage any structures as it tracked across fields for almost five miles. However, it did snap eight to ten power poles at the ground at the intersection of Littleburg Road and Hidden Timber Road. Several large trees in a shelter belt were snapped off and uprooted. Property damages are estimated at $10,000. The same storm produced an EF1 tornado in Tripp County and resulted in $25,000 in property damages. |

| Date | Comments |
|---|---|
| August 6, 2015 | Thunderstorms produced damaging winds in southeast South Dakota during the afternoon and early evening of August 6th. The storms affected mostly Brookings County, but the first report was some distance away in Gregory County, and there were reports in Moody County also. There were also two tornadoes and one report of large hail.<br><br>A tornado damaged the roof, gutters, and siding of three houses, damaged the roof, patio deck, chimney, and garage of another house, and damaged a fence. Damages estimated at $80,000. |
| June 19, 2015 | A long-lived complex of severe thunderstorms tracked from southeastern Montana across northwestern South Dakota. The strongest storms produced hail to six inches in diameter, wind gusts over 80 mph, and a tornado in southern Meade County. Significant structure, property, and crop damage was reported in Butte and Meade Counties. Livestock were killed by the large hail in the Nisland area, with one rancher losing 35 sheep. The storms continued into south central South Dakota, but no reports were received due to a widespread power outage.<br><br>A tornado touched down in rural southern Meade County, damaging buildings and tossing equipment at two ranches. Damage estimated at $100,000. |
| May 10, 2015 | Thunderstorms over southeast South Dakota from late morning to the start of the evening on May 10th produced several tornadoes, including one that caused injuries and severe damage in Delmont in Douglas County. The thunderstorms also produced large hail, damaging winds, and flash flooding in locations extending to the eastern border of the State.<br><br>A tornado, crossing into Douglas County from Charles Mix County, destroyed or damaged 84 structures in and near Delmont, and injured nine people in Delmont. About 50 of the homes and other structures were destroyed or severely damaged. The damage included numerous small farm buildings totally destroyed, most at four farms south of Delmont, several houses severely damaged, a large 100-year-old church severely damaged, and a newly constructed fire hall destroyed. Power lines and poles were down, and the town was without power and water for two days. 100 residents were displaced. Damages estimated at $1.5 million. |
| June 18, 2014 | Thunderstorms during the evening of June 18th produced tornadoes in Jerauld County, with one tornado crossing briefly into Beadle County. The tornadoes included one that caused severe damage to Wessington Springs. There was also a report of large hail.<br><br>A tornado severely damaged two-family farms, including destroying a farmhouse as the family took shelter in their basement. A couple in the house suffered minor injuries. The tornado also damaged trees, power poles, and power lines; and caused an unknown amount of crop damage. The tornado crossed briefly into Beadle County before lifting. Damage estimated at $325,000. |
| June 17, 2014 | Thunderstorms during the late evening of June 17th produced a tornado near Humboldt South Dakota in Minnehaha County and large hail near Dolton in McCook County.<br><br>The tornado blew down the exterior walls of a house, in which a family escaped injury by taking shelter in the basement. The tornado also tore the roof off a farm storage building, tore the metal roof off a metal building, blew down electrical poles, and caused tree damage, including several trees snapped off at the trunks. Damage estimated at $100,000. |
| October 4, 2013 | A tornado crossed the Missouri River from Dakota County in Nebraska and entered Union County. The tornado severely damaged the roof of a house, and collapsed a chimney, carport and porch roof, and the walls of a garage in the same house. The tornado also caused tree damage, including trunks snapped, overturned an irrigation system, and damaged the roof, siding, and/or gutters of at least four other houses. Damage estimated at $450,000. |
| May 28, 2013 | A tornado touched down on the west side of Allen Road south of Allen and rolled a mobile home down a hill. It tore off the roof and collapsed several walls of a small stick-built house on the east side of the road before dissipating. Damage was estimated at $100,000. |

| Date | Comments |
|---|---|
| June 22, 2012 | A severe thunderstorm tracked eastward from Wyoming across southern Fall River County. The storm produced enormous hail near Edgemont and a tornado between Edgemont and Ardmore. The tornado damaged buildings on a ranch north of Ardmore and blew down power poles and trees. A large wooden barn was completely destroyed; its walls and roof were blown more than 100 yards away. Two large sheds lost roofs and walls, and smaller sheds were blown apart. A modular house sustained minor damage. Damage was estimated at $500,000. |
| June 12, 2011 | A cluster of severe thunderstorms moved east from northeastern Wyoming and southeastern Montana across Harding and Butte Counties. The storms produced hail, wind gusts near 80 mph, and a small tornado west of Redig. The tornado destroyed part of a barn, rolled large steel calf shelters, blew down steel stockade walls, and lifted a calf shelter over a nine-foot fence. |
| May 9, 2011 | A severe thunderstorm produced a tornado northeast of Wall and wind gusts to 60 mph over far eastern Meade County. A large electric transmission tower was crumpled, seven wooden power poles were snapped, and trees were snapped. |
| June 16, 2010 | FEMA-1929-DR<br><br>An intense low-pressure system developed across the Northern Plains states and impacted the region on June 17. At least 61 tornadoes were reported that afternoon and evening across North Dakota, South Dakota, and Minnesota. A supercell around Dupree and Faith spawned 16 or more tornadoes, with four and possibly five on the ground at the same time. |
| May 22, 2010 | Severe weather shifted north as a low-pressure system tracked across the Northern Plains states on May 22. Isolated tornadoes were reported across portions of central South Dakota that afternoon. The most intense supercell produced a long-lived wedge tornado in and around Bowdle, South Dakota where numerous houses and farm buildings were destroyed, and cars were thrown into the air. It was rated as an EF4, but fortunately remained in rural areas and no injuries were reported. Tornadoes in Edmunds and McPherson Counties damaged 60 utility poles. FEM Electric customers on 40 meters were without power for 48 hours. Emergency repair and restoration costs for FEM Electric were estimated at $210,000. |
| July 9, 2009 | Severe storms developed over Fall River County and moved eastward across southwestern and south-central South Dakota. The storms produced large hail and strong wind gusts. Two tornadoes were observed in Todd County and two tornadoes touched down in southern Tripp County. A small tornado touched down on a farm west of the intersection of 286th Street and 313th Avenue. The tornado blew a garage off its foundation, tipped over a combine, and snapped large cottonwood trees. |
| May 12, 2009 | An F1 tornado traveled for eight miles with a width of 200 yards. The tornado touched down west of Dupree and tracked eastward before dissipating northeast of Dupree. It dented several grain bins, blew over a small mobile home and semi-trailer truck, tore sheet metal off sheds, and toppled a large communications tower. |
| June 5, 2008 | An F1 tornado 100 yards wide damaged a path ten miles long. The tornado severely damaged a home, destroyed outbuildings, and damaged storage bins at a farm near Ravinia. The tornado also caused tree damage along its path.<br><br>An F2 tornado caused damage to silos, farm buildings, power lines, and numerous trees southeast of Baltic. |
| May 29, 2008 | An F-1 Tornado two miles long and 100 yards wide destroyed a barn, damaged or destroyed several outbuildings, scattered lumber across a field, and damaged trees and power lines. Damages were estimated at $100, 000. |
| May 5, 2007 | Severe Storms, Tornadoes, and Flooding (FEMA-1702-DR) |

| Date | Comments |
|---|---|
| | Twenty-five tornadoes were recorded in southeast South Dakota. It was the most significant tornado outbreak in southeast South Dakota since June 24, 2003.<br><br>The strongest tornado, an EF-3, occurred in Aurora County. On the ground for five miles, it did its most significant damage to a pheasant hunting lodge/preserve, where numerous buildings and trees were severely damaged and numerous adult and chick pheasants were lost. Winds were estimated at around 140 mph.<br><br>In Bon Homme County, an EF-2 tornado was on the ground for six miles, severely damaging many homes, barns, outbuildings, and trees.<br><br>An EF-2 tornado traveled through both McCook and Hanson Counties and was observed to be very large before it dissipated. Most of the damage was to trees and a junk yard.<br><br>In western Hanson County, an EF-1 tornado damaged trees and took a roof off a building.<br><br>In Yankton County, a tornado began at the Lewis and Clark Recreation Area and resulted in considerable tree damage and damage to homes. It was on the ground for approximately four miles. For a while, it was joined by a second tornado. These tornadoes were determined to be EF-1s based on the damage homes.<br><br>High winds related to these storms damaged power distribution lines and poles in Bon Homme and Yankton Counties. Seven poles were damaged in Bon Homme County for a total of $13,014 in damages. Twenty-five poles were damaged in Yankton County for $34,809 in damages. 20 outages affected 214 customers, leaving them without power for roughly 9 hours.<br><br>Source: NWS Sioux Falls and SHMT |
| September 16, 2006 | Seven tornadoes touched down over southeast South Dakota. The strongest, an F2, was in McCook County and damaged several buildings and killed several cattle. An F1 tornado in Minnehaha County damaged some buildings and downed power lines. There was no damage reported from the other storms (F0s).<br><br>Source: NWS Sioux Falls |
| August 26, 2006 | Severe weather in east central South Dakota produced at least three tornadoes. In Beadle County, two tornadoes did considerable damage to farmsteads, power lines, and crops. One was a 24.5-mile-long-track F2/F3 tornado with winds up to 200 mph that measured between 400 and 500 yards at its widest. Another tornado touched down in Kingsbury County but did little to no damage.<br><br>Source: NWS Sioux Falls |
| May 2, 2006 | An F1 tornado touched down in Kingsbury County. While the tornado was generally F0, there were a couple of periods where it approached F1 intensity. It hit a hog operation, destroying a barn and two other outbuildings, downing several trees, and killing numerous hogs.<br><br>Source: NWS Sioux Falls |
| June 24, 2003 | Sixty-seven tornadoes touched down in South Dakota on this day. This rare occurrence tied the U.S. record at the time for the most tornadoes within a state in a 24-hour time period. However, the 67 tornado touchdowns recorded that day occurred in a period of less than eight hours. The strongest of the 67 tornadoes was an F4, which destroyed the town of Manchester and injured five people. Winds were estimated to be between 207 and 260 mph.<br><br>The tornado warning issued by the NWS in Sioux Falls provided the residents of Manchester with 28 minutes of advance warning. The NWS offices in Aberdeen and Sioux Falls issued more than 350 warnings, statements, and storm reports on the evening of June 24. The 67 tornado touchdowns recorded that day represented a significant portion of the 85 total tornado |

| Date | Comments |
|---|---|
| | touchdowns recorded for all of 2003. Despite the historic events of this day and the destruction of the town of Manchester, no presidential disaster declarations were issued. |
| June 23, 2002 | Four separate tornado tracks and two satellite tornadoes were confirmed across McPherson and Brown Counties.<br><br>The first was an F0, the second an F1, the third and F3, and the fourth an F4. This was the first F4 tornado recorded in Brown County.<br><br>Source: NWS Aberdeen |
| July 27, 2001 | In Lincoln County, an F1 tornado downed numerous trees and damaged storage sheds and buildings along Main Street in Lennox, including the VFW (Veterans of Foreign Wars).<br><br>Source: NWS Sioux Falls |
| July 11, 2000 | An F2 tornado hit Lake County and damaged the Lake County Speedway.<br><br>Source: NWS Sioux Falls |
| June 4, 1999 | Severe Storms, Flooding, and Tornadoes (FEMA-1280-DR)<br><br>A deadly tornadic storm moved across southwest South Dakota during the late afternoon and evening of June 4. Multiple tornadoes (F1 and F2) were observed from several supercells that moved toward the northeast from west of Chadron, Nebraska, to near Kyle, South Dakota, between 5:30 and 8:00 p.m. The most severe damage occurred where the paths of these storms passed near the community of Oglala in Oglala Lakota County (previously Shannon County), South Dakota. Oglala was heavily impacted by the tornadoes as were other smaller communities on the Pine Ridge Indian Reservation.<br><br>The Red Cross estimated that 123 homes sustained major damage and an additional 139 sustained minimal damage. FEMA deemed 49 homes beyond repair and demolished them. In one area, all the telephone poles were snapped and tossed, mobile homes were thrown over 100 yards with debris strewn over a quarter of a mile, and a newly framed house was leveled with wood projectiles in the ground 100 yards downwind. The total public assistance damage for the disaster was $1,029,000. One person was killed and over 40 were injured; 22 required medical attention at area hospitals. The fatality was the first from a tornado in western South Dakota since 1939 and only the third ever recorded in western South Dakota.<br><br>Very large hail was also reported in the area. Grapefruit-sized hail was observed two miles west of Oglala with golf ball and baseball-sized stones reported in Oglala itself. |
| May–June 1998 | Flooding, Severe Storms, and Tornadoes (FEMA-1218-DR)<br><br>By late afternoon of May 30, 1998, the atmosphere over the north central United States had become favorable to a significant outbreak of severe weather. At approximately 8:40 p.m., following a series of thunderstorm warnings and numerous funnel sightings in the area, a violent tornado struck the town of Spencer, South Dakota, approximately 45 miles west northwest of Sioux Falls in extreme western McCook County. Deemed the deadliest tornado in recorded South Dakota history, the F4 tornado killed 6 people, injured more than one-third of the town's 320 residents, and destroyed most of the town's 190 buildings, including all public and numerous private facilities. Only 12 structures were left standing in the entire town of Spencer. An assisted living center was destroyed, and since it had no basement, there was no protection from the tornado. Most of the fatalities were residents of the center. In addition to the town of Spencer, some farms in Hanson and McCook Counties were heavily damaged. Total damage was estimated at $18 million.<br><br>During the storm, electrical service was out. Survivors reported that the warning siren system lost power prior to the touchdown of the tornado. |

| Date | Comments |
|---|---|
| June 14, 1993 | Pierre - Three homes damaged. No deaths.<br>Arlington - Minor damage. |
| March 29, 1981 | A winter storm front created a tornado near Martin, which destroyed a mobile home and injured one occupant. |
| May 12, 1984 | Clark and Codington Counties - 18 to 20 farmsteads and homes were directly affected and ten homes severely damaged. |
| June 19, 1979 | Watertown - Damage to trees, roofs, and power lines.<br>Bon Homme, Turner, Yankton, Hanson, Sanborn Counties - Tornado damage.<br>Letcher - Tornado caused minor injuries with numerous reports of tree and building damage.<br>Springfield - Tree damage. |
| June 1978 | Aberdeen - On June 15 and 16, Aberdeen and Marshall County experienced tornadoes, hail, and some flooding. Five trailers were damaged by tornadoes. Marshall County had crop and building damage from hail and tornado winds |
| Summer 1977 | Arlington - Minor damage. |
| July 23, 1973 | Ft. Pierre/Pierre - The tornado began in Ft. Pierre where it did minor damage; one grain elevator and a few mobile homes were affected. It jumped the Missouri River and then "skipped" through Pierre. Houses and businesses were damaged, and a few homes were completely destroyed. Many mobile homes were either scattered about or piled upon one another. No deaths. Ten people were injured. Damage amounted to over half a million dollars. |
| June 18, 1967 | Rapid City - One motel suffered heavy structural damage along with several other buildings in the city. No deaths. Three people were injured. Over $2 million in damage was done. |
| May 21, 1962 | Gregory County - Several homes were destroyed as was farm equipment, automobiles, and livestock. Many miles of power poles and lines were also knocked down. Damage exceeded $500,000.<br>Mitchell - Damage was estimated at about $2 million to Mitchell and the surrounding countryside. |
| July 31, 1949 | Beresford and Elk Point - A series of tornadoes struck the countryside between Beresford and Elk Point in the southeast corner of the State. Property damage exceeded $1 million. |
| June 29, 1947 | Howard and Carthage - Occurred in the rural area of Howard and Carthage. Damage was light. A barn and airplane hangar were damaged. One death resulted. |
| June 12, 1947 | Turner/Yankton Counties - The rural area of Turner/Yankton Counties was struck by a tornado that did hundreds of thousands of dollars in damage. Barns, houses, and sheds were destroyed, and crop damage was listed as heavy. There were no recorded deaths or injuries. |
| July 9, 1932 | South of Sioux Falls (Minnehaha County) - One person died, 11 were people injured, and damage was estimated at $150,000. A number of horses and cattle were killed or injured, buildings were knocked down, and telephone and power lines were destroyed. This tornado was from a storm that also dropped baseball-sized hail throughout the area. |

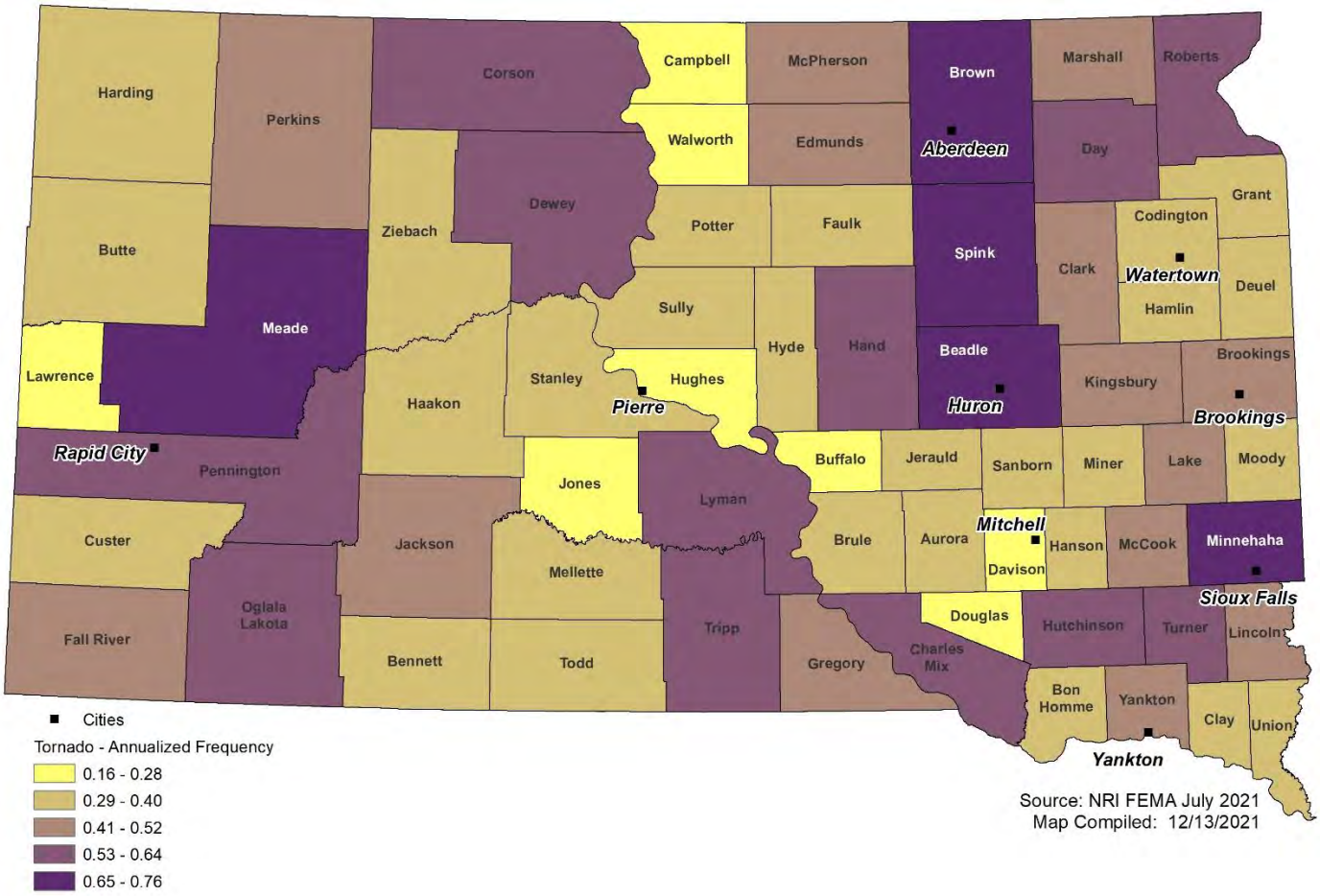
Source: NCEI, unless otherwise noted.

## Probability of Future Occurrence

According to the National Center for Environmental Information, there were 726 tornadoes F1 or higher, in South Dakota between 1950 and 2021 (71 years). Based on this information, the probability that at least one tornado with a magnitude F1 or higher will occur in South Dakota is 10%.

Figure 3-63 depicts the annualized frequency of any tornado (F0/EF0 or higher) in each county based on the NRI and historical data, for the period of record of 1996 through 2019.

**Figure 3-63 Annualized Frequency of Tornadoes by County**




## Magnitude/Severity (Extent)

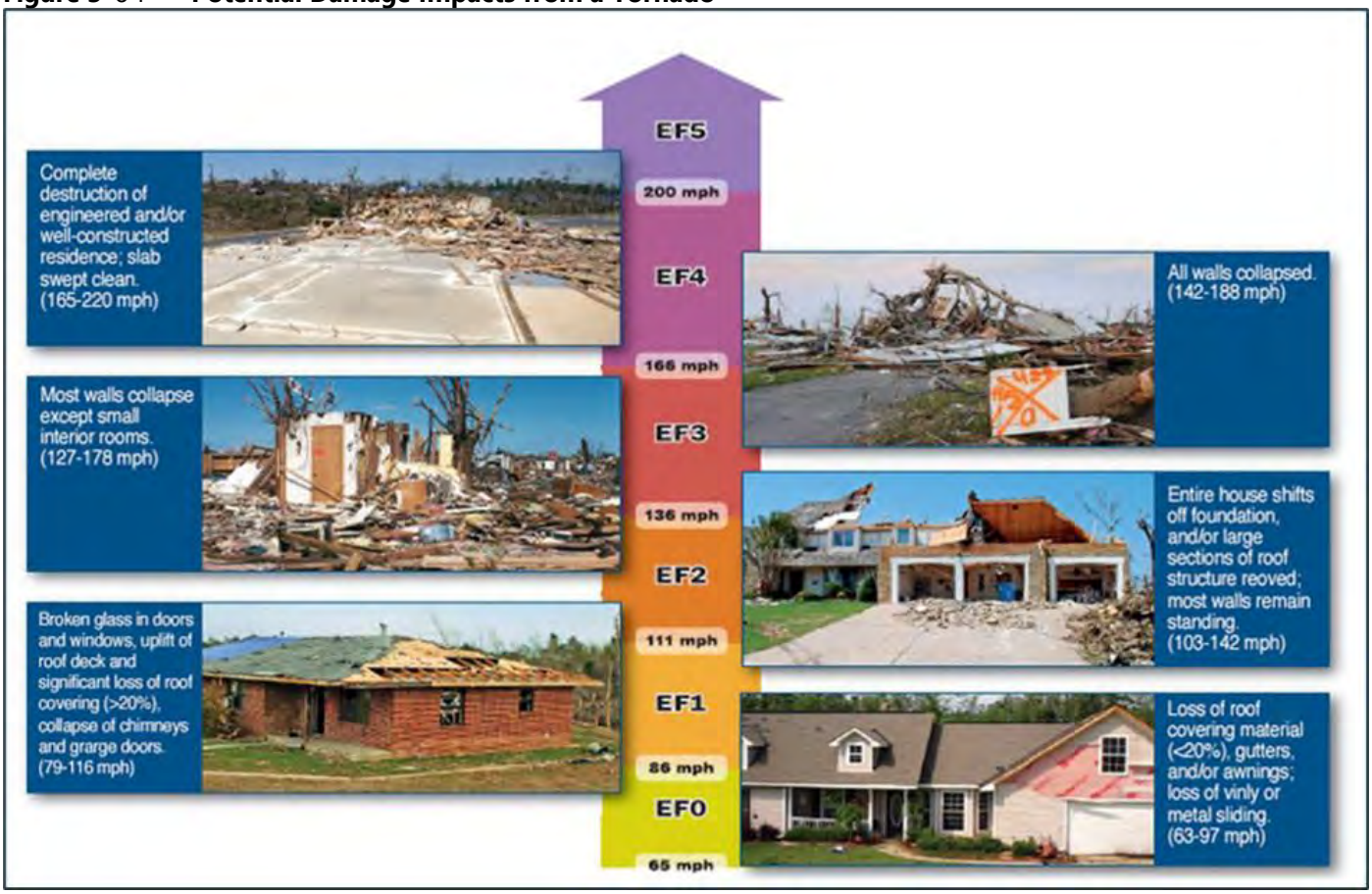
Prior to February 1, 2007, tornado intensity was measured by the Fujita (F) scale. This scale was revised and is now the Enhanced Fujita scale. Both scales are sets of wind estimates (not measurements) based on damage. The new scale provides more damage indicators (28) and associated degrees of damage, allowing for more detailed analysis, better correlation between damage and wind speed. It is also more precise because it takes into account the materials affected and the construction of structures damaged by a tornado. Table 3-49 shows the wind speeds associated with the original Fujita scale ratings compared to the Enhanced Fujita scale. Figure 3-64 shows the potential damage impacts from a tornado at each enhanced Fujita number.

**Table 3-49 The Fujita Scale and Enhanced Fujita Scale**

| Fujita Scale | | | Derived | | Operational EF Scale | |
|---|---|---|---|---|---|---|
| F Number | Fastest ¼ Mile (mph) | 3-Second Gust (mph) | EF Number | 3-Second Gust (mph) | EF Number | 3-Second Gusts (mph) |
| 0 | 40-72 | 45-78 | 0 | 65-85 | 0 | 65-85 |
| 1 | 73-112 | 79-117 | 1 | 86-109 | 1 | 86-110 |
| 2 | 113-157 | 118-161 | 2 | 110-137 | 2 | 111-135 |
| 3 | 158-207 | 162-209 | 3 | 138-167 | 3 | 136-165 |
| 4 | 208-260 | 210-261 | 4 | 168-199 | 4 | 166-200 |
| 5 | 261-318 | 262-317 | 5 | 200-234 | 5 | Over 200 |

Source: NWS EF: Enhanced Fujita, F: Fujita, mph: Miles per Hour

**Figure 3-64 Potential Damage Impacts from a Tornado**




Source: National Oceanic and Atmospheric Administration

## Climate Change Considerations

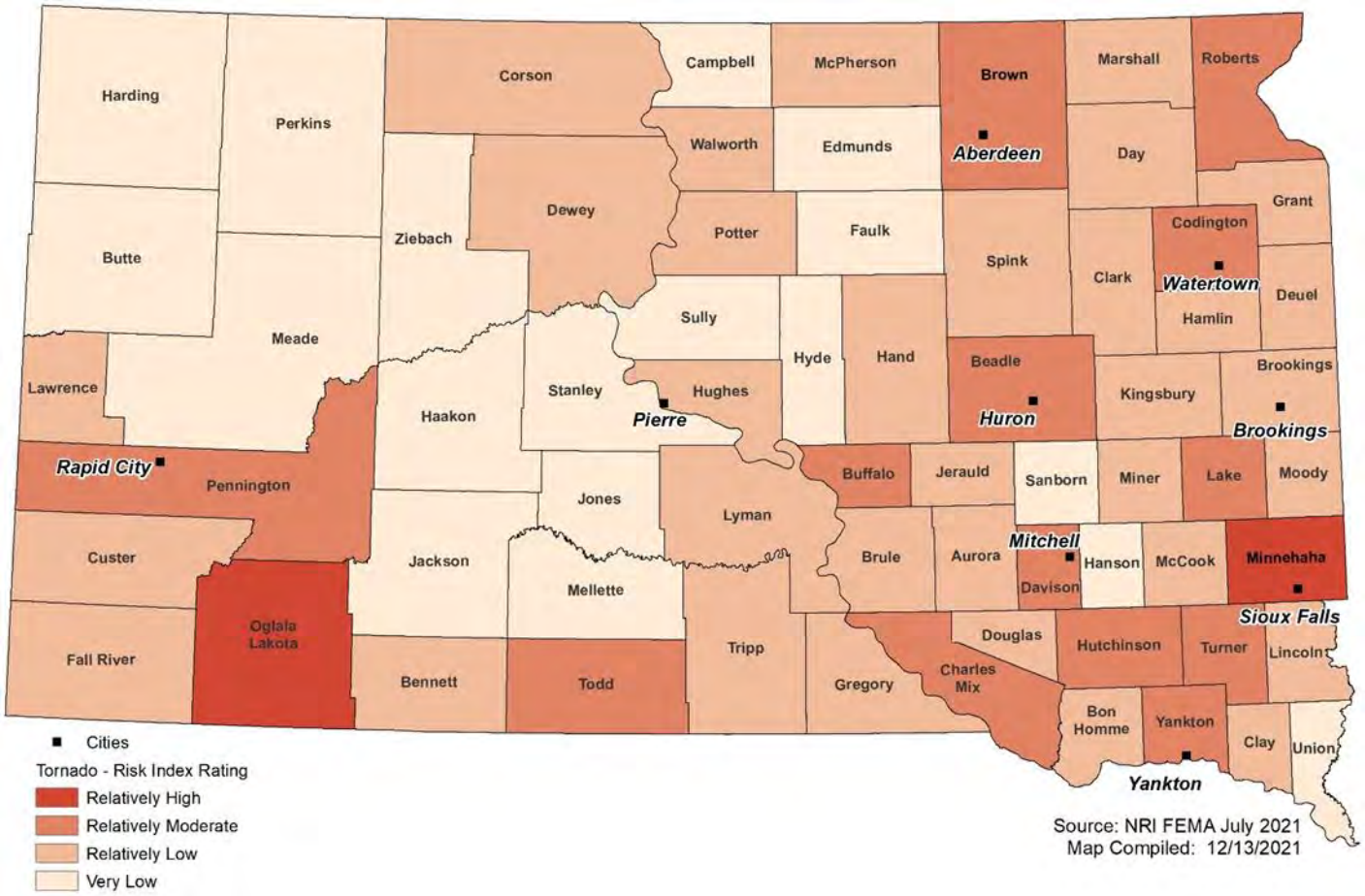
There presently is not enough data or research to quantify the magnitude of change that climate change may have related to tornado frequency and intensity. NASA's Earth Observatory has conducted studies which aim to understand the interaction between climate change and tornadoes. Based on these studies meteorologists are unsure why some thunderstorms generate tornadoes and others do not, beyond knowing that they require a certain type of wind shear. Tornadoes come from about 1 percent of thunderstorms, usually supercell thunderstorms that are in a wind shear environment that promotes rotation. As noted in the summer storm profile there are some studies that show a potential for a

decrease in wind shear in mid-latitude areas. As there is a lot of uncertainty with the influence of climate change on tornadoes future updates to the mitigation plan should include the latest research on how the tornado hazard frequency and severity could change. The level of significance of this hazard should be revisited over time.

## Vulnerability Assessment

While all 66 counties in the State of South Dakota are vulnerable to tornado hazards, every county in South Dakota is vulnerable to tornadoes, only Minnehaha and Oglala Lakota Counties have a relatively high-risk rating for tornadoes; this is likely a result of building exposure in Minnehaha and higher social vulnerability risk in Oglala Lakota counties. Figure 3-65 illustrates the relative risk of South Dakota counties to tornadoes based on data in the NRI.

**Figure 3-65 NRI Tornado Risk Rating by County in South Dakota**




### *People*

Populations vulnerable to tornadoes include people caught outside during a storm and people without adequate shelter such as a basement or a safe room. The availability of sheltered locations such as basements, buildings constructed using tornado-resistant materials and methods, and public storm shelters all reduce the exposure of the population.

People can be injured in a variety of ways during a tornado, including being directly picked up or thrown by wind gusts, being hit by debris, or being in a structure destroyed during a tornado. According to the NCEI, there were 726 tornadoes in South Dakota between 1950 and 2021 rated greater than an F1. In this

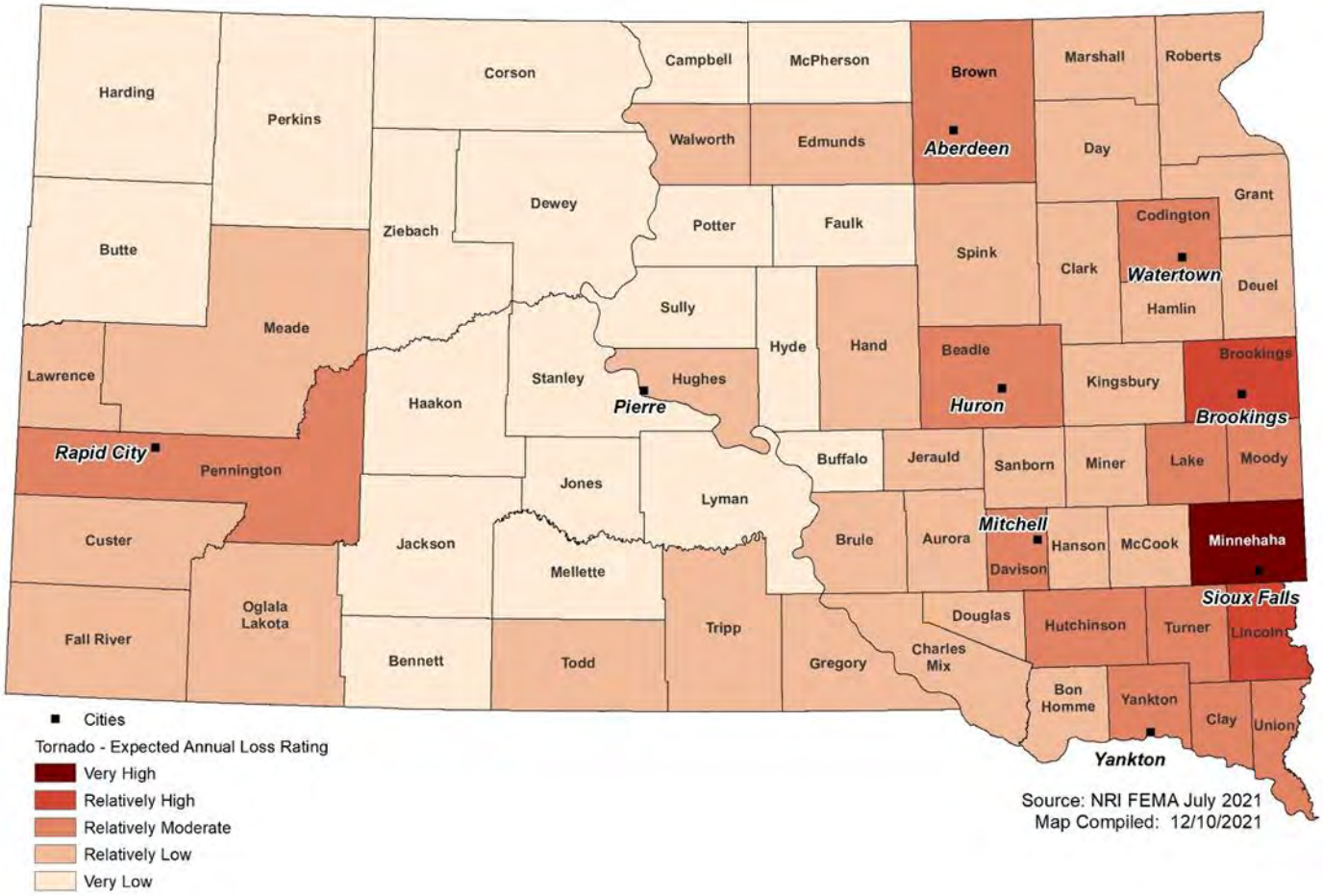
time period, there were 27 deaths and 466 injuries, which averages out to approximately two deaths and seven injuries each year.

### *Property*

To provide additional insight into potential losses caused by tornadoes, historic loss data were also analyzed on a statewide scale. Between 1950 and 2021, there were 726 tornadoes rated greater than an F1. Total property damage for these events is estimated at $706,258,000. This suggests that South Dakota averages 10 tornadoes rated F1 or greater and $10 Million in losses each year. Of these storms, seven resulted in major disaster declarations, with a total relief cost estimated at $180 million. This averages out to $2,583,254 million per major disaster. Based on the frequency of events, South Dakota averages one major disaster-level tornado every 330 events or approximately every 10 years.

Figure 3-66 shows the EAL rating for all South Dakota counties. Using data from the NRI tool, the EAL ratings are calculated using the annualized frequency and historic loss ratio for each county. Due to the population size., building exposure, as well as number of damaging past events, Minnehaha is the only county with a very high rating for EAL due to tornadoes. Brookings and Lincoln counties fall within the relatively high rating for expected annual losses.

**Figure 3-66 Expected Annual Loss Due to Tornadoes by County**



### *Critical Facilities and Infrastructure*

Secondary impacts of tornado damage often result from damage to infrastructure. Downed power and communications transmission lines, coupled with disruptions to transportation, create difficulties in reporting and responding to emergencies. These indirect impacts of a tornado put tremendous strain on a community.

In the immediate aftermath, the focus is on emergency services. Law enforcement activities focus on scene security. Fire and EMS personnel rescue the injured, put out any fires caused by broken gas lines or other similar hazards and assist in the cleanup. Utility crews restore power, phone, communications and other utility services. Public gathering places including (but not limited to) schools, community centers, shelters, nursing homes and churches, may have increased impacts at certain times of day if struck by a tornado. Due to the random nature of these hazards, a more specific risk assessment was not conducted for this plan.

### *Economy*

Economic impacts are dependent on the size and path of the tornado. An EF5 tornado that hits a populated business area or other critical infrastructure could have a profound economic impact. Impacts to smaller businesses would likely be more pronounced, including longer-term closures due to more destruction. Other economic impacts could include increased insurance payouts and premiums. See also the average annual losses noted in the Property subsection.

### *Environment and Cultural Resources*

Tornadoes can cause massive damage to the natural environment, uprooting trees and littering areas with debris. This is part of a natural process, however, and the environment will return to its original state in time.

## Development Trends and Consequence Summary

The counties identified in Figure 3-66 above with the greatest (very high and relatively high) expected annual losses are also the counties (Minnehaha, Lincoln and Brookings) greatest increase in housing units in the past 10 years. Due to the random nature of tornado events, it is not possible to measure potential exposure county-by county. Vulnerability to tornadoes can be increased through the implementation of development regulations that require safe rooms, basements, or other structures that reduce risk to people would decrease vulnerability.

**Table 3-50 Tornado Consequence Table**

| Category | Narrative |
|---|---|
| Impact on the Public | Anyone without adequate shelter during an event at high risk of injury and death; impacts will be localized to the immediate area around the tornado path. |
| Impact on the Economic Condition of the State | Potential loss of facilities or infrastructure function or accessibility and uninsured damages; impact to transportation sector and movement of goods. |
| Impact on the Environment | Significant impact related to tree damage, possible cascading water quality issues from damaged water treatment facilities. Debris issues. |
| Impact on Property, Facilities, and Infrastructure | Buildings, vehicles, signage and/or any exposed or unsecured property may be affected during a tornado; property may be destroyed or have significant damage. |
| Impact on the Public Confidence in Government | Public holds high expectations of government capabilities for warning, public information, and response and recovery activities related to a tornado, high expectations for rapid restoration of critical facilities. Ability to respond and |

| Category | Narrative |
|---|---|
| | recover may be impaired if planning, response, and recovery is not timely and effective. |
| Impact on Responders | Exposure exists to personnel performing routine duties when event occurs; storm-related duties are primarily post-event; however unsafe structural or environmental conditions may persist during the response period. |
| Impact on Continuity of Operations and Continued Delivery of Services | Loss of facilities or infrastructure function or accessibility or ability to provide services; power interruption is likely if not adequately equipped with back-up generation. |
| Cascading Hazards | Hazardous Materials |

### 3.3.8 Windstorm

#### Hazard Description

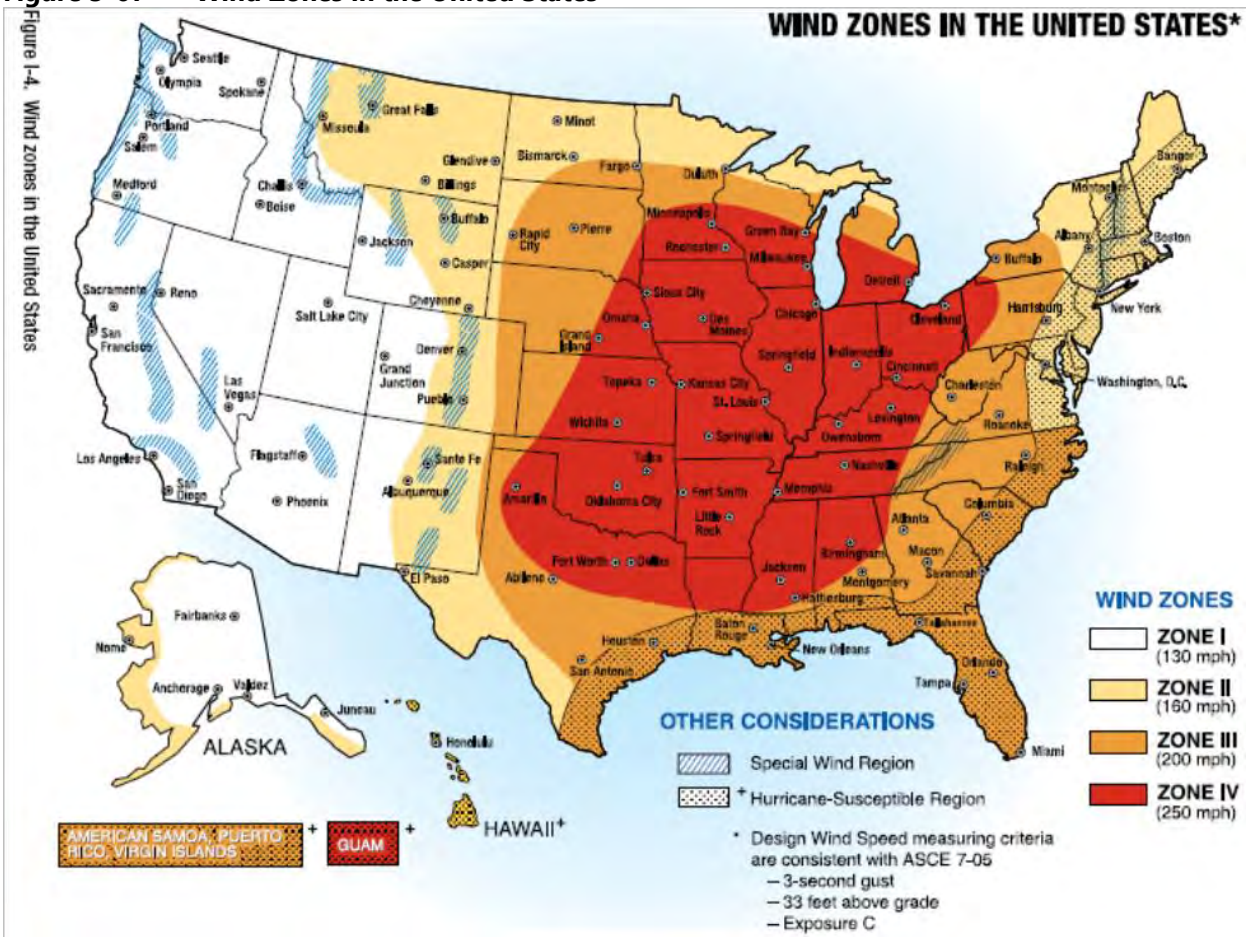
Straight-line winds are generally any thunderstorm wind that is not associated with rotation (i.e., is not a tornado). It is these winds, which can exceed 100 mph, that represent the most common type of severe weather in South Dakota and are responsible for most wind damage related to thunderstorms. Since thunderstorms do not have narrow tracks like tornadoes, the associated wind damage can be extensive and affect entire (and multiple) counties. Objects like trees, barns, outbuildings, high-profile vehicles, and power lines/poles can be toppled or destroyed, and roofs, windows, and homes can be damaged as wind speeds increase. One type of straight-line wind is the downburst, which can cause damage equivalent to a strong tornado and can be extremely dangerous to aviation.

High winds and downbursts associated with thunderstorms over the Northern Plains typically happen between late April and early September, but given the right conditions, they can develop as early as March. They are usually produced by supercell thunderstorms or a line of thunderstorms that typically develop on hot and humid days. Straight-line winds may also exacerbate existing weather conditions, as in blizzards, by increasing the effect on temperature and decreasing visibility due to the movement of particulate matters through the air, as in dust and snowstorms.

#### Location

The entire State is susceptible to high wind events. Figure 3-67 illustrates the wind zones in the United States. Most of South Dakota is in Zone III, which is vulnerable to winds up to 200 mph. The westernmost part of the State is in Zone II, which is susceptible to winds up to 160 mph.

**Figure 3-67 Wind Zones in the United States**




Source: Taking Shelter from the Storm (FEMA 2008)

## Past Events

According to the NCEI Storm Events Database, there were 8,310 windstorm events (7,153 thunderstorm wind, 1,149 high wind, and eight strong wind events) in South Dakota between 1955 and 2021. There were 11 deaths and 149 injuries in this time period. Total property and crop damage for events between 1993 (when damage figures began being kept) and 2021 is estimated at $153,056,500. This suggests that South Dakota averages 126 wind events, $2,319,038 in wind losses, and approximately 2.3 injuries each year.

Figure **3**-68 Wind Occurrences by Magnitude 1955-2019

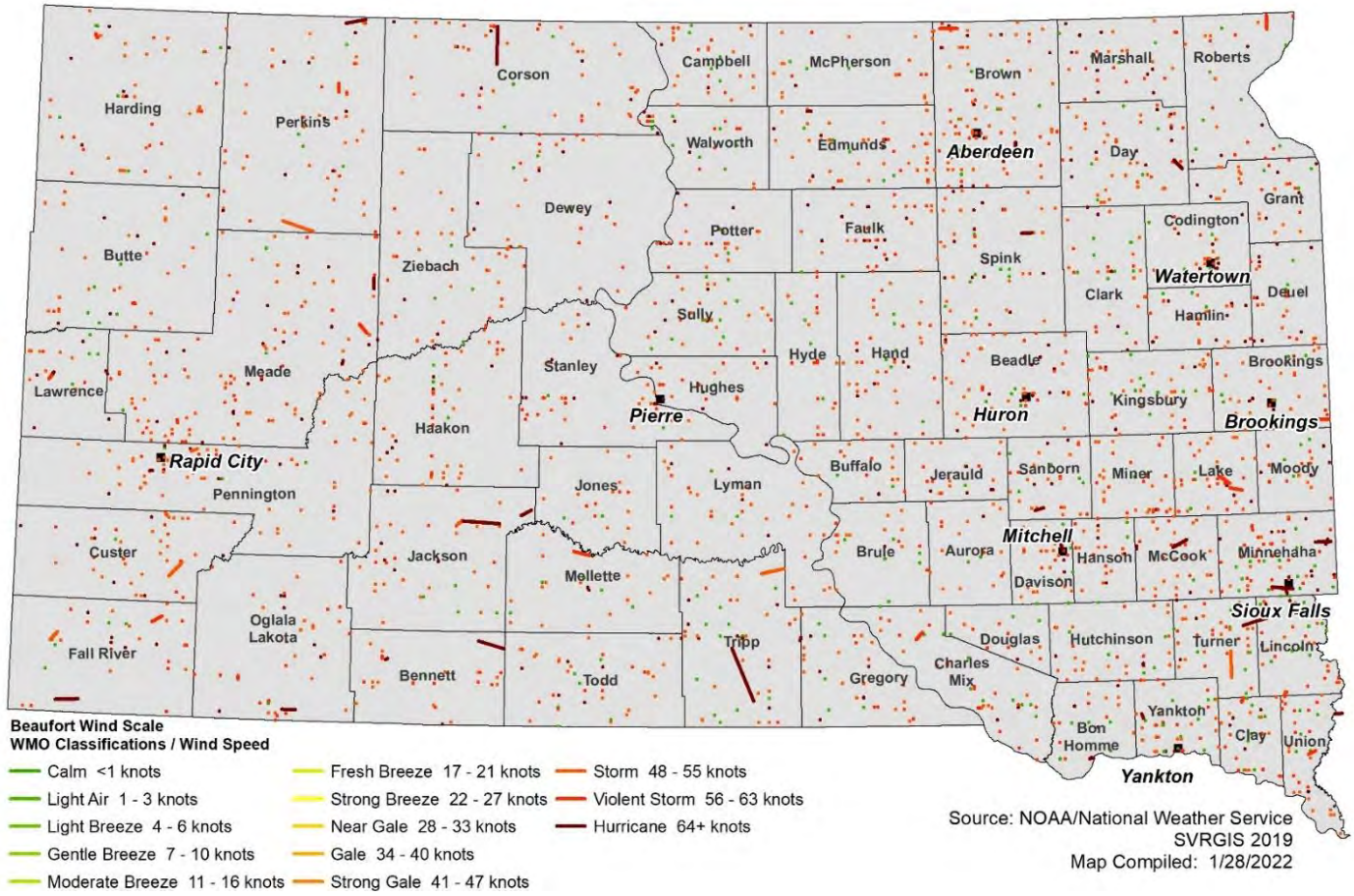



**Table 3-51 South Dakota Wind Events**

| Date | Comments |
|---|---|
| August 28, 2021 | Severe thunderstorms developed across north central South Dakota around midnight and proceeded east through the overnight hours. Of particular note, a long-track supercell produced severe weather from just east of the Missouri River in Walworth County along the length of Highway 12 through the rest of the State, a distance of about 180 miles. Additional severe thunderstorms developed across the area during and after this long-track supercell dissipated, during the mid-morning. The strongest storms produced tennis to baseball-sized hail and damaging wind gusts. |
| August 26, 2021 | A broad, organized line of thunderstorms moved across north central and northeastern South Dakota during the early morning hours and produced damaging severe winds to near 80 mph at times. Winds of up to over 60 mph then developed on the backside of the system. Trees, branches, power lines and poles were downed, and some structural damage occurred including a grain bin that was destroyed, and a roof was torn off a building and a billboard along the northbound side of Interstate 29 was broken in half. |
| January 13, 2021 | An intense low-pressure system slowly crossed the region, bringing a prolonged period of very strong northwesterly winds. A tight pressure gradient remained across the Northern Plains, with 36 hours of strong winds over much of the western South Dakota Plains. Gusts of 60 to 80 mph were reported across much of the area, with a few higher gusts from Buffalo to the Rapid City area. Some minor damage resulted with isolated power outages and tractor |

| Date | Comments |
|---|---|
| | trailers were tipped over on Interstate 90. Wind gusts rolled a semi-truck over on U.S. Highway 14 just west of De Smet. |
| June 9, 2020 | Strong frontal forcing resulted in the redevelopment of elevated thunderstorms during the very early morning to the west of the band from the previous evening. Additional severe thunderstorms developed near a slowly advancing cold front during the late afternoon and evening hours across southeast South Dakota. Property damages were extensive including: A concrete silo was toppled and a door to a metal shed bent inward. Damage was done to several trees, and the covering was ripped off a hoop barn. On a farmstead, a concrete silo was toppled, trees uprooted, and windows broken on the house. Cattle and calf shelters were damaged. Several calves were killed. A barn was destroyed, along with damage to the roof and siding of a home. The main floor of a home was destroyed. A detached garage was also destroyed. Numerous trees were uprooted or snapped throughout Mt. Vernon. Several power poles were downed or snapped by wind. A semi-truck and trailer were tipped over along with damage to two other vehicles. |
| September 10, 2019 | A long-lived severe thunderstorm moved east-northeast from Nebraska across south central South Dakota. In addition to the tornadoes, widespread wind damage to trees and damage to residences were reported. A total of nine people were injured in the storms around Sioux Falls. Repeated cells resulted in flash flooding by later evening and into the overnight hours. |
| July 17, 2019 | A complex of thunderstorms developed during the evening across western South Dakota, moving east and becoming more organized as the low-level jet increased focus into south central and southeast South Dakota late at night. Three people were injured as the strong winds went through the Snake Creek Campground. Injuries occurred when tree branches fell on tents. Several campers rolled by high winds. |
| July 22, 2018 | A long-lived supercell thunderstorm developed over eastern Haakon County and tracked southeast across south central South Dakota. The storm produced large hail and strong wind gusts across parts of the area. Estimated seventy mph winds blew a semi-truck and camper over on Interstate-90 west northwest of Okaton with some minor injuries. Part of the interstate was closed for a time to clean up the debris. |
| May 22, 2017 | A line of showers and thunderstorms produced gusty north winds over eastern Pennington County. Sudden wind gusts caused a pickup pulling a camper on Interstate-90 near the New Underwood area to lose control. As the camper swayed across the highway, the top of the camper blew off and landed on the other side of the interstate. No one was injured. |
| August 11, 2016 | A severe thunderstorm developed over southwestern Ziebach County and tracked northeast across southern portions of the county. The storm produced strong wind gusts around 70 mph. |
| September 4, 2016 | Thunderstorms with damaging winds affected parts of southeast South Dakota from the Missouri River to Sioux Falls. The winds caused substantial damage to the City of Springfield in Bon Homme County. Damages included the destruction of six houses as well as damaging houses, damaging businesses, several unattached garages and destroying farm outbuildings and other farm structures. As well as causing widespread tree damage including knocking trees down. It is also reported that the wind moved a large boat 25 yards from a parked position. Property damage is reported to be $1 million. |
| February 18, 2016 | A strong cold front crossed the region, bringing gusty northwest winds to much of western and south-central South Dakota. Wind gusts from 60 to 80 mph accompanied the front late on the 18th into the nighttime hours. Wind gusts around 65 mph redeveloped on the 19th across portions of northwestern South Dakota and the Black Hills as a tight pressure gradient remained in place over the Northern Plains. |

| Date | Comments |
|---|---|
| July 30, 2013 | A long-lived supercell thunderstorm developed over western Haakon County and moved south southeast across south central South Dakota. Very large hail was reported in some areas, along with strong wind gusts, and a small tornado near Philip. The wind-driven hail caused extensive damage to houses from Corn Creek to Parmelee. The combination of large hail and wind caused extensive damage to buildings and vehicles around town. |
| June 21, 2013 | A strong warm front along with very unstable air and strong deep layer winds brought several supercell thunderstorms along with a damaging line of thunderstorms/bow echo to parts of central and northeast South Dakota during the afternoon hours. Damaging winds up to 90 mph uprooted large trees and caused considerable structural and crop damage and loss of power to those in its path. The worst wind damage was located at Lake Poinsett, Watertown, and Milbank. A woman was killed, and her husband was seriously injured on Lake Poinsett when their lake house was destroyed. Numerous trees were downed along with many structures damaged or destroyed. Many trees had fallen onto homes, cabins, and trailers. The bowling alley in Clear Lake lost its roof along with numerous pole barns being destroyed along the storm's path. Thousands of people were also left without power. Four tornado touchdowns occurred along with hail up to the size of softballs. Isolated flash flooding also occurred. Codington, Hamlin, Grant, and Deuel Counties were all declared in a federal disaster declaration. Total damage estimates were around 1,100,000 dollars. |
| May 28, 2013 | A line of thunderstorms produced a small tornado that touched down briefly and strong straight-line winds south of Allen.<br><br>Straight-line wind damage was observed along BIA Road 22 southeast of Allen. The winds tore part of the roof off a small building and ripped shingles and metal roofing off two houses. A mobile home was rolled and completely smashed. A large cottonwood tree was snapped. |
| April 15, 2012 | Very strong northerly winds affected southeast South Dakota during the evening of April 15th. Winds gusted to over 60 mph in parts of the area. A large outbuilding was destroyed near the western edge of Hitchcock, and a power pole standing in water was snapped off 4.5 miles east of Hitchcock. |
| April 2, 2012 | A strong cold front passed through the region during the night. Strong north to northwest winds developed behind the front for several hours. The strongest winds occurred in the Rapid City area, where wind gusts to 65 mph were recorded. A semi-trailer was blown over on Interstate 90 six miles east of New Underwood. |
| April 30, 2011 | A tight pressure gradient over the region resulted in strong northwesterly winds across western and central South Dakota. Sustained winds of 35 to 55 mph with gusts near 80 mph caused minor damage around Newell and Sturgis. The strongest winds were over the northwestern South Dakota Plains. A large metal sign at a campground east of Sturgis was blown over. A pickup truck and travel trailer were flipped over south of Bear Butte. |
| June 10, 2010 | Damaging winds, not directly from thunderstorms, affected the Madison to Brookings South Dakota area during the morning of June 10th. High winds severely damaged a barn. The winds also caused tree damage, with a playhouse damaged by tree debris. Vehicles were damaged by flying tree debris. |
| May 24, 2010 | An intense low-pressure system and cold front produced strong winds across southwestern South Dakota. Ahead of the low, strong south the southwest winds developed across south central South Dakota during the early afternoon. Behind the front, winds switched to the west across southwestern South Dakota in late afternoon. Sustained winds of 30 to 45 mph, with gusts to 70 mph, were recorded over much of the area. Some trees were downed by the wind. Minor damage occurred around the Hot Springs area. |

| Date | Comments |
|---|---|
| August 7, 2009 | A super cell thunderstorm developed across the northern Black Hills and moved eastward across the Sturgis area, southern Meade County, northeastern Pennington County, Haakon County, and northeastern Jackson County. The storm produced baseball-sized hail near Sturgis, then strong winds of 61 knots and hail larger than baseball-sized developed as the storm moved across the plains. The storm hit Sturgis during the annual motorcycle rally and caused extensive damage to motorcycles, vehicles, and property. Minor injuries from the hail were also reported. |
| July 13, 2009 | High winds developed behind an existing area of thunderstorms causing damage along with some injuries. Wind gusts to 50 to 70 mph were estimated or measured across parts of north central and northeast South Dakota. As a result, A mobile home was rolled twenty feet and destroyed by gradient winds associated with a weak low-pressure area. The mobile home was not tied down and caught fire as it rolled into a propane tank. The three people inside the mobile home at the time all escaped with minor injuries. |
| October 26, 2008 | Strong northwest winds reached sustained speeds of 40 mph or more with gusts to around 60 mph over all of southeast South Dakota during the morning and afternoon of October 26th.High winds sustained at 40 to 45 mph and gusting to over 60 mph caused damage to trees, shingles, and road signs. The tree damage included one very large weeping willow tree blown down in De Smet. |
| July 31, 2008 | In the early morning hours of July 31st, a line of storms originating in North Dakota began to expand and surge southeast into northeast South Dakota. As the storms moved southeast, they began to tap into warmer, more humid air and rapidly evolve into a line of severe thunderstorms. Widespread damage occurred in a wide swath extending from Long Lake in McPherson County all the way into eastern Grant County and southern Big Stone County in Minnesota. The most extensive damage was generally found along and near U.S. Highway 12 from Aberdeen to Milbank. Several observing stations in the path of this system measured wind speeds ranging from 70 mph to over 115 mph. Estimated wind speeds from damage surveys indicated even stronger winds with peak speeds of 120 mph.<br><br>Over fifty communities in northeast South Dakota and the surrounding rural areas received minor to major tree and structural damage as straight-line winds from 70 to 120 mph raced across the area. Webster and Waubay received the most extensive damage from the storms. Thousands of trees were snapped or uprooted, hundreds of grain bins were damaged or destroyed, hundreds of homes, businesses, and outbuildings were damaged or destroyed along with many power poles and miles of power lines downed. Many mobile homes, campers, and boats were damaged or destroyed along with many road and business signs. Countless homes, vehicles, and campers were also damaged by fallen trees. Thousands of acres of crops were also damaged or completely destroyed by the winds and hail. The greatest crop damage occurred in the Roslyn, Grenville, Eden, and Pickerel Lake areas in Marshall and Day Counties. Many acres of corn were blown down and not able to come back.<br><br>The large hail combined with the strong winds also broke out countless windows in homes and vehicles along with damaging the siding on homes. Thousands of people were left without power for up to several days. Large hay bales were moved up to 700 yards by the high winds. A semi was overturned on Highway 12 near Webster, injuring the driver. Near Milbank on Highway 12, two other semis were blown off the road resulting in injuries to both drivers. A State Forestry Specialist said it was one of the worst tree damage events he has ever seen in the Webster area. A fifty-eight-year-old man died two miles north of Waubay during the cleanup after the storms when he was pinned between a backhoe and a tree. |
| June 26, 2008 | On the evening of 26 June 2008, a compact upper level low-pressure system tracking through the Northern Plains interacted with a very moist and unstable air mass over western and central South Dakota resulting in a widespread severe weather outbreak. Three |

| Date | Comments |
|---|---|
| | confirmed tornadoes occurred briefly in western Dewey County. Little or no damage was reported, and all three tornadoes were rated EF-0. In addition to the tornadoes, multiple reports of large hail were received over Corson and Dewey Counties, including some to the size of baseballs near the communities of McLaughlin and Isabel. The large hail broke out many home and vehicle windows and damaged many roofs in Dewey, Corson, and Sully Counties. Significant wind damage occurred over sections of Sully County. There were multiple reports of wind gusts in excess of 70 mph, with the most concentrated swath of damaging winds extending from near Sutton Bay, eastward to the city of Onida, then southeast to the community of Harrold.<br><br>The storm survey began near Sutton Bay on Lake Oahe, where a wind gust of 92 mph was recorded. The most significant property damage was found further east near the community of Agar where multiple grain bins were either damaged or destroyed. Nine miles west of Agar, a barn was destroyed, and a large pine tree was snapped in half. Winds in this area were estimated to range from 80 to 100 mph. Near the intersection of Highways 1804 and 175th Street, several Western Area Power Administration (WAPA) electrical transmission towers were completely collapsed. This is consistent with wind speeds ranging from 130-140 mph. In the city of Onida a bank roof was damaged, and the city was without power until the next day. Four miles north of Onida, a feed wagon was tossed nearly 40 feet. In Harrold, several railroad cars were tipped over.<br><br>Also, of great significance during the event was the peak wind speed of 124 mph recorded at the Onida airport. This wind speed is the strongest wind gust ever measured in the Aberdeen County Warning Area (CWA) and the 4th strongest wind speed ever reported in South Dakota |
| January 27, 2008 | Strong southwesterly winds developed across the Black Hills during the afternoon and persisted through much of the night. Wind gusts of 60 to 70 mph were common across the higher terrain of the Black Hills and the northern and eastern foothills. The strongest winds were noted in the Spearfish and Hermosa areas, where a few gusts exceeded 90 mph. The strong winds caused a semi-trailer to jack knife on interstate 90 in Spearfish. Downed tree branches, signs, and damage to roofs were also reported around Spearfish. |
| July 9, 2007 | Severe storms produced wind gusts to 80 mph across south central South Dakota. Roofs were torn off two houses and a trailer house was rolled three times. No injuries were reported. Damage estimates were reported at $75,000. |
| November 19, 2006 | Strong southwest winds developed during the evening across parts of the northern foothills. Winds gusted near 80 mph just west of Spearfish, while gusts over 50 mph were recorded in the Sturgis area. Several power poles and lines were downed in the Spearfish area, with minor damage around Sturgis. |
| August 18, 2006 | Damaging winds associated with a line of thunderstorms moved through Lincoln County and were estimated between 50 and 80 mph. A downburst caused significant damage, especially to crops, which were shredded by windblown hail.<br><br>Source: NWS Sioux Falls |
| May 23, 2006 | Eighty mph straight-line winds damaged a Union County farm. Two outbuildings were destroyed, and a third building lost its roof. A fourth building was also damaged, and debris was strewn along a ¼ mile stretch. Tree damage was also documented in the area.<br><br>Source: NWS Sioux Falls |
| April 17, 2006 | Severe thunderstorms. The earliest reports of large hail and strong winds on record for northwestern South Dakota. |

| Date | Comments |
|---|---|
| | Source: NWS Rapid City |
| June 7-8, 2005 | This was one of the most damaging severe thunderstorm events of the past several years for central and northeast South Dakota. In the late afternoon of June 7, a line of thunderstorms developed across western South Dakota and moved east across the State and into west central Minnesota. Widespread damage was reported. Hundreds of grain bins and countless buildings were damaged or destroyed and numerous trees, power lines, and poles were downed. Winds of 60 to over 100 mph were reported. It illustrated the fact that extreme straight-line winds can do as much damage as tornadoes.<br>Source: NWS Aberdeen |
| March 10, 2005 | Sustained winds of 40 to 45 mph with gusts above 60 mph persisted from mid-morning until late afternoon. The winds caused widespread tree damage with branches and smaller tree debris broken off. Several power lines were knocked down by the wind or by windblown debris. This resulted in several power outages, especially between the Missouri and James Rivers. Damages to buildings were mostly to shingles and gutters. However, a metal storage building was blown over at Mitchell. Also, at Mitchell, construction barriers were blown over, and windows were broken in two vehicles by blowing rocks. An aluminum recycling cage was blown away at Woonsocket. A window was blown out at a school in Freeman. In Sioux Falls, there was damage to the airport tower. |
| July 3-4, 2003 | A line of severe thunderstorms developed in Montana and moved into and across North Dakota, South Dakota, and Minnesota. It brought large hail and winds over 80 mph at times to Brown, Marshall, and Roberts Counties, which resulted in widespread property and crop damage. Approximately 30 percent of Marshall County's 227,000 acres of crops were damaged or destroyed. Trees, branches, and power lines and poles were downed; roofs and siding were damaged from hail and fallen trees; farm outbuildings were damaged or destroyed; and many windows were broken out of homes and vehicles. A crop spraying plane at the Sisseton airport was thrown 450 feet and a 55,000-bushel grain bin in Claire City was blown off its foundation and flattened.<br>On the opposite side of the State, a supercell thunderstorm developed over Lawrence County and moved into Meade County. It moved through Rapid City with 60 to 70 mph winds and moved quickly east-southeast across southwestern and south-central South Dakota producing 60 to 80 mph winds. The strong winds downed many trees and power lines from Rapid City to the Winner area.<br>Source: NCEI, NWS Aberdeen |
| June 9, 2001 | A severe windstorm struck portions of western South Dakota with gusts estimated to 80 mph. The greatest damage occurred in Philip and Wanblee. The damage was consistent with strong straight-line winds.<br>Source: NWS Rapid City |
| August 1, 2000 | A powerful thunderstorm moved into western South Dakota from northeast Wyoming. Winds in the Spearfish area, estimated at 90-110+ mph, were particularly devastating, causing a considerable amount of damage and several injuries. Strong downburst winds were responsible for most of the observed damage. As the storm approached Sturgis, it evolved into a bow echo with winds estimated at 65-80 mph that toppled and blew away merchandise tents that had been set up for the Sturgis Rally. Strong winds in excess of 70 mph were also noted in the Black Hawk, Piedmont, Rapid City, and Ellsworth AFB areas.<br>Source: NWS Rapid City |

| Date | Comments |
|---|---|
| June 3-4, 2000 | Two severe thunderstorms brought strong straight-line winds to Clay and Union Counties. The first storm had wind gusts of 70-75 mph. The second storm had 60-65 mph wind gusts. Trees were damaged, and a picnic shelter was destroyed<br>Source: NWS Sioux Falls |
| August 6, 1999 | Downburst wind event in Meade County. Winds were estimated up to 70 mph at 8:05 p.m. as the front passed through the area. Numerous trees were damaged, and a few were blown down. The worst of the storm hit Ellsworth Air Force Base at 8:18 p.m. where they gusted to 89 mph. Between that time and 8:30 p.m., the wind speed did not drop below 50 mph at the base. Sensors measured gusts of 129 mph and 165 mph. Damage was minimal due the rural location.<br>Source: NWS Rapid City |
| June 20, 1997 | These severe thunderstorms brought strong straight-line winds, estimated at 80-90 mph, which caused widespread tree, crop, power line, and building damage and destruction in Davison County and injured eight people. The damage path was at least 15 miles wide by 50 miles long. Many people believed the damage was caused by a tornado, but the damage assessment proved otherwise.<br>Source: NWS Sioux Falls |

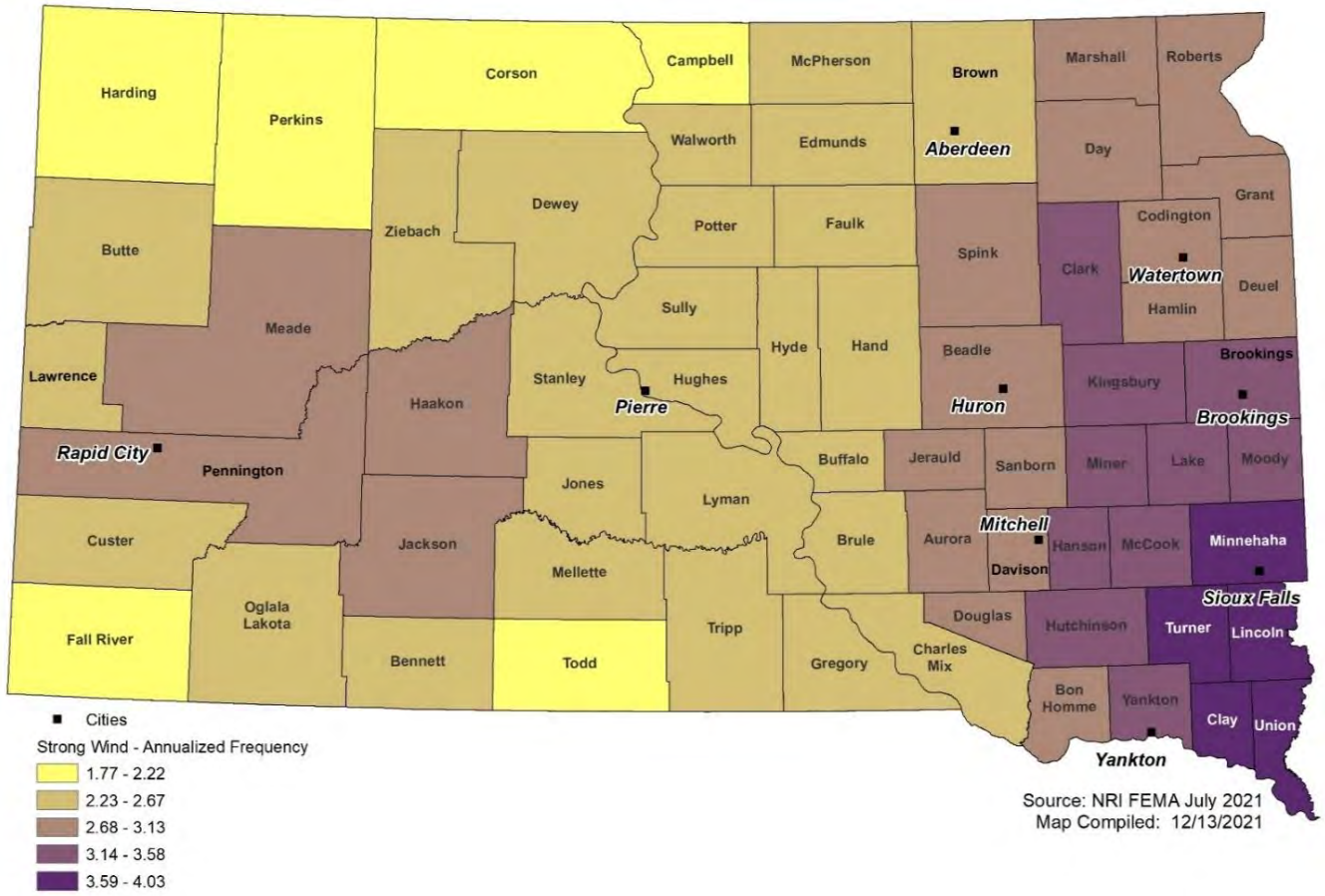
Source: NCEI, if not otherwise sourced

## Probability of Future Occurrence

According to the NCEI Storm Events Database there were 8,310 wind events (excluding events from associated with snow, see event description above) in South Dakota between 1955 and 2021 (66 years). Based on this information, the probability that at least one damaging wind event will occur in South Dakota in any given year is 100 percent.

Figure 3-69 depicts the annualized frequency of recorded strong wind events each year from 1996 to 2020 in each county based on the NRI and historical data. Based on this data, the eastern and southeastern portions of the State experience the greatest number of wind events in a given year.

**Figure 3-69 Annualized Frequency of Wind Events by County**




## Magnitude/Severity (Extent)

The magnitude and severity of wind events can be measured by the Beaufort Wind Scale. The replication of the scale only reflects land-based effects. Beaufort Level 12 events have occurred in South Dakota.

**Table 3-52 Beaufort Wind Scale**

| Beaufort Number | Description | Windspeed (MPH) | Land Conditions |
|---|---|---|---|
| 0 | Calm | <1 | Calm. Smoke rises vertically. |
| 1 | Light air | 1 – 3 | Wind motion visible in smoke. |
| 2 | Light breeze | 3 – 7 | Wind felt on exposed skin. Leaves rustle. |
| 3 | Gentle breeze | 8 – 12 | Leaves and smaller twigs in constant motion. |
| 4 | Moderate breeze | 13 – 17 | Dust and loose paper raised. Small branches begin to move. |
| 5 | Fresh breeze | 18 – 24 | Branches of a moderate size move. Small trees begin to sway. |
| 6 | Strong breeze | 25 – 30 | Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic garbage cans tip over. |
| 7 | High wind, Moderate gale, Near gale | 31 – 38 | Whole trees in motion. Effort needed to walk against the wind. Swaying of skyscrapers may be felt, especially by people on upper floors. |
| 8 | Gale, Fresh gale | 39 – 46 | Some twigs broken from trees. Cars veer on road. Progress on foot is seriously impeded. |

| Beaufort Number | Description | Windspeed (MPH) | Land Conditions |
|---|---|---|---|
| 9 | Strong gale | 47 – 54 | Some branches break off trees, and some small trees blow over. Construction/temporary signs and barricades blow over. Damage to circus tents and canopies. |
| 10 | Storm, Whole gale | 55 – 63 | Trees are broken off or uprooted, saplings bent and deformed. Poorly attached asphalt shingles and shingles in poor condition peel off roofs. |
| 11 | Violent storm | 64 – 72 | Widespread vegetation damage. Many roofing surfaces are damaged; asphalt tiles that have curled up and/or fractured due to age may break away completely. |
| 12 | Hurricane | ≥ 73 | Very widespread damage to vegetation. Some windows may break; mobile homes and poorly constructed sheds and barns are damaged. Debris may be hurled about. |

Source: National Oceanographic and Atmospheric Association, http://www.spc.noaa.gov/faq/tornado/beaufort.html

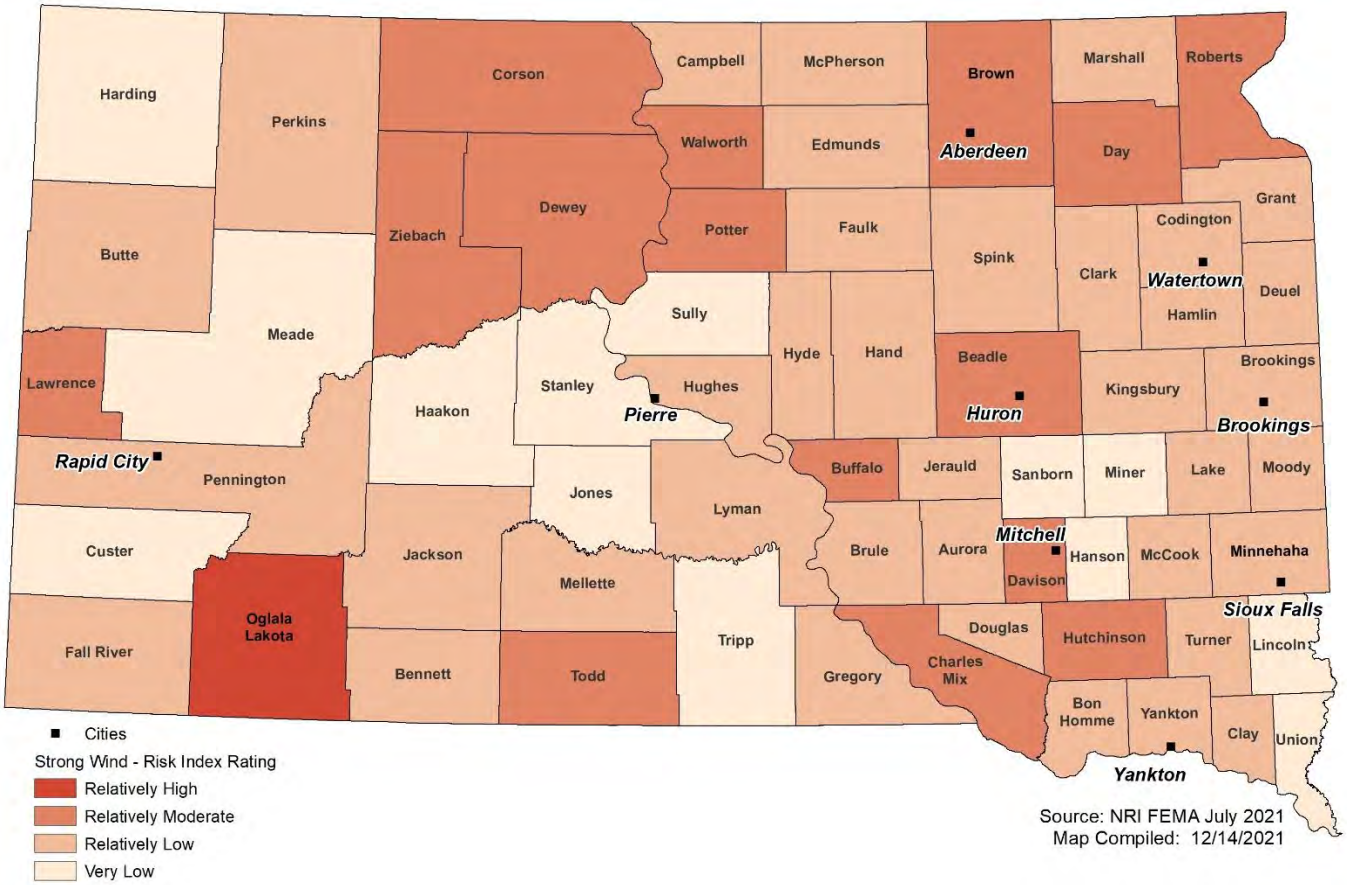
## Climate Change Considerations

According to the Fourth National Climate Assessment, there presently is not enough data or research to quantify the magnitude of potential change that climate change may have on windstorms. Future updates to the mitigation plan should include the latest research on how the windstorm hazard frequency and severity could change. The level of significance of this hazard should be revisited over time.

## Vulnerability Assessment

Every county in South Dakota is vulnerable to windstorm, but some counties have a higher risk than others. In addition, the vulnerability can vary slightly based on the severity of windstorm events. It is difficult to pick an area of higher vulnerability to windstorms in the State if all windstorm events are examined. Counties where at least 100 events have been recorded are fairly evenly distributed across the State. This is largely due to the counties' high ratings for building exposure and population density. In general, the counties with the greatest vulnerability to windstorm events are those in the Black Hills Region and those with major cities. Figure 3-70 illustrates the relative risk of South Dakota counties to tornadoes based on data in the NRI. Based on the NRI data Oglala Lakota is the only county that has a very high rating for windstorm events.

**Figure 3-70 NRI Wind Risk Rating by County in South Dakota**




## *People*

It can be assumed that the State is exposed to some extent to wind events. Certain areas are more exposed due to geographic location and local weather patterns. According to the NCEI data since 1993 there has been 11 deaths and 149 injuries due to wind events. Statewide there is an average of 2.3 injuries every year due to wind events.

Vulnerable populations are the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages can be life threatening to those dependent on electricity for life support. As noted under section 0 Summer Storm, statewide an estimated 9,922 Medicare Beneficiaries or 5% of total Beneficiaries (183,640) rely on electricity to live independently in their homes.

## *Property*

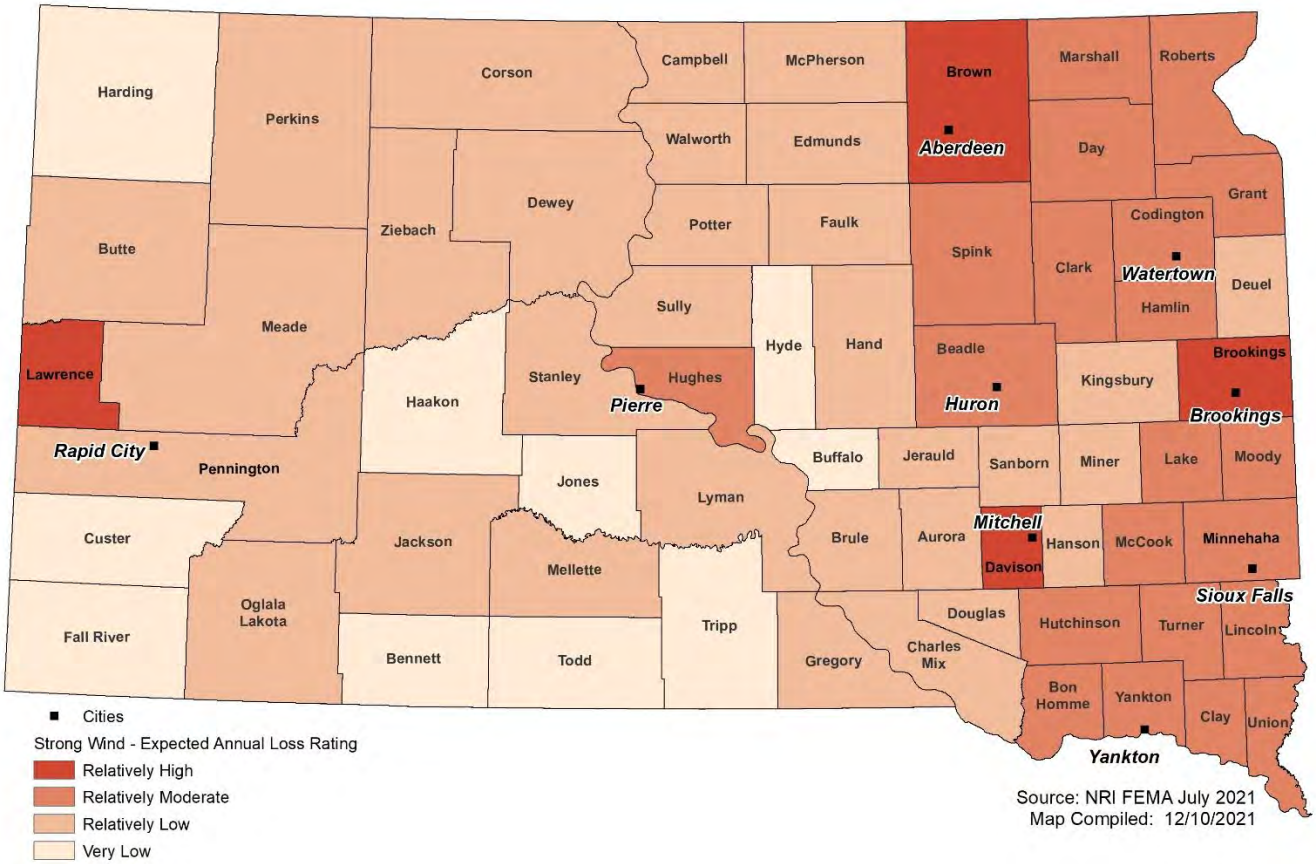
All property is exposed during high wind events, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Generally, damage is minimal and goes unreported. Property located under or near overhead lines or near large trees may be damaged in the event of a collapse.

To estimate potential losses to wind, historic loss data was analyzed. The NCEI data did not lend itself to county-by-county loss summaries, only a statewide summary. Based on historic loss information South Dakota averages 126 windstorms and $2.319 million in wind losses. In addition, South Dakota has experienced three windstorms that resulted in a disaster declaration. Of these three events, the event on

July 22, 2005, was credited entirely to wind, while the other two events also included damages from flooding and/or tornadoes. The total FEMA disaster relief costs for these three events are estimated at over $121.6 million in 2012 dollars, with an average cost of $40.5 million (also in 2012 dollars.) Based on past events, South Dakota can expect a disaster declaration-level windstorm event every 2,342 events or once approximately every 21 years.

Figure 3-71 shows the EAL rating due to windstorm events for all South Dakota counties. Using data from the NRI tool, the EAL ratings are calculated using the annualized frequency and historic loss ratio for each county.

**Figure 3-71 Expected Annual Losses due to Windstorm by County**




## *Critical Facilities and Infrastructure*

High winds can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Cascading hazards caused by high winds can result in 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. Closures of highways could have secondary impacts on local economies.

Electrical infrastructure is especially vulnerable to impacts from severe wind. Additional discussion on vulnerability and potential losses due to severe wind on electric infrastructure can be referenced in section 3.4 Rural Electrical Cooperatives Considerations.

While these Lawrence, Brown, Brookings, and Davison are rated by the NRI as having relatively high expected annual losses, wind events can happen anywhere in the State with considerable impacts. It is noted that Hughes County includes Pierre, the State capital, and has the highest concentration of state-

owned buildings, facilities and employees. While rated 'moderate' in terms of vulnerability to the three hazards it does lie within Wind Zone III (200 mph design wind speed).

### *Economy*

Economic impacts of severe wind are typically short-term. These events can disrupt travel into and out of all areas of the county and create perilous conditions for residents, tourists, and nature alike. Wind can also damage crops and impact the regional agricultural industry. A review of the USDA RMA records shows between 2007 and 2021 statewide there has been a total of $68,452,693 indemnity payments for a total 748,209 acres lost to wind. The estimated average annualized indemnity payments due to wind is $4,889,478.

### *Environment and Cultural Resources*

The environment is highly exposed to high winds. Environmental impacts include the downing of trees and localized flattening of plants by high wind. Forested areas could experience blow-downs.

## Development Trends and Consequence Summary

Based on past mitigation projects associated with windstorms (safe rooms, warning systems, utility line burials and generators) the future vulnerability of many of the high and very high ranked counties will be lessened to a degree by these projects as there is a lot of corresponding overlap. Population increases, and the associated growth of development, may increase a county's risk to damages and losses from windstorms. Refer to section 3.2.5 Land Use, Growth and Development Trends for more information on population and development changes by statewide.

**Table 3-53 Windstorm Consequence Table**

| Category | Narrative |
|---|---|
| Impact on the Public | Anyone without adequate shelter during an event at high risk of injury; impacts will be localized to the immediate area around the windstorm; air quality from blowing dust could have detrimental health impacts. |
| Impact on the Economic Condition of the State | Potential damage to facilities or infrastructure; economic impacts from prolonged power outages. |
| Impact on the Environment | Significant impact related to tree damage. May contribute to soil erosion and dust storms. |
| Impact on Property, Facilities, and Infrastructure | Buildings, vehicles, signage and/or any exposed or unsecured property may be affected during a tornado; property may be destroyed or have significant damage. Older buildings more susceptible to damage. |
| Impact on the Public Confidence in Government | Ability to respond and recover may be impaired if planning, response, and recovery is not timely and effective. |
| Impact on Responders | Unsafe structural or environmental conditions may persist during the response period. |
| Impact on Continuity of Operations and Continued Delivery of Services | Loss of facilities or infrastructure function or accessibility or ability to provide services; power interruption is likely if not adequately equipped with back-up generation. |
| Cascading Hazards | Tornadoes and Summer Storms. Exacerbates wildfire, drought and winter storm hazards. |

## 3.3.9 Hazardous Materials

### Description

South Dakota's Codified Law Chapter 33-15 Emergency Management defines a hazardous material as "any material, including but not limited to, explosives, flammable liquids, flammable compressed gas, flammable solids, oxidizing materials, poisons, corrosive materials, and radiological materials, the loss of control or mishandling of which could cause personal injury or death to humans or damage to property or the environment." A hazardous materials incident can occur during production, storage, transportation, use, or disposal of said materials. These substances are most often released as a result of transportation accidents or chemical accidents in plants and can be caused and complicated by a different type of hazard event (e.g., flood, earthquake). They affect humans through inhalation, ingestion, and direct contact with skin. South Dakota is concerned about transportation, fixed facility, and pipeline hazardous materials incidents.

### *Transportation*

Figure 3-72 illustrates South Dakota's transportation infrastructure. There is not a designated hazardous materials route map, but the interstates and other highways and railroads are the typical corridors that have hazardous materials being transported on them.

In transit, hazardous materials generally follow major transportation routes, including road, rail and pipelines, creating a risk area immediately adjacent to these routes. Information provided by the National Pipeline Mapping System (NPMS) indicate several pipelines conveying gas or hazardous liquids cross the planning area, these are shown in the figure below. Pipeline ruptures can result in major spills, or even explosions.

**Figure 3-72 South Dakota Transportation Infrastructure**

### *Fixed Facilities*

Hazmat incidents can occur at a fixed facility or during transportation. Hazardous materials facilities are identified and mapped by the counties they reside in, along with the types of materials stored there. Some facilities contain extremely hazardous substances; these facilities are required to generate Risk Management Plans (RMPs) and resubmit these plans every five years. According to the Right-to-Know network database there are 162 RMP facilities located in South Dakota.

Along with RMP facilities is the Toxics Release Inventory (TRI). The TRI tracks the management of certain toxic chemicals that may pose a threat to human health and the environment. U.S. facilities in different industry sectors must report annually how much of each chemical is released to the environment and/or managed through recycling, energy recovery and treatment. (A "release" of a chemical means that it is emitted to the air or water or placed in some type of land disposal.) According to NRI mapping data there are 259 such known facilities in South Dakota.

### Location

Hazardous materials incidents can happen throughout the State. Localities where hazardous materials are fabricated, processed, and stored as well as those where hazardous waste is treated, stored, and disposed of are most at risk for hazardous materials incidents. Additionally, localities along transportation corridors that carry these materials to their final destinations are also at risk. More than half of the transportation incidents between 1990 and 2021 occurred in Minnehaha and Pennington Counties, where the State's largest cities, Sioux Falls and Rapid City, are located (see the discussion on past events in the following section).

With the boom in the oil, gas and mining industries seen in the Northern Great Plains, the risk of hazardous materials from mining for resources has increased as new sites are developed. These facilities carry inherent risk for hazardous materials spills or accidents related to transportation of oil and gas extracted from these sites. The majority of these sites are west of the Missouri River and in the northwest and southwest corners of the State.

### *Pipelines*

According to the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA), South Dakota's pipeline system is as follows:

- Hazardous liquid line mileage: 803
- Gas transmission line mileage: 1,661
- Gas gathering line mileage: 0
- Gas distribution mileage: 4,570*
- Total pipeline mileage: 7,034

All mileages are for 2011 and are approximate as some data sources may not have contained a complete record of state pipeline mileage.
*Gas distribution service lines (the connection between the distribution line and the end user) are not included in the gas distribution mileage. The total number of such services is 193,628.

Table 3-54 shows the breakdown of gas transmission line and hazardous liquid line mileage by county. Note that some counties are not listed on the table. Figure 3-73 shows the location of these lines, the majority of which are located in the eastern half of the State.

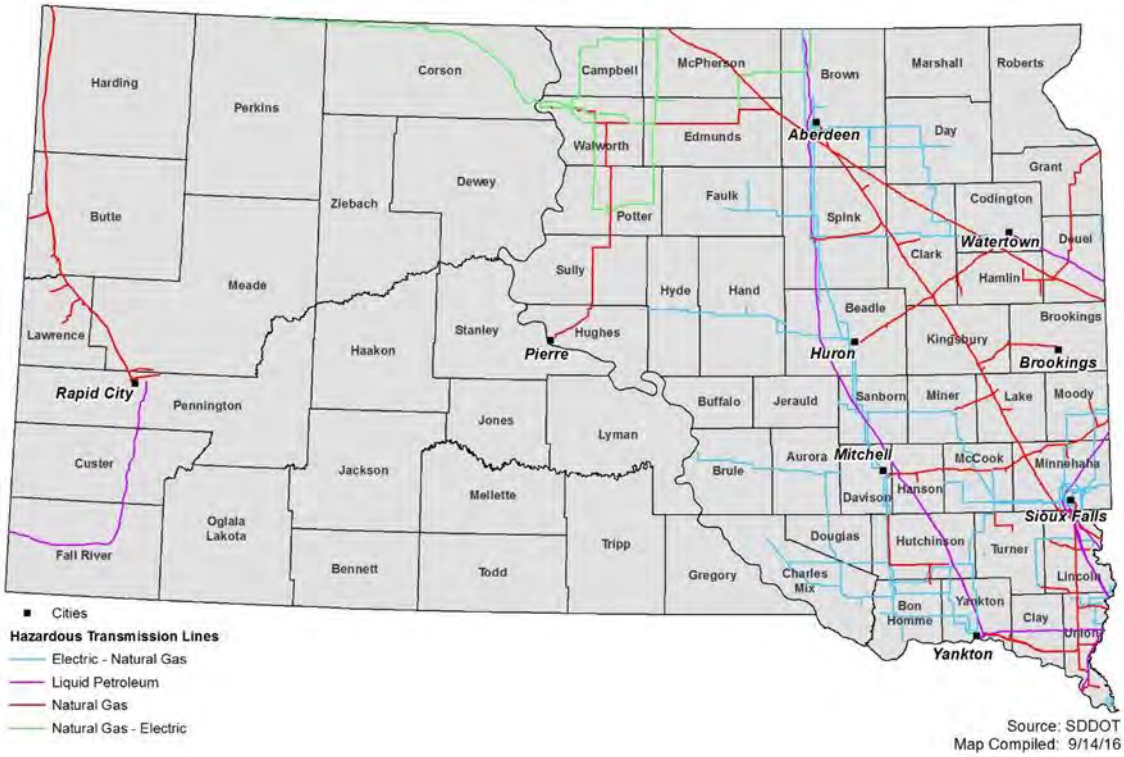
**Table 3-54 Gas Transmission Line and Hazardous Liquid Line Mileage by County (ranked by percent of total)**

| County | Gas Miles | Liquid Miles | Percent of Total |
|---|---|---|---|
| Lincoln | 85 | 106 | 7.70% |

| County | Gas Miles | Liquid Miles | Percent of Total |
|---|---|---|---|
| Minnehaha | 126 | 37 | 6.60% |
| Brown | 83 | 53 | 5.50% |
| Clark | 87 | 39 | 5.10% |
| Spink | 71 | 46 | 4.70% |
| Butte | 99 | 0 | 4.00% |
| Hutchinson | 43 | 52 | 3.80% |
| Union | 74 | 19 | 3.70% |
| Harding | 84 | 0 | 3.40% |
| Kingsbury | 67 | 16 | 3.30% |
| Yankton | 22 | 60 | 3.30% |
| Deuel | 53 | 24 | 3.10% |
| Beadle | 19 | 51 | 2.80% |
| Meade | 60 | 0 | 2.40% |
| Edmunds | 56 | 0 | 2.30% |
| Hanson | 20 | 37 | 2.30% |
| Clay | 36 | 17 | 2.10% |
| Day | 20 | 33 | 2.10% |
| McCook | 40 | 12 | 2.10% |
| Walworth | 54 | 0 | 2.10% |
| Fall River | 0 | 50 | 2.00% |
| Hamlin | 50 | 0 | 2.00% |
| Sully | 50 | 0 | 2.00% |
| Lawrence | 46 | 0 | 1.90% |
| Codington | 28 | 12 | 1.60% |
| Lake | 39 | 0 | 1.60% |
| McPherson | 40 | 0 | 1.60% |
| Pennington | 22 | 18 | 1.60% |
| Miner | 8 | 26 | 1.30% |
| Grant | 30 | 0 | 1.20% |
| Custer | 0 | 29 | 1.10% |
| Sanborn | 0 | 29 | 1.10% |
| Davison | 16 | 8 | 1.00% |
| Marshall | 0 | 26 | 1.00% |
| Moody | 22 | 3 | 1.00% |
| Potter | 26 | 0 | 1.00% |
| Turner | 24 | 0 | 0.90% |
| Hughes | 19 | 0 | 0.70% |
| Brookings | 15 | 0 | 0.60% |
| Roberts | 11 | 0 | 0.40% |
| Totals | 1,660 | 803 | 100% |

Source: PHMSA, http://primis.phmsa.dot.gov/comm/reports/safety/SD_detail1.html

**Figure 3-73 South Dakota Hazardous Materials Transmission Lines**

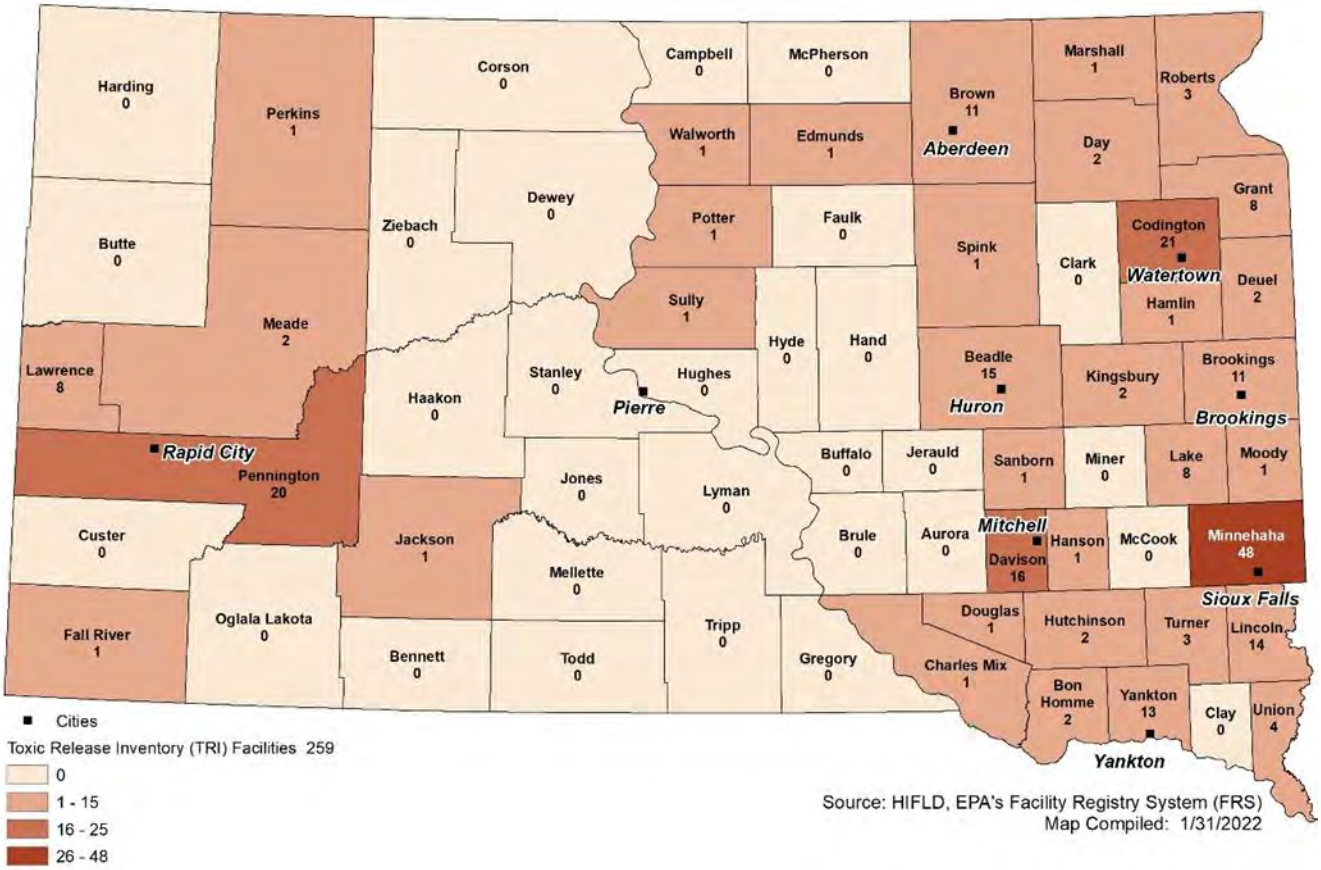



## *Fixed Facility*

Figure 3-74 shows the number of Toxic Release Inventory Facilities (TRI) facilities in each county as of 2022. TRI Facilities are maintained in a database containing information on toxic chemical releases and other waste management activities in the United States. In correlation to the three largest cities in South Dakota of Sioux Falls, Rapid City and Watertown, each of their respective counties carry the largest amount of TRI Facilities.

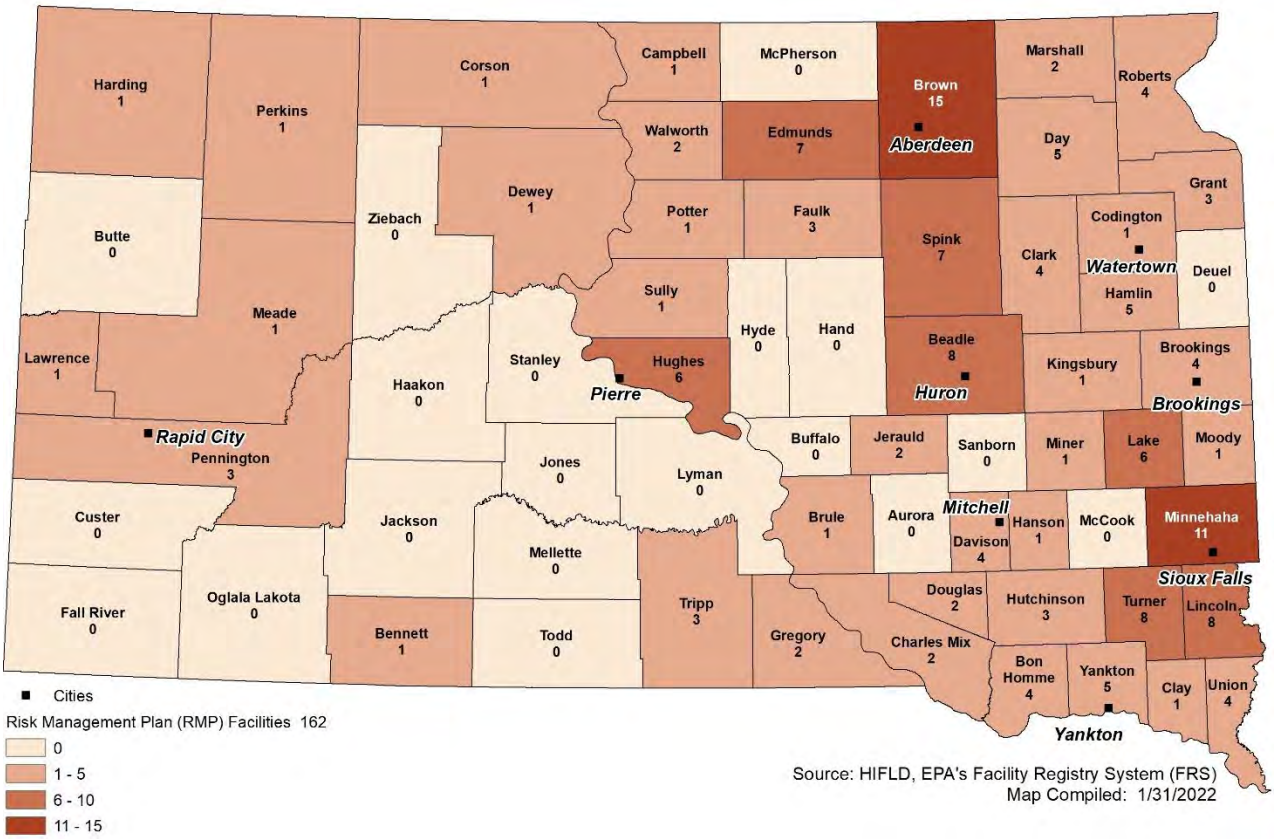
Minnehaha has the largest amount of these types of facilities with 48, Pennington County has 20 TRI Facilities. Watertown/Codington County has 21 total TRI Facilities and Davison County has 18. These four counties make up over 80% of the TRI Facilities.

**Figure 3-74 South Dakota Toxic Release Inventory (TRI) Facilities**




The counties with the most RMP facilities in South Dakota include Brown County with 15, Minnehaha County with 11 and Turner, Lincoln and Beadle Counties with 8 RMP facilities respectively. Minnehaha County has the highest population with South Dakota along with having the second highest number of chemical pipelines in the state. This information is displayed by county in Figure 3-75 below.

**Figure 3-75 South Dakota Risk Management Plan Facilities**




## Past Events

Table 3-54 shows the Significant Pipeline Incidents in South Dakota from 2002-2021. Significant events are classified by the U.S. Dept. of Transportation, Pipeline & Hazardous Materials Safety Administration as including the following conditions:

- Fatality or injury requiring in-patient hospitalization
- $50,000 or more in total costs, measured in 1984 dollars
- Highly volatile liquid releases of 5 barrels or more
    - Or other liquid releases of 50 barrels or more
- Liquid releases resulting in an intentional fire or explosion

Gas distribution incidents caused by a nearby fire or explosion (aka Fire First incidents) that impacted the pipeline system are excluded.

Table 3-55 **Significant Pipeline Incidents in South Dakota: 2002-2021**

| Years | # of Incidents | Fatalities | Injuries | Total Cost (2021 dollars) |
|---|---|---|---|---|
| 2002 | - | - | - | - |
| 2003 | - | - | - | - |
| 2004 | 1 | - | - | $249,250 |
| 2005 | - | - | - | - |
| 2006 | - | - | - | - |

| Years | # of Incidents | Fatalities | Injuries | Total Cost (2021 dollars) |
|---|---|---|---|---|
| 2007 | 2 | - | - | $1,193,426 |
| 2008 | 1 | - | - | $181,070 |
| 2009 | - | - | - | - |
| 2010 | 1 | - | - | $252,581 |
| 2011 | - | - | - | - |
| 2012 | 2 | - | - | $438,898 |
| 2013 | - | - | - | - |
| 2014 | - | - | - | - |
| 2015 | 1 | - | 1 | $222,937 |
| 2016 | 2 | - | - | $10,323,852 |
| 2017 | 1 | - | - | $48,611,483 |
| 2018 | 1 | - | - | $117,532 |
| 2019 | - | - | - | - |
| 2020 | 2 | - | - | $425,357 |
| 2021 | 1 | - | - | $224,788 |
| **Total** | **15** | **-** | **1** | **$62,241,174** |

Source: U.S. Department of Transportation, Pipeline & Hazardous Materials Safety Administration. https://www.phmsa.dot.gov/data-and-statistics/pipeline/

As seen in table above. While there haven't been more than two pipeline spillage incidents within South Dakota in a given year. Each pipeline incident has totaled into the hundreds of thousands to millions of dollars most years. The total of $62,241,174 in a 19-year time span equates to $3.2M in annualized damages.

During the 2021 HIRA update, one event of significance was found to have occurred on November 16, 2017 in Marshall County. The spill occurred along the Keystone Pipeline on farmland in the Town of Amherst. Initial reports from the U.S. DOT PHMSA estimated the spill released 210,000 gallons and was likely caused by mechanical damage during the construction of the pipeline in 2008. In April 2018, the local news source Aberdeen American News reported that a spokeswoman for the pipeline owner, TransCanada Corporation, estimated the spill to be 407,400 gallons, twice as much as was first reported in 2017. According to the PHMSA, this pipeline spill is now considered to the seventh largest onshore oil or petroleum product spill in the U.S. since 2010.

### *Transportation*

The Hazardous Materials Incident Report Subsystem (HMIRS) of the PHMSA Hazardous Materials Information System was established in 1971 to fulfill the requirements of the federal hazardous materials transportation law. Unintentional releases of hazardous materials or the discharge of any quantity of hazardous waste must be reported. The federal law defines hazardous material as "a substance or material that the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and has designated as hazardous materials. The term includes hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, materials designated as hazardous in the Hazardous Materials Table (see 49 CFR 172.101)."

According to the U.S. Department of Transportation's (DOT) Hazardous Materials Information System, South Dakota experienced 991 transportation incidents involving hazardous materials between 1990 and 2021. The total cost of damage associated with these incidents was $3,424,399. This suggests that South Dakota averages over 30 transportation incidents involving hazardous materials and $110,464 in related

damage each year. Among these incidents there were 21 deaths and 87 injuries. Most incidents occurred on the highway.

The majority of the Hazardous Materials Incidents that have occurred within the last 30 years in South Dakota have occurred in the state's most populated counties. The incidents reflected below showcase the Hazardous Materials incidents reported to the Department of Transportation historically since 1990.

**Table 3-56 Transportation Hazardous Materials Incidents, 1990-2021**

| County | # of Events | Fatalities | Total Injuries | Damages ($) | Evacuations |
|---|---|---|---|---|---|
| Minnehaha | 200 | 2 | 19 | 975,000 | 1623 |
| Pennington | 104 | 1 | 12 | 550,836 | - |
| Meade | 60 | - | 12 | - | 31 |
| Brown | 37 | - | 2 | 160,000 | 136 |
| Davison | 34 | - | 4 | - | 45 |
| Brookings | 33 | 3 | 5 | 367,000 | 30 |
| Lawrence | 32 | 1 | 3 | 194,000 | 905 |
| Grant | 31 | 2 | 7 | 207,419 | 181 |
| Beadle | 25 | - | - | - | - |
| Lincoln | 24 | - | 3 | 190,000 | 26 |
| Union | 22 | 1 | 3 | 50,000 | - |
| Yankton | 21 | - | 1 | - | 20 |
| Lake | 20 | - | 2 | - | 306 |
| Codington | 18 | - | - | - | - |
| Charles Mix | 17 | - | - | - | - |
| Hughes | 16 | - | - | - | - |
| Roberts | 16 | 5 | 2 | - | - |
| Turner | 12 | - | - | - | - |
| Custer | 12 | 1 | - | 187,097 | - |
| Brule | 11 | - | 1 | - | - |
| Dewey | 11 | - | - | - | - |
| Lyman | 10 | - | 1 | - | - |
| Harding | 10 | - | - | - | - |
| Edmunds | 9 | - | - | - | - |
| Moody | 9 | - | - | - | - |
| Spink | 9 | - | - | 12,347 | - |
| Stanley | 9 | - | - | 500,000 | 40 |
| Bon Homme | 9 | - | - | - | - |
| Marshall | 8 | - | - | - | - |
| Clay | 7 | - | - | - | - |
| Todd | 7 | - | - | - | - |
| Day | 7 | - | - | - | - |
| Hamlin | 7 | - | - | - | - |
| Potter | 7 | - | 1 | - | - |
| Fall River | 7 | - | - | - | - |

| County | # of Events | Fatalities | Total Injuries | Damages ($) | Evacuations |
|---|---|---|---|---|---|
| Butte | 7 | 2 | - | - | - |
| Buffalo | 6 | - | - | - | - |
| Clark | 6 | - | 1 | - | - |
| Hutchinson | 6 | - | 2 | - | - |
| Tripp | 6 | - | - | - | - |
| Walworth | 6 | - | 2 | - | - |
| Kingsbury | 5 | - | 1 | - | - |
| Shannon | 5 | - | - | - | - |
| Haakon | 5 | - | 1 | - | - |
| Bennett | 4 | - | - | 700 | - |
| Campbell | 4 | - | - | - | - |
| Faulk | 4 | - | - | - | - |
| Hand | 4 | - | - | - | - |
| Hyde | 4 | - | - | - | - |
| Jackson | 4 | - | - | - | - |
| McCook | 4 | - | - | - | - |
| Aurora | 3 | - | - | - | - |
| Deuel | 3 | - | - | - | - |
| Gregory | 3 | - | - | - | - |
| Miner | 3 | - | - | - | - |
| Sanborn | 3 | - | - | - | - |
| Sully | 3 | - | - | - | - |
| Ziebach | 3 | - | - | - | - |
| Jones | 2 | - | - | 30,000 | - |
| Corson | 2 | - | - | - | - |
| Douglas | 2 | - | - | - | - |
| Perkins | 2 | - | - | - | - |
| Hanson | 1 | - | - | - | - |
| Jerauld | 1 | - | - | - | - |
| Ogala Lakota | 1 | - | - | - | - |
| Mellette | 1 | - | - | - | - |
| McPherson | - | - | - | - | - |
| **Total:** | **991** | **21** | **87** | **$3,424,399** | **3045** |

Source: DOT's Office of Hazardous Materials Safety Incident Reports Database, https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/search.aspx

## Probability of Future Occurrence

### *Fixed Facility*

Not enough available data exists in order to calculate probability for a fixed facility incident. In general, these can be expected to occur less frequently than transportation-related incidents.

### *Transportation*

According to the U.S. DOT's Hazardous Materials Information System, there were 991 transportation incidents involving hazardous materials in South Dakota between 1990 and 2021 (31 years). The largest number of incidents have occurred within the state's most populated areas. Based on this information, approximately 32 transportation incidents involving hazardous materials will occur in South Dakota annually.

### *Pipeline*

According to the U.S. DOT's Office of Pipeline Safety, there were 15 pipeline incidents in South Dakota between 2002 and 2021. Based on this information, the probability that at least one pipeline incident will occur in South Dakota annually is 100%.

## Magnitude/Severity (Extent)

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 predict precise impacts. Materials found in South Dakota will have at least one of the impacts listed above, and probably more, but the location and type of incident will determine the magnitude.

## Climate Change Considerations

Climate change is not anticipated to affect the frequency or severity of hazardous materials incidents.

## Vulnerability Assessment

The counties in South Dakota contain energy pipelines, railroad tracks which carry many types of hazardous materials, and state highways running through the counties. A variety of hazardous materials originating in the Region or elsewhere are transported along these routes and could be vulnerable to accidental spills. Consequences can vary depending on whether the spill affects a populated area vs. an unpopulated but environmentally sensitive area.

As illustrated in the table below the top five counties and cities in South Dakota contain the largest amount of Toxic Release Facilities. Minnehaha and Codington counties where, Sioux Falls and Watertown are located respectively, have the most Toxic Release Inventory Facilities. Minnehaha County also possesses the highest amount of Hazmat Transportation Incidents in South Dakota since 1990, many of which have occurred in Sioux Falls. Pennington is second in that regard, with 104 hazmat transportation spills.

**Table 3-57 South Dakota Top Counties for Hazardous Materials Facilities and Incidents**

| County | TRI Facilities Per County | RMP Facilities Per County | Transportation Incidents Per County (1990-2021) |
|---|---|---|---|
| Minnehaha | 48 | 11 | 200 |
| Codington | 21 | 1 | 18 |
| Pennington | 20 | 3 | 104 |
| Davison | 16 | 4 | 34 |
| Beadle | 15 | 15 | 25 |
| **Total:** | **120** | **34** | **381** |

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.

### *People*

Hazardous materials incidents can cause injuries, hospitalizations, and even fatalities to people nearby. People living near hazardous facilities and along transportation routes may be at a higher risk of exposure, particularly those living or working downstream and downwind from such facilities. For example, a toxic spill or a release of an airborne chemical near a populated area can lead to significant evacuations and have a high potential for loss of life.

In addition to the immediate health impacts of releases, a handful of studies have found long-term health impacts such as increased incidence of certain cancers and birth defects among people living near certain chemical facilities. However there has not been sufficient research done on the subject to allow detailed analysis.

Based on the data in the past events section, there are 2.8 injuries and 0.6 deaths annually from transportation incidents over a 31-year period. Note that some of these deaths and injuries may have been a result of a crash, vs. a result of the release.

### *Property*

The impact of a fixed hazardous facility, such as a chemical processing facility is typically localized to the property where the incident occurs. The impact of a small spill (i.e. liquid spill) may also be limited to the extent of the spill and remediated if needed. A blanket answer for potential impacts is hard to quantify, as different chemicals may present different impacts and issues. Property within a half mile in either direction of designated hazardous materials routes is at increased risk of impacts. While cleanup costs from major spills can be significant, they do not typically cause significant long-term impacts to property. However, some larger incidents involving pipelines, railroads, or explosive materials may cause significant and overwhelming damage to the surrounding communities. Based on the data in the past events section, $3.2M in annual losses associated with pipeline incidents, and $110k in annual damages associated with transportation incidents.

### *State Assets, Critical Facilities and Infrastructure*

Impacts of hazardous material incidents on critical facilities are most often limited to the area or facility where they occurred, such as at a transit station, airport, fire station, hospital, or railroad. However, they can cause long-term traffic delays and road closures resulting in major delays in the movement of goods and services. These impacts can spread beyond the planning area to affect neighboring counties, or vice-versa. While cleanup costs from major spills can be significant, they do not typically cause significant long-term impacts to critical facilities.

### *Economy*

The primary economic impact of hazardous material incidents result in lost business, delayed deliveries, property damage, and potential contamination. Large and publicized hazardous material-related events can deter tourists and recreationists too. If incidents occur along major transportation corridors, they can temporarily close routes and result in traffic delays. Economic effects from major transportation corridor closures can be significant.

### *Environment and Cultural Resources*

Hazardous material incidents may affect a small area at a regulated facility or cover a large area outside such a facility. Widespread effects occur when hazards contaminate the groundwater and eventually the municipal water supply, or they migrate to a major waterway or aquifer. Impacts on wildlife and natural resources can also be significant. These types of widespread events may be more likely to occur during a transportation incident, such as a pipeline spill, and can have far reaching and devastating impacts on the natural environment and habitats if they occurred near one of the several wildlife refuges in Brown County.

## Development Trends and Consequence Summary

Future development and population growth could result in increases in the number of people potentially exposed to the impacts of hazardous materials incidents in certain areas of the State. The number of hazardous materials that are stored, used, and transported across the State may continue to increase over the coming years if regional growth continues. The largest growing city in South Dakota is the Sioux Falls metro area. Its population grew by 19.8% from 2010 to 2020 to 273,566 residents. During this same time period, the population of South Dakota increased overall by 9.6%.

Growth and development trends such as these must be taken into consideration when assessing vulnerability of jurisdictions to hazardous materials incidents. Southeastern counties are more vulnerable to fixed facility incidents in general due to the number of facilities there. The counties with these facilities are listed in the hazard profile section. Available data does not support further refinement of vulnerability to fixed facility or transportation incidents based on historic losses.

**Table 3-58 Hazardous Materials Consequence Table**

| Category | Narrative |
|---|---|
| Impact on the Public | Impact is dependent upon characteristics of the chemicals associated with the incident. Health impacts from contamination in water or air; anyone without adequate shelter or appropriate protection during an event at high risk of injury and death. |
| Impact on the Economic Condition of the State | Potential loss of facilities or infrastructure; potential impact to tourism depending on severity and location of the event. |
| Impact on the Environment | Significant impact related to water quality and air quality; significant impact to animal habitats depending on location and severity. |

| Category | Narrative |
|---|---|
| Impact on Property, Facilities, and Infrastructure | Vulnerabilities to critical infrastructure, facilities, properties, equipment, vehicles, and communications and utility infrastructure. |
| Impact on the Public Confidence in Government | Ability to respond and recover may be questioned and challenged if planning, response, and recovery is not timely and effective. |
| Impact on Responders | Exposure exists to response personnel performing routine duties when event occurs; appropriate protection required. |
| Impact on Continuity of Operations and Continued Delivery of Services | Potential loss of facilities or infrastructure function or accessibility or ability to provide services. |
| Cascading Hazards | Explosions could result in grass or wildfires. |

## 3.3.10 Geologic Hazards

### Hazard Description

A geologic hazard is the result of a natural earth process resulting in impacts that pose a threat to life and/or property. For purposes of this plan, the geologic hazards profiled consists of landslides, mudflows, expansive soils, subsidence, and earthquakes.

#### *Landslide*

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 damage and 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 movement include saturation by water, steepening of slopes by 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.

Landslides are defined as a rapid slipping of a mass of earth or rock from a higher elevation to a lower level under the influence of gravity and water lubrication. More specifically, rockslides are the rapid downhill movement of large masses of rock with little or no hydraulic flow, similar to an avalanche. Water-saturated soil or clay on a slope may slide downhill over a period of several hours. Earthflows of this type are usually not serious threats to life because of their slow movement, yet they can cause blockage of roads and do extensive damage to property.

#### *Mudflow*

Mudflows (or debris flows) are rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or “slurry.” A slurry can flow rapidly down slopes or through channels and can strike with little or no warning at avalanche speeds. A slurry can travel several miles from its source, growing in size as it picks up trees, cars, and other materials along the way. After a wildfire, heavy

rainfall can create mudflows that may increase risks to people, structures, and infrastructure located below such areas.

Damages from mudflows are covered under the NFIP; landslides are not.

### *Expansive Soil*

Expansive soils 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. 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. 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.
- **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.

Cracked foundations, floors and basement walls are typical types of damage done by swelling soils. Damage to the upper floors of the building can occur when motion in the structure is significant. Expansive soils will also shrink when they dry out. This shrinkage can remove support from buildings or other structures and result in damaging subsidence. Fissures in the soil can also develop. These fissures can facilitate the deep penetration of water when moist conditions or runoff occurs. This produces a cycle of shrinkage and swelling which places repetitive stress on structures.

### *Subsidence*

Land subsidence is the sinking of the land over manmade or natural underground voids. Subsidence occurs naturally and also through man-driven or technologically exacerbated circumstances. Natural causes of subsidence occur when water in the ground dissolves minerals and other materials in the earth, creating pockets or voids. When the void can no longer support the weight of the earth above it, it collapses, causing a sinkhole depression in the landscape. Often, natural subsidence is associated with limestone erosion, but may also occur with other water-soluble minerals. Man-driven or technology-exacerbated subsidence conditions are associated with the lowering of water tables, extraction of natural gas, or subsurface mining activities. As the underground voids caused by these activities settle or collapse, subsidence occurs on the surface.

Subsidence can result in serious, localized structural damage to buildings, roads, irrigation ditches, canals, streams, underground utilities, and pipelines. It can disrupt and alter the flow of surface or underground water. The consequences of improper use of land subject to ground subsidence can be excessive economic losses, including the high costs of repair and maintenance for buildings, irrigation works, highways, utilities, and other structures. This results in direct economic losses to citizens as well as indirect economic losses through increased taxes and decreased property values.

### *Earthquake*

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Earthquakes east of the Rocky Mountains are less frequent than in the western United States and are typically felt over a much broader region. Most of North America east of the Rocky Mountains has infrequent earthquakes, and the region from the Rockies to the Atlantic Ocean can go years without an earthquake large enough to be felt. Several U.S. states have never reported a damaging earthquake. The earthquakes that do occur in this region are typically small and occur at irregular intervals.

East of the Rockies it is difficult to determine the specific fault that is responsible for an earthquake since this vast region is far from plate boundaries, which are in the Atlantic Ocean, the Caribbean Sea, and in California and offshore from Washington and Oregon. Known faults do exist in this "stable continental region," but numerous smaller or deeply buried faults remain undetected, even most of the known faults are poorly located at depths typically associated with earthquakes. Additionally, it is difficult to determine if a fault is still active and capable of generating an earthquake. Consequently, in most areas east of the Rockies, the best guide to earthquake hazards is the earthquakes themselves.

South Dakota is somewhat more seismically active than other areas in the Northern Great Plains, although the earthquake magnitudes have been relatively minor to date. At least two mechanisms may be important in the generation of earthquakes. These include initiation of movement along pre-existing fractures due to crustal plate movements or movements due to glacial rebound. Ground motion accelerations can be calculated based upon historical seismic records, but the poor quality of the database does not allow great confidence to be placed in those calculations. These calculations show highs in ground motion acceleration that correspond reasonably closely with areas of greater earthquake frequency.

## Location

### *Landslides*

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.

Areas that are typically considered safe from landslides include areas that have not moved in the past, relatively flat-lying areas away from sudden changes in slope, and areas at the top or along ridges, set back from the tops of slopes.

In certain areas of South Dakota landslides do occur. Figure 3-76 below illustrates areas of landslide susceptibility in South Dakota, indicating that landslides are most likely to occur in the Black Hills and Missouri River areas. Over the years, many landslides have been dealt with by the State of South Dakota and in particular the SDDOT. SDDOT has spent a lot of time stabilizing landslides throughout the State. Two of the larger slides were the U.S. 12 Missouri River Crossing at Mobridge and the U.S. 212 Missouri River crossing at Forest City. At Mobridge, stone columns were used for the first time in the United States to stabilize a clay-shale landslide. Forest City also used stone columns and incorporated the use of massive concrete shear pins installed by a slurry wall process to stabilize the approach berm. This was the first time in the United States that this technique was used to mitigate a landslide of this magnitude. A civil engineer, who was head of the SDDOT Geotechnical Activity Section from 1969 to 2001, achieved

national recognition for his innovative work with these two landslides. A slide area also exists near Cheyenne Crossing along U.S. Highway 14A in Lawrence County. Road crews were engaged in landslide repair efforts at the site in 2012 and continuing into 2013. A potential landslide area existed near Yates Pond in Lawrence County along U.S. Highway 14A, but SDDOT mitigated this area in 2010.

**Figure 3-76 South Dakota Landslide Incidence and Susceptibility**

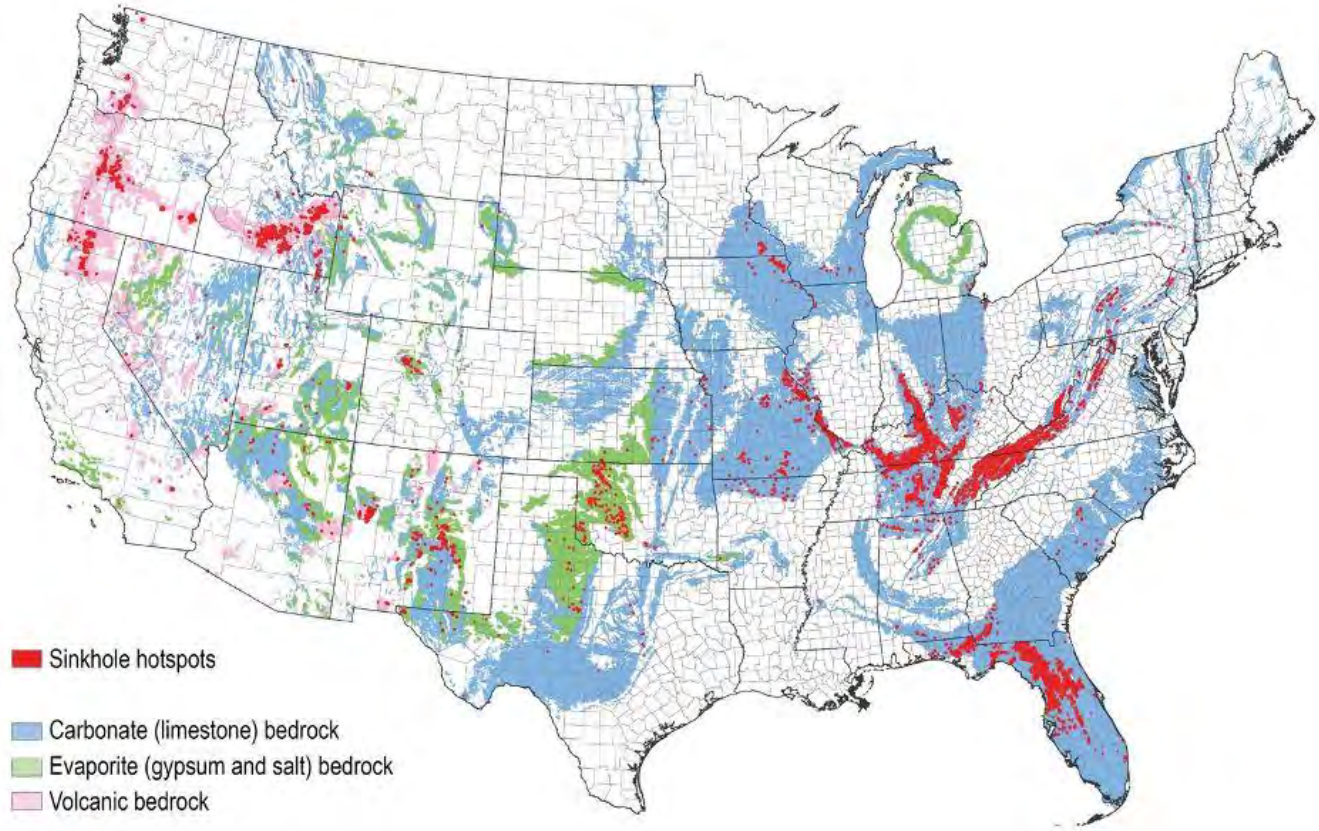
Source: U.S. Geological Survey, map generated by https://nationalmap.gov/

## *Subsidence*

There are certain areas in South Dakota at risk to subsidence (see Figure 3-77). The Niobrara Formation (Upper Cretaceous) and its equivalents are the most widespread carbonate rocks in western Kansas, eastern Nebraska, and southeastern South Dakota. The Niobrara is generally covered by more than 50 ft. (15 m) of younger sediments. Small fissures, less than 1,000 ft. (300 m) long and up to 100 ft. (30 m) deep, are present, but they are not common and are generally irregularly spaced with 1,000 ft. (300 m) or more of solid rock between fissures.

In western South Dakota and adjacent parts of Wyoming and Montana, Paleozoic, and Cretaceous carbonate rocks, arched steeply upwards, encircle the structural dome that forms the Black Hills. Caves and open fissures are common in the Paleozoic carbonate rocks. A few caves contain many miles of passages but most of the cave passages and fissures in the Black Hills area only extend up to 3,000 ft. (900 m) in length and are generally less than 150 ft. (45 m) in depth. Closely spaced solution joints also are prevalent.

**Figure 3-77 Karst Map of the Conterminous United States**

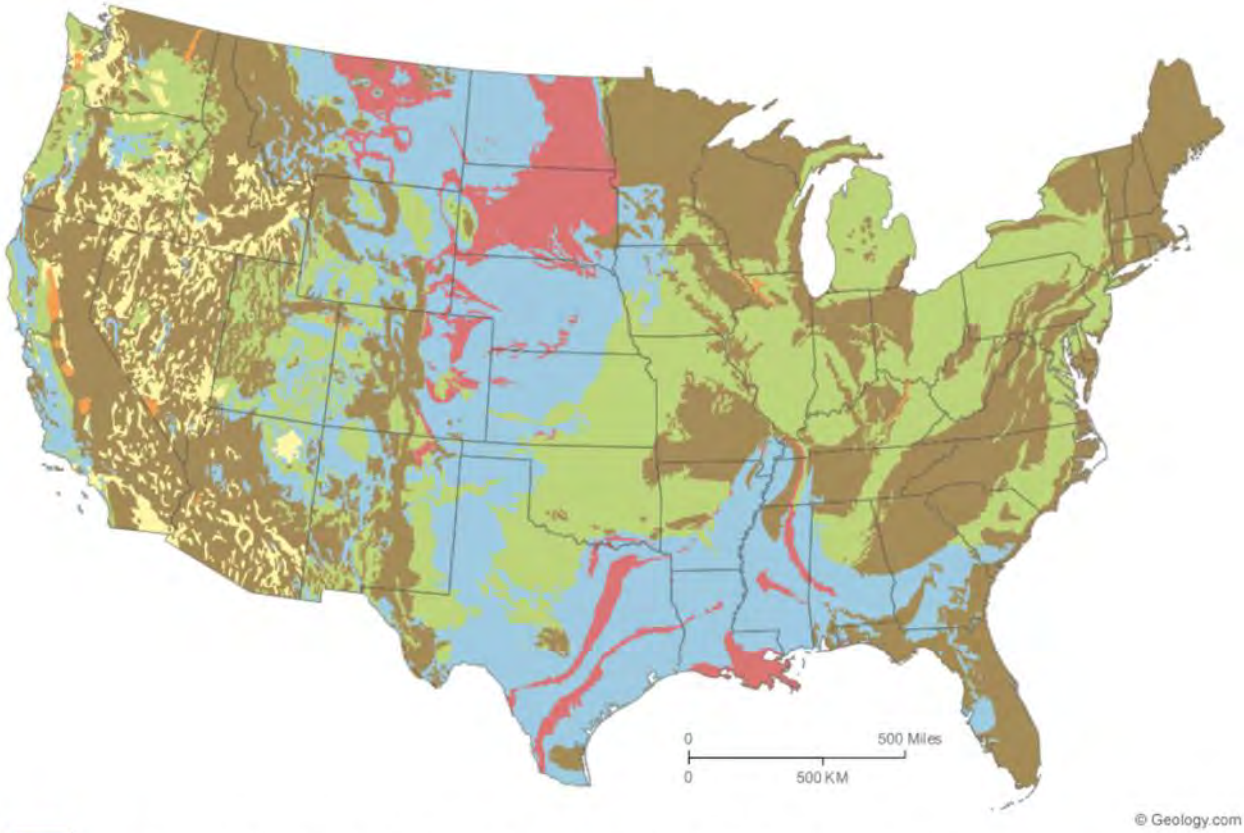



Source: USGS https://www.usgs.gov/media/images/karst-map-conterminous-united-states-2020

### *Expansive Soils*

There are certain areas of South Dakota at risk to expansive soils. Figure 3-78 below shows the geographic distribution of soils which are known to have expandable clay minerals which can cause damage to foundations and structures. It also includes soils that have a clay mineral composition which can potentially cause damage. The map is meant to show general trends in the geographic distribution of expansive soils. It is not meant to be used as a property evaluation tool. It is useful for learning areas where expansive soils underlie a significant portion of the land and where expansive soils might be a localized problem. According to this map, most of the State has high potential for expansive soils.

**Figure 3-78 Generalized Expansive Soils Nationwide**




Over 50 percent of these areas are underlain by soils with abundant clays of high swelling potential.

Less than 50 percent of these areas are underlain by soils with clays of high swelling potential.

Over 50 percent of these areas are underlain by soils with abundant clays of slight to moderate swelling potential.

Less than 50 percent of these areas are underlain by soils with abundant clays of slight to moderate swelling potential.

These areas are underlain by soils with little to no clays with swelling potential.

Data insufficient to indicate the clay content or the swelling potential of soils.

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.

### *Earthquake*

A zone of higher earthquake frequency extends from the northeastern corner of the State and a generally higher frequency of earthquakes is recorded along the eastern flank of the Black Hills and in the southwestern corner of the State. The earthquakes occurring in South Dakota appear to be concentrated along the Great Lakes Tectonic Zone and possibly along the boundaries of the structural provinces in the Precambrian, crystalline basement.

The Black Hills, being a structural dome, is full of faults and joints dating to the uplift some 50 million years ago. Very little strain now accumulates along them, so only small, rare earthquakes have occurred in

the region during historic times. Work by several geologists during the last decade or so have shown that much of the region has widely spaced joints and faults breaking the earth's crust into blocks, each a township size in area. Fortunately, there is very little strain to release as earthquakes in South Dakota. In the south central part of the State, the South Dakota Geologic Survey have mapped some of these blocks and have identified individual block-bounding faults that have moved 40 feet or more vertically and a few hundreds of feet horizontally in very small increments during the last 50 million years.

### Past Events

Table 3-59 provides information regarding past landslides, mudflows, subsidence, and expansive soils.

**Table 3-59 South Dakota Landslides and Mudflows**

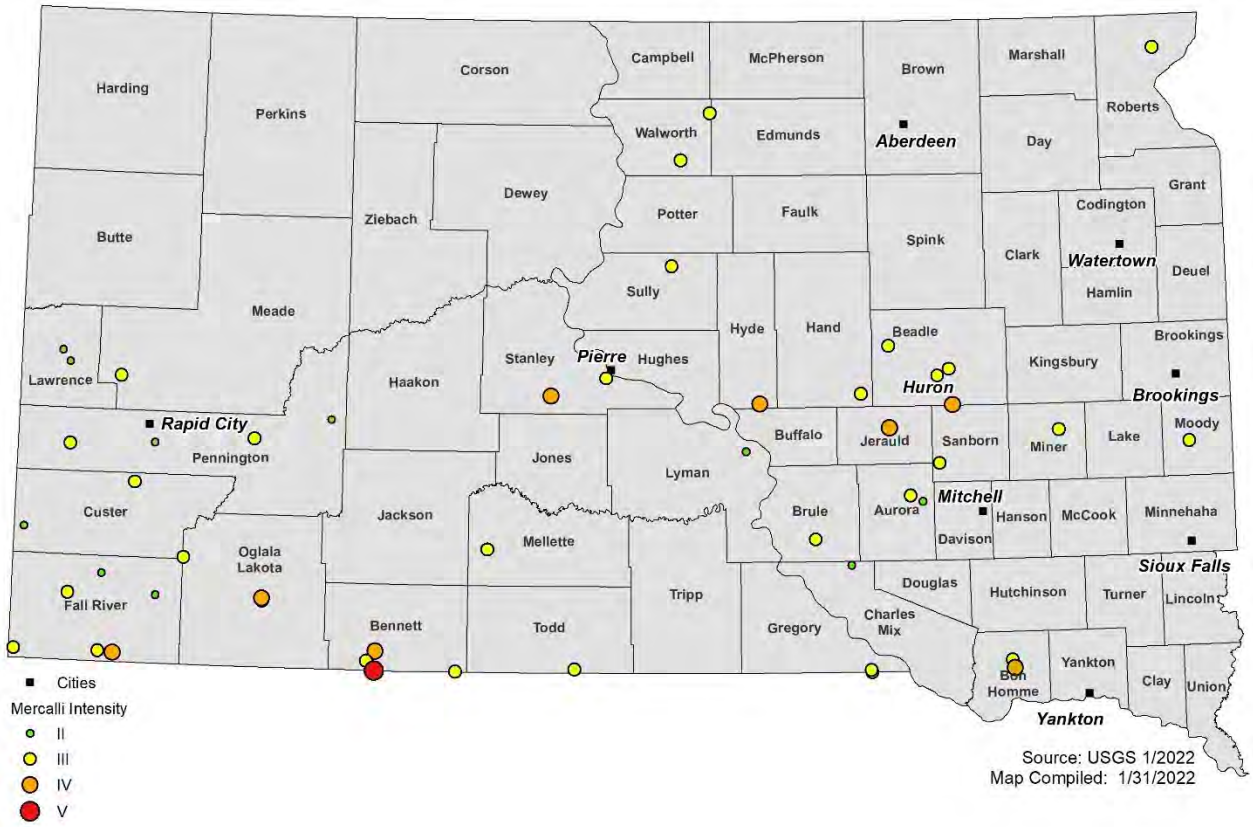
| Date | Comments |
|---|---|
| January 8, 2021 | A 300-foot long landslide forced the closure of Highway 240 south of Wall in Badlands National Park. |
| 2012-2013 | Road crews worked to repair a slide area near Cheyenne Crossing along U.S. Highway 14A in Lawrence County. Repair efforts included excavating landslide debris and constructing a new back slope. |
| 2006 | A landslide near Wasta in Pennington County took the water system out for a week. |
| August 8, 2004 | A heavy rain at the rate of about one inch per hour fell over the area burned by the Grizzly Gulch fire in Lawrence County just six weeks before. The result was that the steep hillsides lost most of their topsoil, which flowed down into Deadwood. Hardest hit was the area of the Northern Hills General Hospital where a retaining wall was damaged, Whistler's Gulch Campground and Mile High Mobile Home Park, and properties along Sherman Street in Deadwood. Cleanup would have been well over one million dollars, but the use of a state prison work crew and volunteers reduced the out-of-pocket expense to property owners. |
| 2001 | A mudflow caused by heavy rain occurred after the Black Hills Grizzly Gulch Fire in 2001. The mudflow caused damage to many homes in the burn area or below. |
| June 1976 | Flash Flooding, Mudslides (FEMA-511-DR)<br>In a 24-hour period on June 13-14, 3 to 10 inches of rain fell in the northern Black Hills. And additional two to three inches of rain plus heavy snow was recorded over this area on the June 15 and 16. The runoff from this precipitation did considerable damage in the counties of Lawrence, Meade, Butte, and Harding. There was also a problem with mudslides and landslides. |
| May 1952 | Sturgis/Deadwood - Heavy rains brought flash flooding that tore up streets and gas pipelines in Sturgis. Bridges were washed out and water erosion caused rockslides. Water damage and landslides also occurred in Deadwood. |

Limited information was available regarding past impacts from swelling soils. Modern building practices often take this hazard into account and incorporate mitigation. The SDDOT does normal maintenance and accounts for this hazard in their construction practices, which does result in additional costs for mitigation and road maintenance. Research yielded little information regarding past impacts from subsidence.

According to the USGS, no major earthquakes have been reported in South Dakota since 1967. However, earthquakes have historically caused relatively minor damage in South Dakota. Documented damages include cattle stampedes, shaking buildings, falling, or rattling dishes and pictures, stuck doors and windows, cracked window glass, foundations heaving or cracking, wall and ceiling plaster cracks, and furniture moving. Table 3-60 and Figure 3-79 below provide the locations and information of past earthquakes in South Dakota which have caused noticeable impacts.

Table 3-60 below details notable earthquakes centered or felt in South Dakota, with details provided primarily by the USGS, as well as an abridged version of Carl A. von Hake's "South Dakota History" in Earthquake Information Bulletin, Volume 9, Number 1, January–February 1977.

**Figure 3-79 Earthquakes in South Dakota 1906-2021**




Source: U.S. Geological Survey

**Table 3-60 South Dakota Earthquakes**

| Date | Comments |
|---|---|
| June 4, 2021 | Magnitude 3.7, 10 km northeast of Anoka, Nebraska along the South Dakota/Nebraska Stateline. Modified Mercalli Intensity (MMI) of V – Moderate |
| March 26, 2021 | Magnitude 3.4, 10 km east of Edgemont |
| January 4, 2021 | Magnitude 3.1, 5 km north of Tyndall |
| December 9, 2020 | Magnitude 3.2, 10 km northwest of Bowdle |
| August 15, 2017 | Magnitude 3.0, 8 km east of Agar |
| February 7, 2014 | Magnitude 3.0, Northwest of Platte |
| December 12, 2013 | Magnitude 3.5, South of Colonial Pine Hills |
| January 16, 2012 | Magnitude 3.0 near Custer/Fall River/ Oglala Lakota County (previously Shannon County) borders |
| November 15, 2011 | Magnitude 3.3 in Fall River County |
| November 14, 2011 | Magnitude 4.0 in Fall River County |
| August 9, 2011 | Magnitude 3.4 near Hughes/Stanley County border |
| September 25, 2009 | Magnitude 3.8 at 10:11 am. 30 miles northwest of Belle Fourche |
| February 7, 2007 | Maximum Intensity III - Magnitude 3.1, 4:35 a.m. 7 miles west southwest of Wasta, 17 miles west northwest of Wall |
| October 19, 2005 | Magnitude 3.1 |

| Date | Comments |
|---|---|
| January 24, 2004 | Magnitude 2.5 |
| January 5, 2004 | Magnitude 2.8 |
| November 21, 2003 | Magnitude 3.5 |
| May 25, 2003 | Intensity IV at Kyle and Gordon, III at Pine Ridge and Chadron - Magnitude 4.0, 1:32 a.m. 35 miles east of Pine Ridge, 115 miles southwest of Pierre |
| July 26, 2002 | Magnitude 3.1 |
| July 12, 1998 | Magnitude 3.1 |
| May 3, 1996 | Magnitude 3.1 |
| February 6, 1996 | Intensity V - 9:10 a.m. 24 miles south southwest of Yankton (Magnitude 3.6). Felt by many people. The quake caused Gavins Point Dam personnel to conduct dam safety checks.<br>Intensity V - 9:08 a.m. Northwest of Mt. Rushmore (3.7 Richter). Felt by many people who noticed typical earthquake ground movement.<br>Both quakes were centered about 5 km below the surface. Neither quake can be definitely associated with any mapped fault, but both are near known or postulated faults |
| July 3, 1995 | Intensity III - Southwest of Ft. Thompson (2.8 Richter) |
| March 18, 1994 | Intensity III - Hot Springs (2.8 Richter) |
| September 5, 1993 | Intensity III - Deadwood (2.7 Richter) |
| October 25, 1990 | Intensity V - Aurora County north of Plankinton and west southwest of Storla |
| March 2, 1990 | Intensity IV - Oglala Lakota County (previously Shannon County) north of Manderson |
| January 28, 1990 | Intensity V - Oglala Lakota County (previously Shannon County) north of Manderson |
| November 26, 1989 | Intensity III - Walworth County near Lowery |
| October 15, 1987 | Intensity III - Beadle County northeast of Wessington |
| July 9, 1987 | Intensity III - Beadle County near Virgil |
| May 25, 1986 | Intensity IV - Sanborn County slightly northeast of Storla |
| March 4, 1983 | Intensity VI - On Hyde–Buffalo County border south of Mac's Corner |
| November 15, 1982 | Intensity V - Bon Homme County near Avon |
| July 11, 1982 | Intensity V - Moody County near Egan |
| September 13, 1981 | Intensity V - Bennett County southeast of Batesland on the Nebraska border |
| May 16, 1975 | Intensity IV - Fall River County near Edgemont |
| October 19, 1971 | Intensity IV - 3:15 p.m. Jackson County halfway between Kadoka and Norris. Glass rattled |
| November 23, 1967 | Intensity V - Lyman County east of Hamill near Tripp-Lyman County border. Magnitude 4.4, felt in Winner, Rosebud, White River areas. Many residents were frightened in Gregory, where furniture shifted, and windows cracked. Livestock stampeded through fences on some farms |
| Jun 26, 1966 | Intensity VI - 5:59 a.m. Meade County between Bethlehem and Tilford. Magnitude 4.1, slight damage at Rapid City. At Keystone, well water was muddied for several hours. At Rapid City, concrete steps cracked away from a house and a patio cracked. At Deadwood, there was a fallen tree due to the shock. At Keystone, one observer reported he could see the ground moving. Pictures on walls bounced, buildings creaked, and dishes rattled. There was a gradual onset with a bumping swaying motion. In Rapid City, buildings creaked, and loose objects rattled. There was a rapid onset with a bumping motion, and moderately loud earth sounds were also heard |
| August 26, 1964 | Intensity IV - Pennington County south of Wall in Badlands National Park |
| March 28, 1964 | Intensity VII - Epicenter in western Nebraska. Magnitude 5.1. Duration: 10 seconds. Depth: 65.98 miles. (This quake was not actually in South Dakota but caused damage anyway. It is listed here to represent the danger from earthquakes that originate outside the State's borders) |

| Date | Comments |
|---|---|
| March 27, 1964 | Unknown strength due to proximity of the Great Alaska Quake - 9:00 p.m. Near Van Taussell, Wyoming. Felt throughout Black Hills with an apparent intensity of IV. (This quake was not actually in South Dakota but caused damage anyway. It is listed here to represent the danger from earthquakes that originate outside the State's borders) |
| March 24, 1964 | Intensity V - 12:12 a.m. Custer County north northeast of Hot Springs near Fall River-Custer County border. Felt by all at Wind Cave National Park. Small rocks fell in cave, buildings creaked, and loose objects rattled. Moderately loud, rumbling noise heard. Abrupt onset, trembling motion. Duration: 3–5 seconds |
| December 31, 1961 | Intensity VI - 10:35 a.m. Stanley County near Wendte. Felt by many in Pierre. Slight damage. Plaster cracked, cement floors cracked, refrigerator doors shaken open, clothes dryer moved several inches. Fishermen along the Missouri River reported that the moment the quake struck; hundreds of fish jumped into the air. Buildings shook and loose objects rattled.<br>Intensity V - Murdo - felt by many. Plaster on walls cracked, venetian blinds swayed, dishes rattled, faint earth sounds heard, trembling motion with abrupt onset.<br>Intensity IV - Presho and Winner.<br>Intensity I-III - Draper, Hayes, Huron, Midland, Onida, Philip, and White River |
| January 12, 1959 | Intensity IV - 7:15 a.m. Spink County near Doland. Felt by many; rumbling sound followed by what sounded like a boiler explosion. Dishes and windows rattled |
| December 3, 1957 | Intensity IV - 1:30 a.m. Davison County near Loomis. Awakened several people in Mount Vernon, where buildings creaked, and loose objects rattled. At Mitchell, houses shook, and windows and doors rattled. Livestock was "alarmed and all bunched up" |
| December 31, 1953 | Intensity IV - Gregory County south of Burke |
| December 21, 1953 | Intensity IV - Perkins County near Zeona |
| November 14, 1952 | Intensity IV - Pennington County near Silver City |
| December 14, 1949 | Intensity III - Gregory County near Dallas |
| Jun 3, 1949 | Intensity IV - Potter County near Gettysburg |
| March7, 1949 | Intensity III - Hand County near Miller |
| August 25, 1947 | Intensity IV - Gregory County near Bonesteel |
| July 23, 1946 | Intensity VI - Jerauld County near Wessington Springs. In Wessington water mains cracked at two points |
| November 10, 1945 | Intensity IV - 3:00 a.m. Bon Homme County east of Kingsbury and southeast of Tyndall. Rattled dishes |
| May 16, 1943 | Intensity IV - 12:40 p.m. Custer County north northeast of Hot Springs near Fall River-Custer County border. Felt by many "like heavy trucks rumbling down the street." Dishes rattled |
| March 11, 1942 | Intensity III - 11:55 a.m. Meade County near Sturgis. Light shock felt in Deadwood, Fort Meade, Lead, Piedmont, Sturgis, Terraville, Trojan, Whitewood, and Black Hawk |
| May 25, 1941 | Intensity V - 12:25 a.m. Custer County north northeast of Hot Springs near Fall River-Custer County border. In Hot Springs, one wall reported cracked. Pictures and light fixtures swayed in Hot Springs, Rapid City, and Martin. Not felt in Longvalley, Belvidere, Oelrichs, or Cottonwood |
| Jun 10, 1939 | Intensity IV - 12:30 p.m. Gregory County on Nebraska border south of Fairfax. There was one shock of about 15 seconds duration. It was of a gradual bumping nature, direction northwest to southeast, with a rumbling sound |
| November 4, 1938 | Intensity IV - 10:10 and 10:15 p.m. Gregory County near Whetstone Bay. Felt in Academy, Lake Andes, Burke, Colome, Dallas, Gregory, and Platte |
| October 11, 1938 | Intensity V - 3:37 a.m. Minnehaha County between Renner and Sioux Falls. In Sioux Falls, buildings jarred, beds shook, dishes rattled, and pictures and other loose objects swayed. A rumbling subterranean noise came as a climax of the earthquake. The recording pens on water and electric meters at the municipal water works were jarred. Sioux Falls police received more than 50 calls from citizens. |

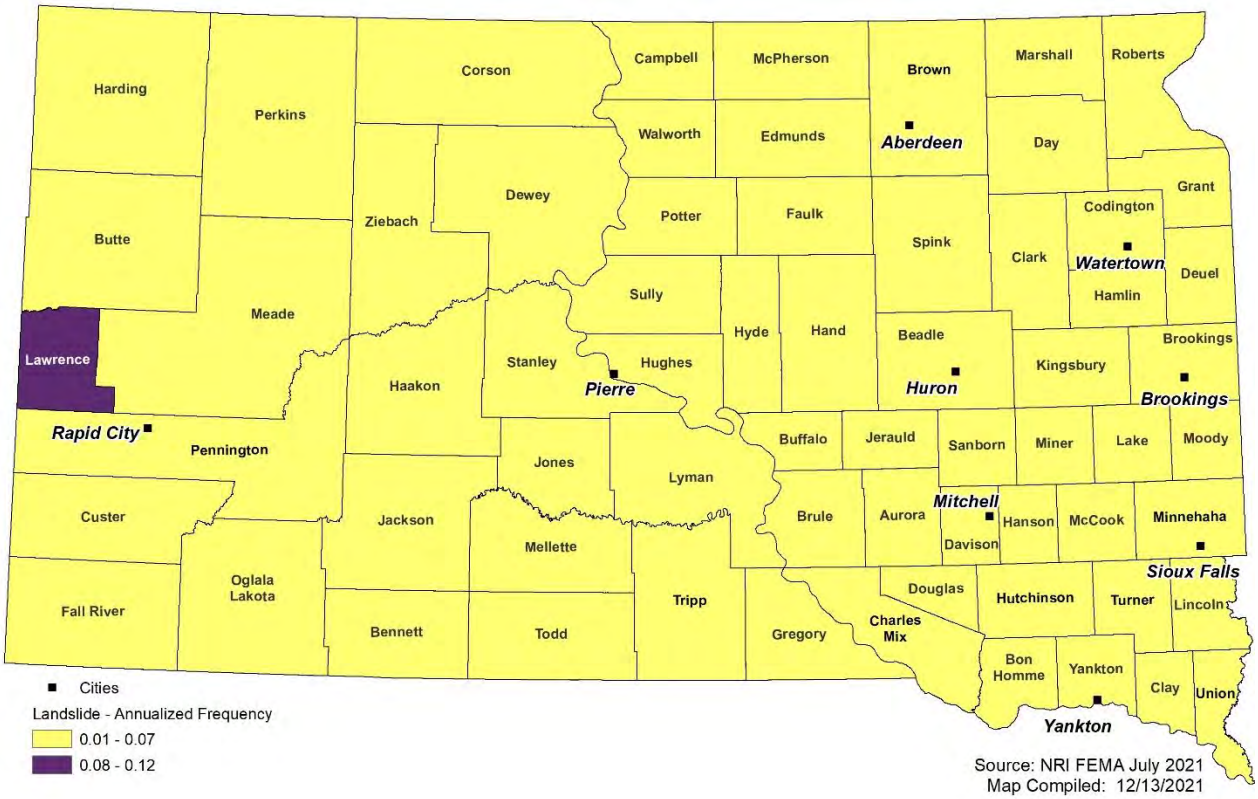
| Date | Comments |
|---|---|
| | Intensity IV - Humboldt, Madison, Parker, Spencer, and Yankton.<br>Intensity III and under - Canton, Centerville, Egan, Hudson, Lennox, Salem, Sherman, and Vermillion. Not felt in Beresford, Brookings, Howard, Mitchell, or Olivet |
| October 1, 1938 | Intensity V - 4:15 p.m. Brule County near Chamberlain |
| January 2, 1938 | Intensity IV - 11:05 a.m. Beadle County near Broadland |
| October 30, 1936 | Intensity IV - Custer County north northeast of Hot Springs near Fall River. Not felt elsewhere |
| November 1, 1935 | Intensity III - Moody County between Egan and the Minnesota border on Highway 34 |
| August 30, 1934 | Intensity IV - On the Brule and Charles Mix County border between Bijou Hills and Academy: Abrupt trembling motion accompanied by a rumbling sound, felt by many, small objects moved. Also felt in Pukwana |
| January 29, 1934 | Intensity IV - 6:30 a.m. Marshall County north northwest of Kidder near Newark. Awakened several, dishes rattled, rumbling sound |
| January 17, 1931 | Intensity IV - Aurora County east of Platte Lake and south of White Lake. Felt by many. Trembling motion with loud sounds |
| October 6, 1929 | Strong Shock - 6:30 a.m. City of Yankton. Deep rumbling resembling distant thunder set windows rattling. Some dishes thrown from shelves. Felt around Yankton and at Gayville and Volin about 15 miles to the east |
| November 16, 1928 | Intensity V - Pennington County near Mystic City. Felt at Custer and Rochford |
| December 30, 1924 | Intensity IV - 10:10, 10:15, 10:20, and 10:30 p.m. - Custer County north northeast of Hot Springs near Fall River-Custer County border |
| January 2, 1922 | Intensity VI - Brule County near Chamberlain |
| September 24, 1921 | Intensity IV - Aurora County east of Platte Lake and south of White Lake |
| March 16, 1921 | Intensity III - Minnehaha County near Sioux Falls at Lincoln County border |
| July 14, 1920 | Intensity III - Fall River County near Oelrichs |
| June 29, 1916 | Intensity III - Tripp County near Winner |
| February 24, 1916 | Intensity III - Oglala Lakota County (previously Shannon County) -near Pine Ridge |
| October 23, 1915 | Intensity V - Jackson County near Kadoka. Loud noises and some cracks in the ground |
| Jun 2, 1911 | Intensity V - Beadle County near James River crossing into Sanborn County. Felt in the James River Valley |
| May 10, 1906 | Intensity VI - Bennett County near southeast corner and on the Nebraska border. Felt from Rushville to Valentine, Nebraska |
| March 14, 1900 | Intensity III - 5:00a.m. Brown County near northeast corner of Richmond Lake.<br>Intensity III - 3:00a.m. Brown County near northeast corner of Richmond Lake |
| December 6, 1899 | Intensity IV - Hand County near Miller |
| October 12, 1895 | Intensity V - Pennington County near Hayward |
| October 11, 1895 | Intensity IV–V - Pennington County near Hayward. Felt at Rochford, Keystone, and Hill City |
| December 29, 1879 | Intensity V - Yankton County near Yankton |
| August 17, 1876 | Intensity IV - Lyman County near Lower Brule |
| October 9, 1872 | Intensity V - At Sioux City, Iowa. Severe effects at Yankton and White Swan. Felt in all or most of South Dakota |
| February 9, 1872 | Intensity III - Stanley County near Mission Ridge |

## Probability of Future Occurrence

Although historical landslide/mudflow/subsidence/expansive soil occurrence data is limited it can be assumed that these geological processes will continue to occur occasionally in the future. Landslides and expansive soils may typically occur most often during wet climate cycles or following heavy rains, but in limited areas of the State. Figure 3-80 below illustrates the projected annualized frequency of landslides in South Dakota from the NRI based off the frequency of past distinct events by census tract. According to

this data, Lawrence County in the Black Hills Region is the county with the most elevated risk for landslides in the State.

**Figure 3-80 Annualized Frequency of Landslides in South Dakota**

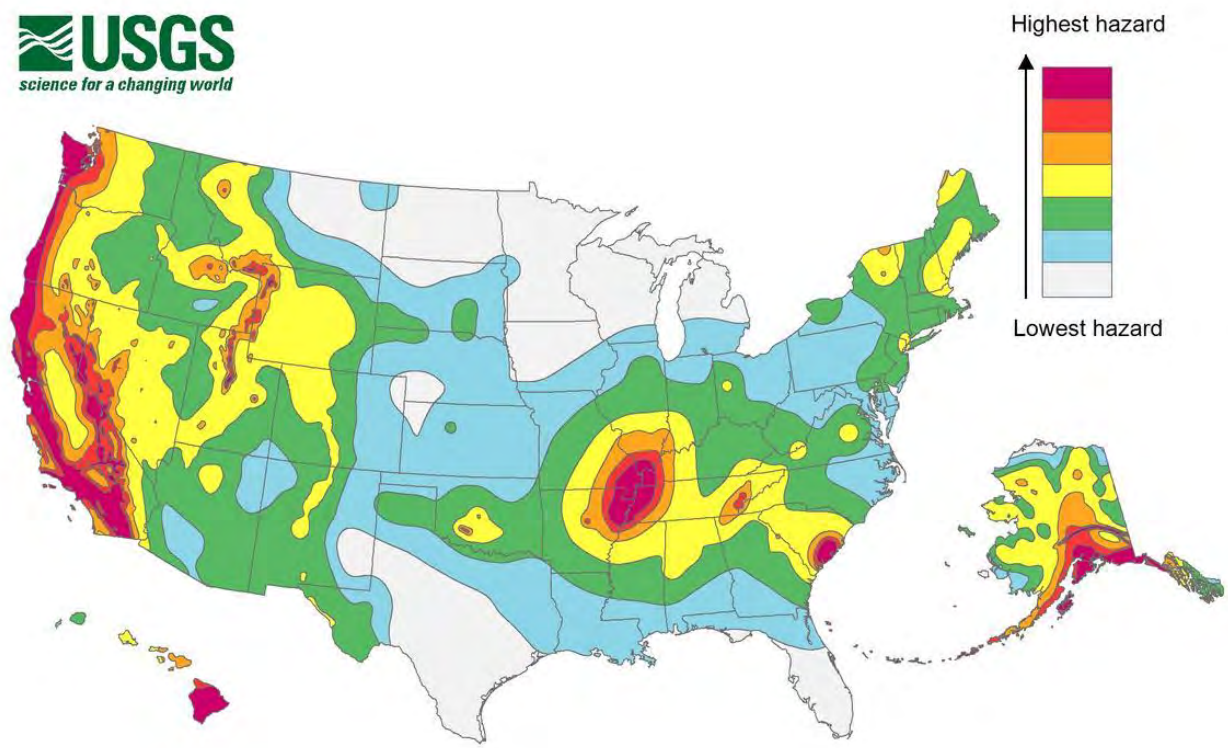



Source: NRI

South Dakota is relatively geologically stable based upon the sparse data available. However, there is potential for larger earthquakes than the magnitude 4.4 earthquake that struck the Black Hills in 1964. The U.S. Geological Survey estimates this risk as only a 10 percent chance of exceeding a 5.1 magnitude in any one 50-year period. The map in Figure 3-81 shows ground motions that have a 2 percent chance of being equaled or exceeded in a 50-year period.

Figure 3-81 below illustrates the State of South Dakota's probability for a large earthquake relative to the rest of the county. This map is an earthquake hazard map generated by the USGS showing peak ground accelerations, or the maximum acceleration of the ground during a given seismic event, which a 2 percent probability of being exceeded in 50 years. According to the SUGS, the maps is based on the most recent 2018 models for the conterminous U.S. and are based on seismicity and fault-slip rates and take into account the frequency of earthquakes of various magnitudes. According to this study, South Dakota is on the lowest end of the hazard scale compared to the rest of the county.

**Figure 3-81 Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years**




Source: U.S. Geological Survey, National Earthquake Information Center

## Magnitude/Severity (Extent)

The extent of landslides and debris flow events within South Dakota range from negligible to significant, depending on the event. Landslides and rockslides can result in the destruction of infrastructure such as roadways, water and sewer lines, electrical and telecommunications utilities and drainage where they are present. There is relatively limited potential for complete destruction of buildings and death and injury from landslides and debris flow.

There is a high degree of exposure to expansive soils across much of South Dakota, however the potential magnitude of expansive soils events and damages is likely negligible. Sporadic impacts related to expansive soils have been reported thus far, primarily affecting road infrastructure. Because damages from expansive soils tend to happen gradually 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 sidewalks, foundations, roads, railways, bridges, and power lines.

The greatest dangers associated with subsidence are related to property damages incurred by the hazard. There are minimal risks of injury and death from unexpected subsidence or accidental exposure to it, but the risk is possible. No injuries or deaths related to subsidence have been reported in South Dakota. Sudden and localized subsidence events, such as sinkholes, can cause damage to building foundations, roadways, and utilities, such as was the case in a 2020 event in Black Hawk that led to the displacement of 12 families when a sinkhole leading to an abandoned mine opened beneath their neighborhood.

For extent, the severity of an earthquake, or the amount of energy released during an earthquake is usually expressed in terms of intensity or magnitude as described further below.

**Intensity**: Intensity represents the observed effects of ground shaking at any specified location and earthquake shaking decreases with distance from the earthquake epicenter. Intensity is an expression of the amount of shaking at any given location on the ground surface based on felt or observed effects. Seismic shaking is typically the greatest cause of losses to structures during earthquakes. Intensity is measured with the Modified Mercalli Intensity (MMI) scale. The intensity of ground shaking at a particular site or structure is a function of many factors including: 1) earthquake magnitude, 2) distance from the epicenter, 3) duration of strong ground motion, 4) local geologic conditions (soil type and topography), and 5) the fundamental period of the structure. A brief description of those factors is presented below. The Modified Mercalli Intensity scale is summarized in Table 3-61, along with the effects associated with the MMI scale. Damage typically occurs in MMI of scale VII or above, an intensity which has never been recorded in South Dakota.

**Earthquake Magnitude:** Magnitude represents the amount of seismic energy released at the hypocenter of an earthquake. It is based on the amplitude of the earthquake waves recorded. Seismologists have developed several magnitude scales; one of the first was the Richter Scale, developed in 1932 by the late Dr. Charles F. Richter of the California Institute of Technology. The Richter scale is numeric and has a logarithmic relationship between scale factors, so that a difference of one scale number represents a tenfold increase in measured amplitude, which in turn corresponds to an approximate 31x energy release difference when compared to the next whole number value. The Moment Magnitude scale ($M_w$, or M), which is a measurement of energy released by the movement of a fault and is the modern method used by seismologists to measure earthquakes. Overall, as the amount of energy released by an earthquake increases, the potential for ground shaking impacts also increases.

**Table 3-61 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

## Climate Change Considerations

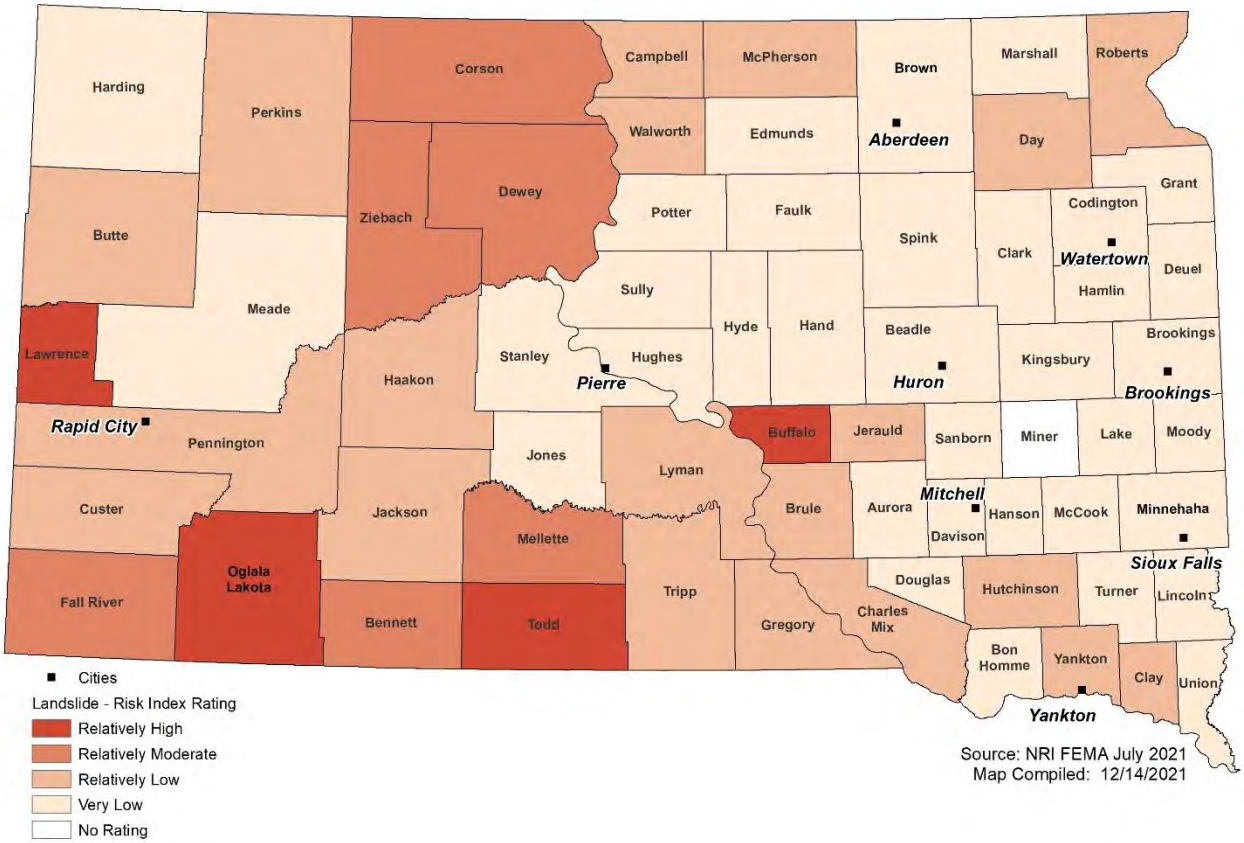
Climate change is not expected to directly affect the frequency or intensity of most geological processes which result in these hazards such as earthquake, expansive soils, or subsidence.

Landslides or mudflows however can be triggered by climatic events, such as periods of intense rainfall and runoff events. Projected climate change-associated variance in rainfall events may result in more high intensity events, which may increase landslide frequency. In addition, the increased potential of wildfire occurrence also escalates the risk of landslide and debris flows in the period following a fire, when slopes lack vegetation to stabilize soils and burned soil surfaces create more rainfall runoff. As climate change affects the length of the wildfire season, it is possible that a higher frequency of large fires may occur into late fall, when conditions remain dry, and then be followed immediately by more intense rainfall in the winter and spring months. As mentioned in other hazard profiles, the Fourth National Climate Assessment project more intense rainfall events for the Northern Great Plains over the coming century.

## Vulnerability Assessment

Providing a detailed vulnerability assessment of geological hazards was not possible at the time of this plan update due to the lack of comprehensive data on individual past events, monetary losses, and casualties from the various geologic hazards, specifically subsidence, expansive soils, and mudflows. Information from the NRI was available to provide a vulnerability assessment of earthquake and landslide. The NRI showed that risk from earthquake in South Dakota was essentially non-existent across each of the indicators used. Information was available through the NRI to analyze the State's vulnerability to landslide. The NRI defines risk as the potential for negative impacts as a result of a natural hazard and determines a community's risk relative to other communities by examining the EAL and social vulnerability in a given community in relation to that community's resilience. This composite risk rating is illustrated in Figure 3-82 below, showing the risk to landslide by county in South Dakota.

**Figure 3-82 Landslide Risk Rating by County in South Dakota**




A Hazus-MH annualized earthquake loss scenario was run for the entire nation in the 2017 and captured in the 'Hazus Estimated Annualized Earthquake Losses for the United States FEMA P-366.' The analysis computes two interrelated metrics to characterize earthquake risk: Annualized Earthquake Loss (AEL) and the Annualized Earthquake Loss Ratio (AELR). The AEL addresses two key components of seismic risk: the probability of ground motion occurring in a given study area and the consequences of the ground motion in terms of physical damage and economic loss. It takes into account the regional variations in risk.

The AEL annualizes expected losses by averaging them per year, which factors in historical patterns of frequent smaller earthquakes with infrequent but larger events to provide a balanced presentation of earthquake risk. The AEL values are also presented on a per capita basis, to allow comparison of relative risk across regions based on population.

The AELR is the AEL as a fraction of the replacement value of the building inventory and is useful for comparing the relative risk of different regions or events. The annualized loss ratio allows gauging the relationship between AEL and building replacement value. Similarly, this ratio can be used as a measure of relative risk between regions and, since it is normalized by replacement value, it can be directly compared across metropolitan areas, counties, or states.

According to the FEMA P-366 report, South Dakota ranked 51st (out of the 50 states plus Puerto Rico and the District of Columbia) for AEL, with an AEL of $374 million. However, the State ranked 46th for the Annualized Earthquake Loss Ratio, indicating that while the earthquake risk in South Dakota may be much lower than most states, it has a building stock that may be less resistant overall to earthquake impacts.

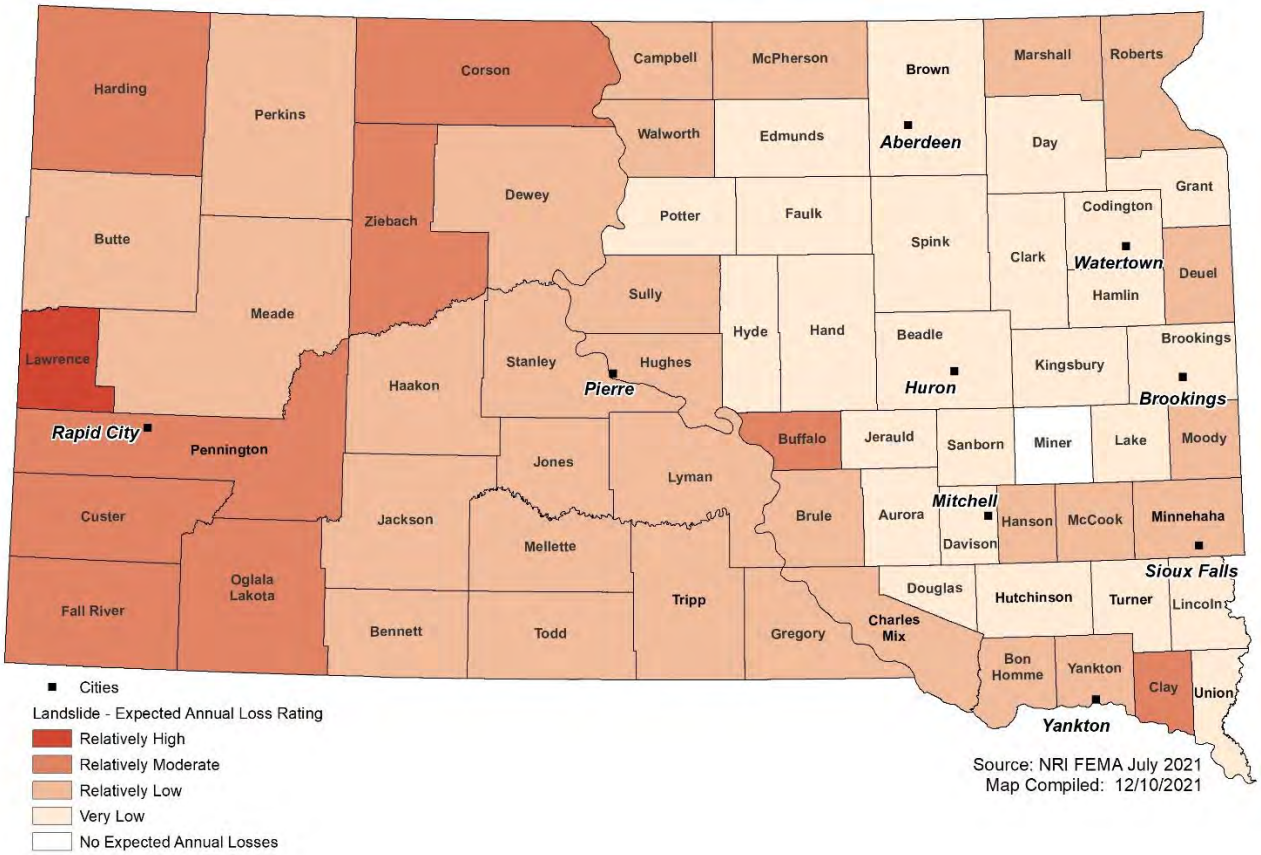
### *People*

People exposed to geologic hazards are most at risk to death or injury from these hazards. This includes not only people residing in areas prone to landslides but also outdoor recreationists and travelers in the State. There have been no recorded deaths or injuries due to earthquakes in South Dakota, so the likelihood of this in the future is minimal, but still possible. Geologic hazards such as subsidence and expansive soils typically result in property damage, not risk to human life. In the event of a sudden sinkhole, it would be possible for people to sustain injuries if they were walking or driving and were caught in the sinkhole.

### *Property*

Each geologic hazard is capable of damaging or destroying physical property. Landslides directly damage engineered structures in two general ways: 1) disruption of structural foundations caused by differential movement and deformation of the ground upon which the structure sits, and 2) physical impact of debris moving downslope against structures located in the travel path. For landslide specifically, information from the NRI for EAL was available as an indicator of risk. EAL represents the average economic loss in dollars resulting from natural hazards each year. It is calculated for each hazard type and quantifies loss for relevant consequence types: buildings, people, and agriculture. EAL is calculated using a multiplicative equation that includes exposure, annualized frequency, and historic loss ratio risk factors for 18 natural hazards, including landslide. Figure 3-83 below illustrates the EAL for landslide for each county in South Dakota. As the map shows, the highest expected annualized losses are for counties in the Black Hills Region in the southwest corner of the State, specifically in Lawrence County which has the highest landslide EAL at $400,000 per year.

**Figure 3-83 Landslide Expected Annual Loss Rating in South Dakota**




The force exerted by earthquakes causes physical damage to buildings, especially those of unreinforced masonry construction. Unreinforced masonry building type structures consist of buildings made of unreinforced concrete and brick, hollow concrete blocks, clay tiles, and adobe. Buildings constructed of these materials are heavy and brittle, and typically provide little earthquake resistance. In small earthquakes, unreinforced buildings can crack, and in strong earthquakes, they have a tendency to collapse. These types of structures pose the greatest structural risk to life and safety of all general building types.

While specific loss estimates are unavailable, expansive soils and subsidence can cause damage in the form of heaving sidewalks, structural damage to walls and basements, the need to replace windows and doors, or dangers and damages caused by ruptured pipelines. Newer construction may have included mitigation techniques to avoid most damage from the hazard, but the dangers continue if mitigation actions are not supported by homeowners. For example, the maintenance of grading away from foundations and the use of appropriate landscaping near structures must be continued to prevent an overabundance of water in vulnerable soils near structures. While continued public education efforts may help increase compliance for landscaping and interior finishing mitigation actions, physical reconstruction of foundations is probably not feasible in all but the most heavily impacted of existing development.

### *State Assets, Critical Facilities and Infrastructure*

Critical facilities and infrastructure are vulnerable to damage from each of the geologic hazards profiled in this plan. Extension, bending, and compression caused by ground deformation from earthquakes, landslides, subsidence, expansive soils, and mudflows can break lifelines. Failure of any component along

the lifeline can result in failure to deliver service over a large region. Once broken, transmission of the commodity through the lifeline ceases, which can have catastrophic repercussions down the line: loss of power to critical facilities such as hospitals, impaired disposal of sewage, contamination of water supplies, disruption of all forms of transportation, release of flammable fuels, and so on. Therefore, the overall impact of lifeline failures, including secondary failure of systems that depend on lifelines, can be much greater than the impact of individual building failures. Linear infrastructure (roads, buried pipelines, etc.) tends to have the most risk to geologic hazards. Several landslide and mudslide occurrences noted in the past events section have resulted in damage to SDOT infrastructure.

### *Economy*

Damage resulting from geologic hazards can result in direct economic losses in the form of damage to buildings and property. These damages can also result in indirect losses, such as decreased property values in hazard exposure areas, the prolonged closure of businesses that are damaged, and the resultant lost wages and revenue if workers are not able to go to work and tourism is disrupted, such as was the case in the landslide incident which closed roads in Badlands National Park.

Transportation routes may become temporarily closed by landslides or mudflows, resulting in further economic disruption. These roads may be used to transport goods across the county or provide access by visitors and tourists. Depending on the amount of damage, the road may simply need to be cleaned off, or may require some level of reconstruction.

### *Environment and Cultural Resources*

Each geologic hazard is primarily a natural process; however, they can have varying impacts to the natural environment, with the potential to permanently alter the natural landscape. For instance, earthquake effects on the environment, natural resources, and historic and cultural assets could be very destructive depending on the type of seismic activity experienced and secondary/cascading effects from an event (e.g. wildfire). The biggest impact would likely be on older properties such as wooden or masonry buildings, though reinforced masonry structures would be much more resilient during earthquakes.

Another example of the interconnectedness of these hazards is groundwater pumping and subsidence. In 2015, South Dakota was ranked 9$^{th}$ among states for the percentage of freshwater coming from groundwater, with the State relying on this method for 60% of its freshwater. Groundwater pumping can cause significant impacts to underground water resources, and the resulting subsidence events may further disrupt and alter the flow of surface or underground water, in a cyclical pattern of environmental degradation. Furthermore, soil compaction resulting from subsidence can permanently reduce aquifer capacity, impacting water supplies long into the future.

Abandoned mines and resultant subsidence can result in significant negative impacts on the environment. According to the USGS, ground subsidence can result in disturbances to the surface environment, damage to vegetation, and disruptions of the historical hydrological patterns. Additionally, fires can start by spontaneous ignition when water and air enter abandoned mine workings via subsidence cracks and pits. These fires can in turn spread to unmined coal as they create more cavities, more subsidence, and more cracks and pits through which air can circulate.

## Development Trends and Consequence Summary

In general, South Dakota has a much lower risk for geological hazards than most other western states, due to the flatter terrain in the central and eastern parts of the State and the overall lack of seismic activity. For most of the geologic hazards profiled, the greatest risk is concentrated in the Black Hills Region and along the Missouri River where geography makes processes such as landslides and mudflows more likely.

Subsidence and expansive soils tend to occur as gradual and ongoing processes throughout the majority of the State, although they do not lead to significant or frequent losses or casualties. As counties such as Pennington and Lawrence see growth in population and housing units at a higher rate as well as higher probability of occurrences for geologic hazards relative to the rest of the State, their exposure and vulnerability inevitably increase as well. Steps to mitigate these risks should be taken as South Dakota accommodates future growth, such as mapping of hazard areas, adoption and enforcement of engineering and building codes for soil hazards, and ordinances to limit development on steep slopes.

**Table 3-62 Landslides, Mudflows, Expansive Soils, Subsidence Consequence Table**

| Category | Narrative |
|---|---|
| Impact on the Public | Staff, recreationists, campers, property owners in remote areas may be at risk to injury or death from debris flows. |
| Impact on the Economic Condition of the State | Potential loss of facilities or infrastructure; potential impact to tourism and land development activities depending on severity; depending on nature of area where landslide occurs, many home-based businesses will be impacted due to destruction of property. |
| Impact on the Environment | Impacts to water quality; erosion and sedimentation may affect critical infrastructure and natural waterways. |
| Impact on Property, Facilities, and Infrastructure | Vulnerabilities to critical infrastructure, facilities, properties, equipment, vehicles, and communications and utility infrastructure within landslide extent. |
| Impact on the Public Confidence in Government | Ability to respond and recover may be questioned and challenged if planning, response, and recovery is not timely and effective. |
| Impact on Responders | Exposure exists to response personnel performing routine duties when event occurs. |
| Impact on Continuity of Operations and Continued Delivery of Services | Potential loss of facilities or infrastructure function or accessibility or ability to provide services. Power interruption is likely if near power lines. |
| Cascading Hazards | |

**Table 3-63 Earthquake Consequence Table**

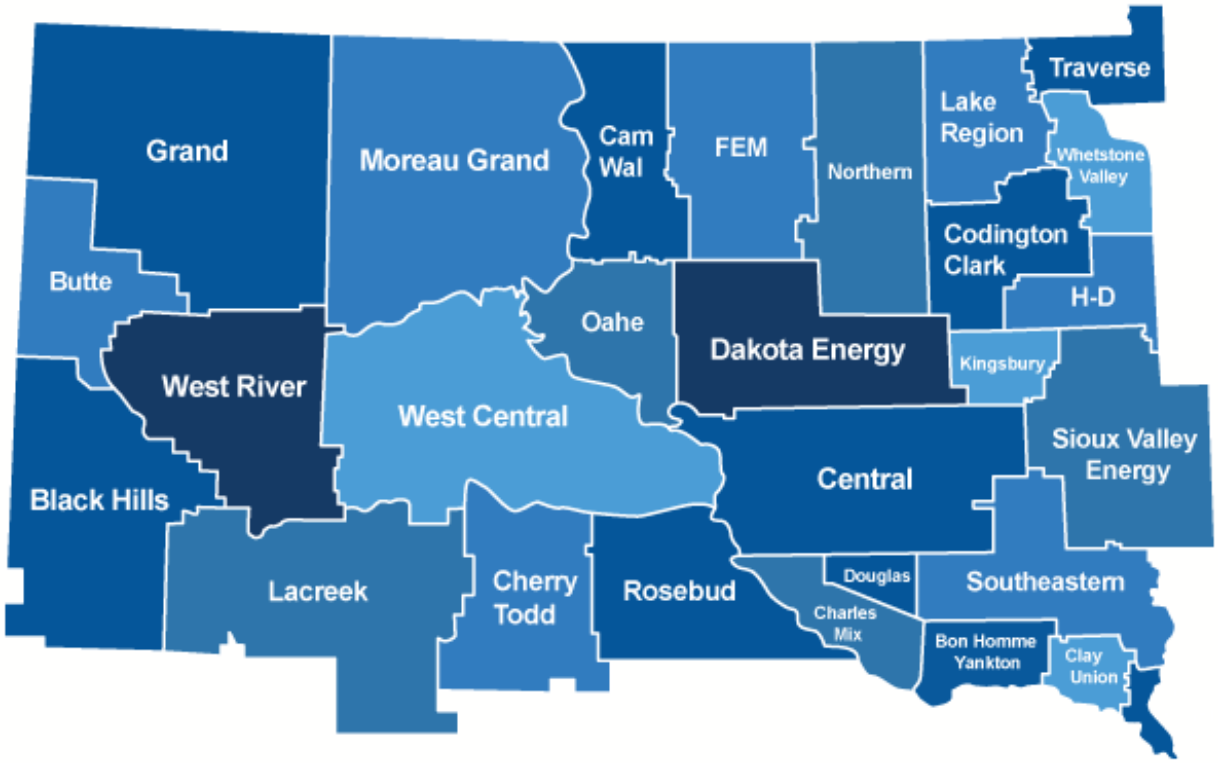
| Category | Narrative |
|---|---|
| Impact on the Public | Increase in sheltering and evacuation demands; vulnerable populations along fault lines will be severely impacted; while likelihood of a damaging event is rare there is potential for mass for injury or death from structural and non-structural building elements |
| Impact on the Economic Condition of the State | Potential business impacts from facility damage, road closures and other transportation issues; potential loss of facilities or infrastructure function or accessibility and uninsured damages; debris management demands (costs/location) |
| Impact on the Environment | Environmental damage variable due to location and magnitude; possible cascading water quality issues from damaged water treatment facilities or impacts to ground and air quality from hazardous material leaks |
| Impact on Property, Facilities, and Infrastructure | Buildings, vehicles, signage, and/or any unsecured property may be damaged or destroyed during a significant event. Older and historic structures more vulnerable. Possible impacts to communications; expected damage to water treatment facilities, government buildings, public safety facilities, power generation and distribution, and healthcare facilities expected to be minor based on Hazus modeling. Potential for breaks and leaks in gas, water and wastewater utility lines and associated disruption |
| Impact on the Public Confidence in Government | Public holds high expectations of government capabilities for public information and response and recovery activities related to large-scale disaster |

| Category | Narrative |
|---|---|
| | events such as earthquake; high expectations for rapid restoration of critical lifelines |
| Impact on Responders | Unsafe structural or environmental conditions may persist during the response period putting search and rescue personnel and other responders at risk; structural damage to hospitals, fire stations, police stations; scale of event will likely overwhelm local resources and require mutual aid assistance from outside the area of impact |
| Impact on Continuity of Operations and Continued Delivery of Services | Loss of facilities or infrastructure function or accessibility or ability to provide services; power interruption is likely if not adequately equipped with back-up generation; large-scale of event will typically overwhelm emergency response and coordination services and may require mutual aid assistance from outside the impacted area |
| Cascading Hazards | Energy Disruption; Urban Fire; Dam/Levee Failure, Hazardous Materials |

## 3.4 Rural Electric Cooperative Considerations

Since 2013 the Rural Electric Cooperatives (REC) have been engaged as participants in the state planning effort, including periodic updates to this HIRA. This discussion focuses on the potential hazard risks to REC's. There are 28 RECs that cover the state, as depicted in the map below.

**Figure 3-84 South Dakota Rural Electric Cooperative Boundaries**




Source: SDREA

### 3.4.1 REC Survey Results

During the 2021 update, a REC online survey was developed to guide RECs on the information needed for refining vulnerability and loss estimates in future updates. This included questions regarding hazard identification and vulnerability assessment from an REC perspective. The survey was distributed to the

RECs through SD OEM and the SD Rural Electric Association. There were 17 responses out of the 28 RECs, a 60% response rate. In total there were 12 questions regarding hazards risk and vulnerability. Refer to Appendix 3D for the survey results.

Based on the survey most cooperatives are moderately (71%) to very (29%) concerned about the possibility of critical electrical infrastructure being impacted by a natural hazard. The natural hazards that have affected or damaged infrastructure in most cooperative services areas in the past were identified as windstorms, winter storms, summer storms, floods and tornadoes (winter storms were accidentally left off the survey, but based on past input from RECs it is certain this is a priority hazard). Past wildfire and geological hazard events were also noted as affecting or damaging critical electric infrastructure. Similarly, the hazards of most concern with the potential for future impacts are winter storms (implied), wind, summer storms, floods and tornadoes. Most of the cooperatives ranked the existing local capability to contend with hazard events in their respective service areas as being medium, with the exception of geological hazards which was ranked as low capability. Of those that responded to the survey, 29% stated their cooperative conducts an annual or bi-annual hazard analysis and risk assessment. While half responded as not performing or not being sure if their cooperative conducts annual risk assessments. Most of the cooperatives (69%) stated they have not conducted a loss avoidance study to quantify or demonstrate the value of infrastructure mitigation efforts. The remaining 31% have conducted a loss avoidance study in the past.

Nearly every cooperative that completed the REC survey (16 out 17) noted they have implemented the mitigation action of undergrounding electric lines in their service area. In response to asking about potential future mitigation actions, 94% chose undergrounding electric lines as being high importance to reduce impacts of natural hazard on service or critical infrastructure. Other future mitigation actions that ranked as high importance include pole replacement, facility backup generation, harden communications, and vegetation management. Similar to undergrounding electric lines, many of these potential future actions are already being implemented in various services areas. Of those that responded to the survey, 76% have received FEMA grant funding to strengthening infrastructure in the past. 100% of survey respondents were interested in leveraging FEMA grant funding in the future.

### 3.4.2 REC Vulnerability Analysis

Historically, winter storms, wind and tornadoes pose the greatest risk to power lines and facilities operated by the REC's. These hazards can knock down power lines, which tend to be the most vulnerable elements of the electrical grid. To determine how this risk may vary across the various RECs, an analysis was done to determine their intersection with counties with a high Expected Annual Loss for Winter Storms, Windstorm, and Tornadoes, based on the FEMA NRI (refer to the EAL maps in the Vulnerability subsections for each hazard section). As many RECs span multiple counties, a representative county was used in some cases as the basis for the selected EAL rating. A score was assigned to the EAL rating for each of the three hazards, summarized below.

- Very High 4
- Relatively High 3
- Relatively Moderate 2
- Relatively Low 1
- Very Low 0

The results of the analysis are summarized in Table 3-64. A cumulative score and rating is captured in the far right columns as an indication of relative cumulative hazard risk.

**Table 3-64 Rural Electric Cooperative Hazard Vulnerabilities**

| Rural Electric Cooperative | Representative County | Winter Storm Expected Annual Loss Rating | Winter Scoring | Strong Wind Expected Annual Loss Rating | Wind Scoring | Tornado Expected Annual Loss Rating | Tornado Scoring | Cumulative scoring | Cumulative Rating |
|---|---|---|---|---|---|---|---|---|---|
| Black Hills Electric Cooperative, Inc. | Custer | Relatively Moderate | 2 | Very Low | 0 | Relatively Low | 1 | 3 | Relatively Low |
| Bon Homme Yankton Electric Association | Yankton | Relatively Low | 1 | Relatively Moderate | 2 | Relatively Moderate | 2 | 5 | Relatively Moderate |
| Butte Electric Cooperative, Inc. | Lawrence | Relatively Moderate | 2 | Relatively High | 3 | Relatively Low | 1 | 6 | Relatively Moderate |
| Cam Wal Electric Cooperative Inc. | Walsworth | Relatively Moderate | 2 | Relatively Low | 1 | Relatively Low | 1 | 4 | Relatively Low |
| Central Electric Cooperative Inc. | Davison | Relatively Moderate | 2 | Relatively High | 3 | Relatively Moderate | 2 | 7 | Relatively High |
| Charles Mix Electric Association Inc. | Charles Mix | Relatively Low | 1 | Relatively Low | 1 | Relatively Low | 1 | 3 | Relatively Low |
| Cherry-Todd Electric Corporation | Todd | Relatively Moderate | 2 | Very Low | 0 | Relatively Low | 1 | 3 | Relatively Low |
| Clay-Union Electric Corporation | Clay | Relatively Low | 1 | Relatively Moderate | 2 | Relatively Moderate | 2 | 5 | Relatively Moderate |
| Codington-Clark Electric Cooperative | Codington | Relatively High | 3 | Relatively Moderate | 2 | Relatively Moderate | 2 | 7 | Relatively High |
| Dakota Energy Cooperative, Inc. | Beadle | Relatively Low | 1 | Relatively Moderate | 2 | Relatively Moderate | 2 | 5 | Relatively Moderate |
| Douglas Electric Cooperative | Douglas | Relatively Moderate | 2 | Relatively Low | 1 | Relatively Low | 1 | 4 | Relatively Low |
| FEM Electric Association | Edmunds | Relatively Moderate | 2 | Relatively Low | 1 | Relatively Low | 1 | 4 | Relatively Low |
| Grand Electric Cooperative, Inc. | Perkins | Relatively Moderate | 2 | Relatively Low | 1 | Very Low | 0 | 3 | Relatively Low |
| H-D Electric Cooperative, Inc. | Hamilton | Relatively Moderate | 2 | Relatively Moderate | 2 | Relatively Low | 1 | 5 | Relatively Moderate |

| Rural Electric Cooperative | Representative County | Winter Storm Expected Annual Loss Rating | Winter Scoring | Strong Wind Expected Annual Loss Rating | Wind Scoring | Tornado Expected Annual Loss Rating | Tornado Scoring | Cumulative scoring | Cumulative Rating |
|---|---|---|---|---|---|---|---|---|---|
| Kingsbury Electric Cooperative, Inc. | Kingsbury | Relatively Low | 1 | Relatively Low | 1 | Relatively Low | 1 | 3 | Relatively Low |
| LaCreek Electric Association, Inc. | Oglala Lakota | Relatively Moderate | 2 | Relatively Low | 1 | Relatively Low | 1 | 4 | Relatively Low |
| Lake Region Electric Association, Inc. | Day | Relatively High | 3 | Relatively Moderate | 2 | Relatively Moderate | 2 | 7 | Relatively High |
| Moreau-Grand Electric Cooperative | Dewey | Relatively High | 3 | Relatively Low | 1 | Very Low | 0 | 4 | Relatively Low |
| Northern Electric Cooperative Inc. | Brown | Very High | 4 | Relatively High | 3 | Relatively Moderate | 2 | 9 | Very High |
| Oahe Electric Cooperative | Hughes | Relatively High | 3 | Relatively Moderate | 2 | Relatively Low | 1 | 6 | Relatively Moderate |
| Rosebud Electric Cooperative | Tripp | Relatively Moderate | 2 | Very Low | 0 | Relatively Low | 1 | 3 | Relatively Low |
| Sioux Valley Energy | Minnehaha | Very High | 4 | Relatively Moderate | 2 | Very High | 4 | 10 | Very High |
| Southeastern Electric Cooperative, Inc. | Lincoln | Relatively High | 3 | Relatively Moderate | 2 | Relatively High | 3 | 8 | Relatively High |
| Traverse Electric Cooperative | Roberts | Relatively High | 3 | Relatively Moderate | 2 | Relatively Moderate | 2 | 7 | Relatively High |
| Union County Electric Cooperative, Inc. | Union | Relatively Low | 1 | Relatively Moderate | 2 | Relatively Moderate | 2 | 5 | Relatively Moderate |
| West Central Electric Association, Inc. | Stanley | Relatively Moderate | 2 | Relatively Low | 1 | Very Low | 0 | 3 | Relatively Low |
| West River Electric Association, Inc. | Pennington | Relatively High | 3 | Relatively High | 3 | Relatively Moderate | 2 | 8 | Relatively High |

| Rural Electric Cooperative | Representative County | Winter Storm Expected Annual Loss Rating | Winter Scoring | Strong Wind Expected Annual Loss Rating | Wind Scoring | Tornado Expected Annual Loss Rating | Tornado Scoring | Cumulative scoring | Cumulative Rating |
|---|---|---|---|---|---|---|---|---|---|
| Whetstone Valley Electric Cooperative | Grant | Relatively High | 3 | Relatively Moderate | 2 | Relatively Low | 1 | 6 | Relatively Moderate |

Based on this analysis, notable RECs with a cumulative risk from winter storm, windstorm, and tornadoes include:

Very High Cumulative Rating:

- Sioux Valley Energy
- Northern Electric Cooperative Inc.

Relatively High Cumulative Rating:

- Southeastern Electric Cooperative, Inc.
- West River Electric Association, Inc.
- Central Electric Cooperative Inc.
- Codington-Clark Electric Cooperative
- Lake Region Electric Association, Inc.
- Traverse Electric Cooperative

Relatively Moderate Cumulative Rating:

- Butte Electric Cooperative, Inc.
- Oahe Electric Cooperative
- Whetstone Valley Electric Cooperative
- Bon Homme Yankton Electric Association
- Clay-Union Electric Corporation
- Dakota Energy Cooperative, Inc.
- H-D Electric Cooperative, Inc.
- Union County Electric Cooperative, Inc.

In addition, wildfire can impact power lines in the Black Hills and parts of southeastern South Dakota (e.g. Lincoln County). The Black Hills, Butte, West River, and Southeastern RECs are more vulnerable to wildfires.

A GIS overlay of power facilities on flood and wildfire hazard areas to identify specific power plant facilities potentially at risk was completed during the 2021 HIRA Update. The results of analysis indicate two power plants in the state located within the 1% flood hazard areas, both of which are hydroelectric. These power plants are located in Charles Mix County, within the Charles Mix Electric Association boundary, and in Lawrence County within the Butte Electric Cooperative boundary. In total there are 46 power plants in the state located within a wildfire risk area. Of the 46 power plants, 17 are located within very high to moderate wildfire areas. The following table shows the results of the wildfire analysis. Appendix 3C has more specifics on these facilities.

**Table 3-65 Power Plants Located within Very High to Moderate Wildfire Hazard Area**

| Wildfire Hazard Area | Cooperative | County | Count |
|---|---|---|---|
| Very High | Dakota Energy Cooperative | Hand | 1 |
| | | Hyde | 1 |
| | Lake Region Electric Association | Roberts | 1 |
| | | **Total** | **3** |
| High | Black Hills Electric Cooperative | Pennington | 2 |
| | Butte Electric Cooperative | Lawrence | 1 |
| | Codington-Clark Electric Cooperative | Clark | 1 |
| | Dakota Energy Cooperative | Hyde | 1 |

| Wildfire Hazard Area | Cooperative | County | Count |
|---|---|---|---|
| | H-D Electric Cooperative | Deuel | 1 |
| | Sioux Valley Energy | Brookings | 1 |
| | | **Total** | **7** |
| Moderate | Cam Wal Electric Cooperative | Campbell | 1 |
| | Central Electric Cooperative | Lyman | 1 |
| | | Brule | 1 |
| | | Aurora | 1 |
| | Grand Electric Cooperative | Butte | 1 |
| | Oahe Electric Cooperative | Hughes | 2 |
| | | **Total** | **7** |

Source: HIFLD, Wood analysis

South Dakota has funded 39 power line burial projects with HMGP funds in an effort to reduce future disaster losses. Since 2005 the State has spent $19 million of HMA grant funding (primarily HMGP) in helping to bury approximately 700 miles of power lines as of 2021. These projects are summarized in Table 3-66 and will reduce future losses and increase power resiliency across the State.

**Table 3-66 REC Mitigation Funding and Miles of Line Buried by County: 2013-2021**

| Rural Electric Cooperative | County | Miles | Total Obligated |
|---|---|---|---|
| Sioux Valley/City of Coleman | Moody | unknown | $70,680 |
| Central | Aurora | 14.5 | $468,393 |
| Dakota Energy | Beadle | 49.25 | $1,449,253 |
| Kingsbury | Brookings | 5.5 | $106,291 |
| Northern | Brown | 29.25 | $654,434 |
| Central | Brule | 9 | $200,520 |
| Central | Buffalo | 3 | $115,500 |
| Butte | Butte | 14.4 | $913,085 |
| Cam-Wal | Campbell | 19.9 | $382,086 |
| Codington-Clark | Clark | 16.5 | $496,235 |
| Codington-Clark | Codington | 18 | $642,412 |
| Town of Colman | Colman | 0.6 | $125,500 |
| Moreau-Grand | Corson | 37 | $1,028,140 |
| Central | Davison | 17.5 | $451,742 |
| Codington-Clark | Day | 4 | $107,516 |
| H-D | Deuel | 4 | $127,200 |
| Moreau-Grand | Dewey | 6.3 | $396,739 |
| Douglas | Douglas | 4.5 | $332,085 |
| FEM | Edmunds | 28.95 | $409,799 |
| FEM | Faulk | 24.2 | $572,943 |
| Whetstone | Grant | 75.9 | $1,746,322 |
| City of Bryant | Hamlin | 6.5 | $401,344 |
| H-D | Hamlin | 8 | $323,543 |
| Dakota Energy | Hand | 28.5 | $711,750 |
| Central | Hanson | 19.75 | $610,097 |
| City of Pierre | Hughes | 0.5 | $140,902 |
| Southeastern | Hutchinson | 25 | $948,546 |
| City of Wessington Springs | Jerald | 0.2 | $29,682 |
| West Central | Jones | 4 | $75,137 |
| Kingsbury | Kingsbury | 63.6 | $1,137,801 |

| Rural Electric Cooperative | County | Miles | Total Obligated |
|---|---|---|---|
| West Central | Lyman | 2.2 | $104,820 |
| FEM | McPherson | 15.5 | $385,359 |
| Central | Miner | 9.5 | $193,278 |
| Traverse and Whetstone | Roberts | 53.7 | $1,160,323 |
| Central | Sanborn | 12 | $541,479 |
| Northern | Spink | 18.5 | $690,244 |
| West Central | Stanley | 5 | $133,721 |
| Oahe | Sully | 2.45 | $139,189 |
| Cam-Wal | Walworth | 34.95 | $1,106,504 |
| Total | | 692.1 | $19,630,594 |

Source: OEM

South Dakota has also used FEMA Public Assistance Section 406 mitigation to fund power line strengthening, burial, and retrofitting as part of project worksheets (PW) during post-disaster reconstruction. The table below (Table 3-67) summarizes the number of projects and mitigation funding associated with Section 406 from disasters in 2008-2019 based on information provided by OEM and through an OpenFEMA data set. The damage category F mitigation dollars shown for DR1759 and DR1887 in the table below are primarily associated with power line burials or upgrades for REC's. DR1759 included funding for Grand Electric Coop and Butte Electric. DR 1887 included funding for Cam-Wal, Central, Dakota Energy, FEM, Grand, Moreau-Grand, and Whetstone Valley Electric cooperatives. Total mitigation funding from these two disasters is over $11M.

**Table 3-67 FEMA Public Assistance Section 406 Project and Mitigation Funding: 2008-2020**

| DR# | Type | Year | Damage Category | # of PW's | Total |
|---|---|---|---|---|---|
| 4469 | Severe Storm(s) | 2019 | F | 12 | $670,461 |
| 4467 | Severe Storm(s) | 2019 | F | 3 | $122,846 |
| 4463 | Flood | 2019 | F | 3 | $49,122 |
| 4448 | Severe Storm(s) | 2019 | F | 7 | $214,212 |
| 4440 | Flood | 2019 | F | 35 | $7,568,987 |
| 4298 | Winter Storm | 2016 | F | 15 | $2,268,759 |
| 4233 | Flooding | 2015 | C | 14 | $117,882 |
| 4186 | Tornado/Flooding | 2014 | C | 48 | $340,282 |
| 4155 | Winter Storm | 2013 | F | 24 | $5,784,998 |
| 4137 | Flood | 2013 | C | 7 | $30,141 |
| 4125 | Flood | 2013 | C | 19 | $31,164 |
| 4115 | Winter Storm | 2013 | F | 1 | $245,759 |
| 1984 | Flood | 2011 | C | 98 | $745,578 |
| 1947 | Flood | 2010 | D+E | 8 | $86,870 |
| 1938 | Flood | 2010 | C | 14 | $712,318 |
| 1929 | Tornadoes/Flooding | 2010 | C | 4 | $71,426 |
| 1915 | Flood | 2010 | C | 102 | $294,124 |
| 1914 | Winter Storm | 2010 | F | 4 | $381,044 |
| 1887 | Winter Storm | 2010 | F | 297 | $9,596,751 |
| 1759 | Winter Storm | 2008 | F | 3 | $1,458,213 |
| | | | | Total | $30,790,937 |

Source: OEM and OpenFEMA Dataset: Public Assistance Funded Projects Details

## 3.5 Hazard Summary

Although the majority of the State is vulnerable to all the hazards identified and discussed previously, impacts may vary widely in different areas of the State and at different times of year. The hazards as identified in Table 3-1 have impacted or have the potential to impact the citizens and governments of the State to one degree or another at any given time. However, based upon the research and analyses conducted for the HIRA over the years, it is evident that drought, floods, winter storms, wildfires, and tornadoes continue to require the most effort and expense in terms of response and recovery activities and their associated costs. The following is a summary of the key vulnerabilities, losses and consequences associated with each hazard, based on the HIRA. This summary was added to the HIRA in 2016 to provide a quick reference for planners in the development of mitigation strategies and was updated in 2021 as part of the HIRA update process.

Table 3-1 Hazard Risk Summary Table

| Hazard | Vulnerability Summary/Problem Statements | State Facility and Critical Infrastructure Impacts | Climate Change Impacts | Overall Planning Significance |
|---|---|---|---|---|
| **Agricultural Pests and Diseases** | • Significant pests and diseases include Foot and Mouth Disease, Trichomoniasis, Avian Influenza, West Nile Virus, Rabies, Asian Soybean Rust, Blight, Soybean Cyst Nematode.<br>• Diseases tracked for plants include sunflowers, canola, safflower, field pea, chickpea, lentil, dry bean, soybeans, corn, alfalfa, flax, winter wheat, spring wheat, barley, oats, rye.<br>• Diseases tracked for animals include cattle, swine, poultry, wildlife.<br>• Cattle losses $52 M in 2010 due to respiratory, digestive and other diseases.<br>• $22,878,707 in total indemnity payments between 2007 and 2020 for plant disease, mycotoxins, and insects; annual loss of $1,759,900.<br>• 269,937 acres of field crops lost to plant disease and insects from 2007 to 2020.<br>• Can have devastating impacts on agricultural economy statewide and beyond.<br>• Agriculture sector impacts can be both direct (impacts to crops in the state) and indirect (impacts to the market from infestations elsewhere).<br>• Livestock exposure is greatest west of the Missouri River.<br>• Crop exposure is greatest east of the Missouri River.<br>• Some outbreaks are associated with drought or warmer than typical winters (such as grasshoppers, anthrax). | • Risk to state owned/leased buildings and infrastructure is expected to be minimal.<br>• Other critical infrastructure impacts are minimal. | • Climate change can alter and increase the range of many invasive weed species; increasingly powerful storms can exacerbate the spread of diseases; warmer temperatures can aid the spread of warm-weather pests into traditionally colder climates.<br>• In general, climate change trends currently projected for the Northern Great Plains by the 4th National Climate Assessment indicate that South Dakota's overall climate may become more suitable for existing pests. | Medium |
| **Summer Storms (Hail and Lighting)** | <u>Hail</u><br>• Hail impacts vary based on hail diameter, duration, location, and exposure.<br>• Over 11,613 separate records of hail incidents between 1996 and 2020.<br>• $8,648,990 in average annual property damage statewide between 1996-2020 for hail; total property damage of $207,575,750. | • Risk to state owned/leased buildings and infrastructure is expected to be minimal; the potential exists for hail damage to state-owned | • As climate change warms the earth and affects weather patterns, science shows that storms have generally become more intense, however | Medium |

| Hazard | Vulnerability Summary/Problem Statements | State Facility and Critical Infrastructure Impacts | Climate Change Impacts | Overall Planning Significance |
|---|---|---|---|---|
| | • $1,869,542 average annual crop damage statewide between 1996 and 2020 for Hail; total crop damage of $44,869,000. Further, USDA crop indemnity payments due to hail have totaled $455,119,168 in the state from 2007 to 2020.<br>• Average hailstone size in the state is 1.15"; largest recorded is 8" (Vivian, Lyman County, 7/23/2010).<br>• NCEI records 41 hail-related injuries; no hail related deaths between 1996 and 2020.<br>• 95% of recorded incidents did not cause property damage, crop damage, injuries, or fatalities.<br><br><u>Lightning</u><br>• 124 separate records of damaging lightning incidents recorded between 1996 and 2020 based on the NCEI; this is likely under counted.<br>• $203,842 average annual property damage statewide between 1996 and 2020 for Lightning; total property damage $4,892,200; only $5,000 in recorded crop damage during this timeframe.<br>• NCEI records 17 lightning-related injuries; five lightning-related deaths between 1996 and 2020. | vehicles and roofs/windows of state facilities.<br>• Other critical infrastructure impacts minimal; potential for limited energy disruption caused by lightning; critical points should be protected from exposure to hail and lightning | research specific to hail and lighting is sparse. | |
| **Flood (Including Dam and Levee Failure)** | • The greatest impacts have historically been to the eastern half of the state, principally, the Big Sioux, Vermillion, and James River Basins, which have recurring problems. Flash flooding is more prevalent in the Black Hills region.<br>• Flood Insurance policy analysis yielded:<br>- The number of policies statewide has fluctuated greatly over the years, from 5,406 in 2010, 6,914 in 2012, 4,684 in 2016, to 2,912 in 2022. The higher policy count in 2012 is likely a carryover from flooding on the Missouri River in 2011 that generated a lot of interest in flood insurance.<br>- Statewide there has been $56,271,948 in flood loss claims paid since 1978 – January 2022, an increase of $16,216,575 from the $40,055,373 sum noted previously in the 2016 HIRA. | • Risk to state owned/leased buildings and infrastructure includes the following based on GIS analysis:<br>- There are state facilities potentially at risk to flooding in the following counties: Brown, Codington, Fall River, Hughes, Lawrence, McCook, Meade, Minnehaha, | • Climate change science indicates increased potential for extreme rainfall events which could lead to increased flooding frequency, intensity, and losses. | High |

| Hazard | Vulnerability Summary/Problem Statements | State Facility and Critical Infrastructure Impacts | Climate Change Impacts | Overall Planning Significance |
|---|---|---|---|---|
| | - Flood loss claims increased from 3,316 in 2010 to 3,344 as of mid-2016, and to 3,927 in 2022.<br>- Flood loss claims result in an average annual loss of $1,278,908<br>• Repetitive loss properties (2 or more claims in a ten-year period) continue to be an issue. The 2021 repetitive loss statistics indicate:<br>- In 2012, the total amount in repetitive loss claims was $6,700,481. As of 2021, the total had increased to $54,550,851.<br>- The number of repetitive loss properties has almost doubled since 2018, to a total of 860, 32 counties now have repetitive loss properties, an increase of 4 counties since 2018.<br>- The counties of Hamlin, Codington, Day, and Minnehaha have the most repetitive loss properties.<br>• Based on analysis from the National Risk Index, the counties of Brown, Charles Mix, Minnehaha, Pennington, and Beadle have the highest level of risk.<br>• Dam failure flooding is included in the flood hazard profile. Of the 2,573 dams, 156 are significant hazard and 86 are high hazard. The majority of these dams are west of the Missouri River including concentrations in the Black Hills and along the Missouri River corridor. | Moody, Pennington, Turner, Walworth, and Yankton.<br>- Within the 1% Annual Chance NFHL category, 27 state facilities are at risk. According to the Critical Facility analysis using State and HIFLD data, there are 2,572 facilities in the same hazard area, 2,362 of them being bridges.<br>- Within the 0.2% Annual Chance NFHL category, 8 state facilities and 141 critical facilities are at risk.<br>- Within the category "Area Protected by Levee," 10 state facilities and 77 critical facilities are at risk.<br>- Facility valuation data was not available but could be used to refine exposure and loss estimates. | | |

| Hazard | Vulnerability Summary/Problem Statements | State Facility and Critical Infrastructure Impacts | Climate Change Impacts | Overall Planning Significance |
|---|---|---|---|---|
| | | • Road and bridge impacts have resulted in numerous and costly disaster assistance claims. | | |
| **Winter Storm** | • According to the NCEI, there were 2,136 winter storms (snow and ice events) in South Dakota between January 1993 and December 2021, and 499 extreme cold events from January 1994 to December 2021. 20 deaths and 127 injuries were attributed to these events.<br>• Total property damage for these events is estimated at $105 million dollars.<br>• South Dakota averages 76 winter storms and $3.7 million in winter storm losses annually, as well as 18 extreme cold events each year.<br>• Approximately 1.4 death every other year and 5 injuries each year.<br>• $10 million in winter-related crop loss indemnities each year.<br>• Cattle impacts have been significant.<br>• According to data from the NRI tool, Brown and Minnehaha are the only counties that rate as very high expected annual losses due to winter storms, likely due to the larger populations in these areas and more development compared to the rural areas of the state. | • Winter storms have been particularly damaging to electric utilities.<br>• Direct impacts to state owned facilities are not likely to result in losses, but winter storms can temporarily disrupt travel on local, state and federal highways and result in significant expenses associated with snow removal and first responders assisting stranded travelers. | • EPA research indicates that the amount of winter precipitation and the number of days with heavy snowfall are projected to increase in northern states. A warming climate may also result in warmer winters.<br>• According to the Fourth National Climate Assessment, rising temperatures in the Northern Great Plains have resulted in shorter snow seasons and rapid melting of winter snowpack. | High |
| **Wildfire** | • Wildfire expected annual losses from the NRI noted that the counties of Pennington (Very High), Meade, Custer, Fall River, and Oglala Lakota, a have the greatest wildfire risk based on an analysis of historic fire occurrence, WUI housing units, and population.<br>• The greatest concentration of Wildland Urban Interface (WUI) structures is located in and around the communities in the Black Hills. Rapid City and bedroom communities within a five-mile radius of the city represent the greatest concentration of | • State fire suppression costs have been more than $2M annually.<br>• An analysis conducted as part of the 2015 Drought Mitigation Plan noted a significant increase in fires, acres burned, and | • Wildfire conditions across South Dakota are likely to worsen in the future due to climate change given that climate projections indicate continued increasing summer temperatures | High |

| Hazard | Vulnerability Summary/Problem Statements | State Facility and Critical Infrastructure Impacts | Climate Change Impacts | Overall Planning Significance |
|---|---|---|---|---|
| | structures located in the forested areas of the Black Hills. The population of new residents in the WUI is growing, especially in Custer, Pennington, and Meade Counties.<br>• In addition to the Black Hills National Forest, there are fire-prone smaller forested areas on the Custer National Forest in Harding County, and BIA Trust and tribal lands on the Pine Ridge Reservation of Oglala Lakota County, and the Rosebud reservation of Todd County. | suppression costs in drought years.<br>• Risk to state owned/leased buildings and infrastructure includes a number of state (101) and local critical facilities (6,110) located in very high, high and moderate risk areas. A more refined vulnerability analysis would be needed to determine site-specific risks.<br>• Other critical infrastructure impacts include impacts to rural electric infrastructure. | and milder temperatures overall, thus an extended fire season. | |
| **Drought (including Extreme Heat)** | • Notable droughts have occurred somewhere in the state on average about every 12 years, which is equivalent of an 8% chance any given year.<br>• Severe drought years can have a devastating financial impact on South Dakota's agricultural industry.<br>• Over a 14-year period from 2007-2020, insured crop losses in South Dakota due to drought have averaged $137 million annually.<br>• Livestock impacts were estimated at $162 million for the 2012 drought and $92 million in the 2013 drought.<br>• Water supply and water quality impacts have been greatest along the Missouri River corridor counties. | • Direct losses to state owned/leased buildings and infrastructure is expected to be minimal.<br>• State parks in South Dakota are likely to suffer the greatest impacts from drought, particularly those that provide water-based recreational activities. Direct losses to the | • Climate change science indicates changing extremes in precipitation are projected across all seasons, including higher likelihoods of both increasing heavy rain and snow events and more intense droughts. The Northern Plains will remain vulnerable to periodic drought | High |

| Hazard | Vulnerability Summary/Problem Statements | State Facility and Critical Infrastructure Impacts | Climate Change Impacts | Overall Planning Significance |
|---|---|---|---|---|
| | • Quantifying losses to other sectors is challenging due to data limitations. A sector-based analysis for the 2015 Drought Mitigation Plan includes additional discussion on:<br>- Agriculture<br>- Wildland Fire<br>- Water Resources<br>- Wildlife<br>- Tourism<br>- Health and Indirect Societal Effects | state can include lost revenue from park access fees and loss in hunting and fishing license revenue.<br>• Other critical infrastructure impacts include impacts to water facilities, reduced hydroelectric power generation during low flows. | because much of the projected increase in precipitation is expected to occur in the cooler months while increasing temperatures will result in additional evapotranspiration. Regarding temperatures and extreme heat, warmer and more extreme temperatures can exacerbate drought impacts and result in consequences regardless of drought. | |
| **Tornado** | • South Dakota's location in the northern region of Tornado Alley makes it susceptible to the formation of tornadoes due to warm Gulf air coming in contact with cool Canadian air fronts and dry air systems from the Rocky Mountains. The intersection of these three systems produces thunderstorm conditions that can spawn tornadoes.<br>• According to the NCEI Storm Events Database, there were 2,437 tornadoes, of which 726 were F1 or higher, in South Dakota between 1950 and 2021 (71 years). Based on this information, the probability that at least one tornado will occur in South Dakota in any given year is 100%.<br>• Annualized losses are estimated at nearly $706 million.<br>• Maps of tornado paths indicate a higher likelihood east of the Missouri River and in the southeastern part of the state.<br>• While all counties in the state are vulnerable to tornadoes according to data in the NRI tool, Minnehaha and Oglala Lakota Counties have a relatively high-risk rating for tornadoes; this is | • Risk to state owned/leased buildings and infrastructure is expected to be limited due to the low likelihood of direct impacts. There are four state owned facilities located in Lincoln County, which has the highest vulnerability to tornadoes.<br>• Other critical infrastructure impacts include impacts to rural electric | • There presently is not enough data or research to quantify the magnitude of change that climate change may have related to tornado frequency and intensity. | Medium |

| Hazard | Vulnerability Summary/Problem Statements | State Facility and Critical Infrastructure Impacts | Climate Change Impacts | Overall Planning Significance |
|---|---|---|---|---|
| | likely a result of building exposure in Minnehaha and higher social vulnerability risk in Oglala Lakota counties. | infrastructure and the potential for direct impacts to local critical facilities. | | |
| **Windstorm** | • According to the NCEI, there were 8,310 windstorm events (7,153 thunderstorm wind, 1,149 high wind, and 8 strong wind events) in South Dakota between 1955 and 2021. There were 11 deaths and 149 injuries in this time period.<br>• Total property and crop damage for events between 1993 (when damage figures began being kept) and 2021 is estimated at $153,056,500.<br>• This suggests that South Dakota could experience 126 wind events, $2.3 million in wind losses, and approximately 2.3 injuries each year.<br>• In general, the counties with the greatest vulnerability to windstorm events are those in the Black Hills region and those with major cities. | • Each very highly ranked county has multiple state-owned critical facilities at risk however direct damages are expected to be minimal if buildings are built to modern codes and standards.<br>• Windstorms can create power outages and exacerbate winter storms. | • There presently is not enough data or research to quantify the magnitude of potential change that climate change may have on windstorms. | Medium |
| **Hazardous Materials** | • Includes both fixed facility and transportation/mobile (air, road, pipeline, rail).<br>• Impacts dependent on type of chemical, type of release, mode, area of release, environmental factors.<br>• U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) statistics indicate 991 reported hazmat incidents (air, highway, water, railway) between 1990-2021 The total cost of damage associated with these incidents was $3,424,399.<br>• This suggests that South Dakota averages over 30 transportation incidents involving hazardous materials and $110,464 in related damage each year.<br>• Counties with the most pipelines and potentially higher exposure to an incident are Lincoln, Minnehaha, Brown, Clark, Spink, Butte, Hutchinson, Union, Harding, and Kingsbury; most of these are in the eastern third of the state. | • Risk to state owned/leased buildings and infrastructure is expected to be minimal; higher risk to facilities that store hazardous materials, or those facilities close to designated transportation routes. | • None expected. | Moderate |

| Hazard | Vulnerability Summary/Problem Statements | State Facility and Critical Infrastructure Impacts | Climate Change Impacts | Overall Planning Significance |
|---|---|---|---|---|
| | • The state has 259 Toxic Resource Inventory facilities and 162 Risk Management Plan facilities; most of these are located in areas with higher populations including Minnehaha, Codington, Pennington, Davison and Beadle. | | | |
| **Geologic Hazards –**<br><br>**Includes Expansive soils,**<br><br>**Subsidence**<br><br>**Earthquake**<br><br>**Landslide** | • Includes expansive soils, subsidence, landslide, mudflow, and earthquake.<br>• Extensive expansive soils distribution across state based on US-wide mapping.<br>• Subsidence (sinkhole) potential with Karst terrain in Black Hills, southeast.<br>• Landslides in Black Hills and Missouri River Bluff counties; NRI expected annual losses from landslides greatest in Lawrence County<br>• Expected losses from earthquakes are very low; According to the FEMA P-366 report, South Dakota ranked 51st (out of the 50 states plus Puerto Rico and the District of Columbia) for AEL, with an AEL of $374 million.<br>• A 300-foot-long landslide forced the closure of Highway 240 in Badlands National Park in 2021. | • Risk to state owned/leased buildings and infrastructure thus far is largely limited to state highways and bridges.<br>• Other critical infrastructure impacts likely to be limited but could include impacts to bridges, pipelines, water distribution systems, roads, and other linear facilities. | • None expected. | Low |

# Appendix 3A

# South Dakota Population and Growth by County

**Table 3A- 1 Overall Population Growth by County**

| County | 2010 Population | 2020 Population | # Change from 2010 to 2020 | % Change from 2010 to 2020 |
|---|---|---|---|---|
| Aurora | 2,745 | 2,747 | 2 | 0.07% |
| Beadle | 18,169 | 19,149 | 980 | 5.39% |
| Bennett | 3,430 | 3,381 | -49 | -1.43% |
| Bon Homme | 7,023 | 7,003 | -20 | -0.28% |
| Brookings | 33,314 | 34,375 | 1,061 | 3.18% |
| Brown | 38,408 | 38,301 | -107 | -0.28% |
| Brule | 5,309 | 5,247 | -62 | -1.17% |
| Buffalo | 2,077 | 1,948 | -129 | -6.21% |
| Butte | 10,298 | 10,243 | -55 | -0.53% |
| Campbell | 1,386 | 1,377 | -9 | -0.65% |
| Charles Mix | 9,287 | 9,373 | 86 | 0.93% |
| Clark | 3,645 | 3,837 | 192 | 5.27% |
| Clay | 13,932 | 14,967 | 1,035 | 7.43% |
| Codington | 27,938 | 28,325 | 387 | 1.39% |
| Corson | 4,182 | 3,902 | -280 | -6.70% |
| Custer | 8,445 | 8,318 | -127 | -1.50% |
| Davison | 19,885 | 19,956 | 71 | 0.36% |
| Day | 5,588 | 5,449 | -139 | -2.49% |
| Deuel | 4,312 | 4,295 | -17 | -0.39% |
| Dewey | 5,662 | 5,239 | -423 | -7.47% |
| Douglas | 2,973 | 2,835 | -138 | -4.64% |
| Edmunds | 3,983 | 3,986 | 3 | 0.08% |
| Fall River | 6,845 | 6,973 | 128 | 1.87% |
| Faulk | 2,357 | 2,125 | -232 | -9.84% |
| Grant | 7,241 | 7,556 | 315 | 4.35% |
| Gregory | 4,217 | 3,994 | -223 | -5.29% |
| Haakon | 1,847 | 1,872 | 25 | 1.35% |
| Hamlin | 5,989 | 6,164 | 175 | 2.92% |
| Hand | 3,345 | 3,145 | -200 | -5.98% |
| Hanson | 3,419 | 3,461 | 42 | 1.23% |
| Harding | 1,250 | 1,311 | 61 | 4.88% |
| Hughes | 17,642 | 17,765 | 123 | 0.70% |
| Hutchinson | 7,200 | 7,427 | 227 | 3.15% |
| Hyde | 1,396 | 1,262 | -134 | -9.60% |
| Jackson | 3,274 | 2,806 | -468 | -14.29% |
| Jerauld | 2,007 | 1,663 | -344 | -17.14% |
| Jones | 975 | 917 | -58 | -5.95% |
| Kingsbury | 5,075 | 5,187 | 112 | 2.21% |
| Lake | 12,368 | 11,059 | -1,309 | -10.58% |
| Lawrence | 24,657 | 25,768 | 1,111 | 4.51% |
| Lincoln | 51,548 | 65,161 | 13,613 | 26.41% |

| County | 2010 Population | 2020 Population | # Change from 2010 to 2020 | % Change from 2010 to 2020 |
|---|---|---|---|---|
| Lyman | 3,877 | 3,718 | -159 | -4.10% |
| Marshall | 4,683 | 4,306 | -377 | -8.05% |
| McCook | 5,649 | 5,682 | 33 | 0.58% |
| McPherson | 2,429 | 2,411 | -18 | -0.74% |
| Meade | 26,951 | 29,852 | 2,901 | 10.76% |
| Mellette | 2,100 | 1,918 | -182 | -8.67% |
| Miner | 2,316 | 2,298 | -18 | -0.78% |
| Minnehaha | 182,882 | 197,214 | 14,332 | 7.84% |
| Moody | 6,367 | 6,336 | -31 | -0.49% |
| Oglala Lakota* | 14,218 | 13,672 | -546 | -3.84% |
| Pennington | 108,242 | 109,222 | 980 | 0.91% |
| Perkins | 3,033 | 2,835 | -198 | -6.53% |
| Potter | 2,340 | 2,472 | 132 | 5.64% |
| Roberts | 10,374 | 10,280 | -94 | -0.91% |
| Sanborn | 2,336 | 2,330 | -6 | -0.26% |
| Spink | 6,598 | 6,361 | -237 | -3.59% |
| Stanley | 2,983 | 2,980 | -3 | -0.10% |
| Sully | 1,438 | 1,446 | 8 | 0.56% |
| Todd | 9,882 | 9,319 | -563 | -5.70% |
| Tripp | 5,512 | 5,624 | 112 | 2.03% |
| Turner | 8,272 | 8,673 | 401 | 4.85% |
| Union | 15,029 | 16,811 | 1,782 | 11.86% |
| Walworth | 5,511 | 5,315 | -196 | -3.56% |
| Yankton | 22,684 | 23,310 | 626 | 2.76% |
| Ziebach | 2,826 | 2,413 | -413 | -14.61% |

Source: United States Census Bureau

**Table 3A- 2 10 Largest Counties by Population**

| 10 Largest Counties | 2010 Population | 2020 Population | # Change from 2010 to 2020 | % Change from 2010 to 2020 |
|---|---|---|---|---|
| Minnehaha County | 169,468 | 197,214 | 27,746 | 16.37% |
| Pennington County | 100,948 | 109,222 | 8,274 | 8.20% |
| Lincoln County | 44,828 | 65,161 | 20,333 | 45.36% |
| Brown County | 36,531 | 38,301 | 1,770 | 4.85% |
| Brookings County | 31,965 | 34,375 | 2,410 | 7.54% |
| Meade County | 25,434 | 29,852 | 4,418 | 17.37% |
| Codington County | 27,227 | 28,325 | 1,098 | 4.03% |
| Lawrence County | 24,097 | 25,768 | 1,671 | 6.93% |
| Yankton County | 22,438 | 23,310 | 872 | 3.89% |
| Davison County | 19,504 | 19,956 | 452 | 2.32% |

Source: United States Census Bureau

**Table 3A- 3 10 Smallest Counties by Population**

| 10 Smallest Counties | 2010 Population | 2020 Population | # Change from 2010 to 2020 | % Change from 2010 to 2020 |
|---|---|---|---|---|
| Faulk County | 2,364 | 2,125 | -239 | -10.11% |
| Buffalo County | 1,912 | 1,948 | 36 | 1.88% |
| Mellette County | 2,048 | 1,918 | -130 | -6.35% |
| Haakon County | 1,937 | 1,872 | -65 | -3.36% |
| Jerauld County | 2,071 | 1,663 | -408 | -19.70% |
| Sully County | 1,373 | 1,446 | 73 | 5.32% |
| Campbell County | 1,466 | 1,377 | -89 | -6.07% |
| Harding County | 1,255 | 1,311 | 56 | 4.46% |
| Hyde County | 1,420 | 1,262 | -158 | -11.13% |
| Jones County | 1,006 | 917 | -89 | -8.85% |

Source: United States Census Bureau

**Table 3A- 4 Counties Experiencing Population Loss**

| 10 Smallest Counties | 2010 Population | 2020 Population | # Change from 2010 to 2020 | % Change from 2010 to 2020 |
|---|---|---|---|---|
| Brule County | 5,255 | 5,247 | -8 | -0.15% |
| Tripp County | 5,644 | 5,624 | -20 | -0.35% |
| Spink County | 6,415 | 6,361 | -54 | -0.84% |
| Bon Homme County | 7,070 | 7,003 | -67 | -0.95% |
| Lyman County | 3,755 | 3,718 | -37 | -0.99% |
| Sanborn County | 2,355 | 2,330 | -25 | -1.06% |
| Dewey County | 5,301 | 5,239 | -62 | -1.17% |
| Lake County | 11,200 | 11,059 | -141 | -1.26% |
| Bennett County | 3,431 | 3,381 | -50 | -1.46% |
| Deuel County | 4,364 | 4,295 | -69 | -1.58% |
| Fall River County | 7,094 | 6,973 | -121 | -1.71% |
| McPherson County | 2,459 | 2,411 | -48 | -1.95% |
| Edmunds County | 4,071 | 3,986 | -85 | -2.09% |
| Walworth County | 5,438 | 5,315 | -123 | -2.26% |
| Moody County | 6,486 | 6,336 | -150 | -2.31% |
| Todd County | 9,612 | 9,319 | -293 | -3.05% |
| Haakon County | 1,937 | 1,872 | -65 | -3.36% |
| Corson County | 4,050 | 3,902 | -148 | -3.65% |
| Miner County | 2,389 | 2,298 | -91 | -3.81% |
| Day County | 5,710 | 5,449 | -261 | -4.57% |
| Perkins County | 2,982 | 2,835 | -147 | -4.93% |
| Douglas County | 3,002 | 2,835 | -167 | -5.56% |
| Campbell County | 1,466 | 1,377 | -89 | -6.07% |
| Mellette County | 2,048 | 1,918 | -130 | -6.35% |
| Gregory County | 4,271 | 3,994 | -277 | -6.49% |
| Jackson County | 3,031 | 2,806 | -225 | -7.42% |
| Marshall County | 4,656 | 4,306 | -350 | -7.52% |
| Hand County | 3,431 | 3,145 | -286 | -8.34% |
| Jones County | 1,006 | 917 | -89 | -8.85% |
| Faulk County | 2,364 | 2,125 | -239 | -10.11% |
| Hyde County | 1,420 | 1,262 | -158 | -11.13% |
| Ziebach County | 2,801 | 2,413 | -388 | -13.85% |
| Jerauld County | 2,071 | 1,663 | -408 | -19.70% |

Source: United States Census Bureau

# Appendix 3B

# South Dakota Flood Insurance Policies and Losses by County 1978-January 2022

| County | # of Policies | Total Coverage | Total Premium | Total Claims Since 1978 | Total Paid Since 1978 | RL Claims |
|---|---|---|---|---|---|---|
| Aurora | 4 | $865,600 | $3,160 | 2 | $99,980 | 0 |
| Beadle | 11 | $2,633,800 | $8,039 | 23 | $368,084 | 6 |
| Bon Homme | 5 | $1,295,000 | $2,204 | 2 | $24,184 | 0 |
| Brookings | 95 | $14,436,000 | $101,704 | 98 | $966,934 | 15 |
| Brown | 175 | $37,638,000 | $205,149 | 486 | $3,283,855 | 52 |
| Brule | 1 | $200,000 | $1,166 | 7 | $252,857 | 0 |
| Butte | 39 | $5,490,300 | $33,246 | 12 | $11,833 | 2 |
| Campbell | 2 | $490,000 | $863 | 1 | $165,942 | 0 |
| Charles Mix | 10 | $2,005,000 | $5,739 | 10 | $504,260 | 2 |
| Clark | 14 | $2,141,000 | $9,638 | 12 | $189,919 | 5 |
| Clay | 12 | $3,558,000 | $5,743 | 12 | $50,954 | 2 |
| Codington | 350 | $71,528,500 | $328,911 | 463 | $6,411,610 | 162 |
| Corson | 1 | $350,000 | $494 | 0 | $0 | 0 |
| Custer | 57 | $12,641,600 | $48,488 | 51 | $645,519 | 0 |
| Davison | 50 | $10,478,600 | $34,386 | 23 | $840,402 | 4 |
| Day | 15 | $2,315,200 | $27,351 | 261 | $4,152,879 | 53 |
| Deuel | 1 | $350,000 | $494 | 1 | $3,758 | 0 |
| Dewey | 1 | $250,000 | $1,094 | 0 | $0 | 0 |
| Douglas | 1 | $141,600 | $2,267 | 1 | $520 | 0 |
| Edmunds | 3 | $1,050,000 | $1,482 | 5 | $2,980 | 0 |
| Fall River | 10 | $1,693,400 | $19,634 | 1 | $25 | 0 |
| Faulk | 1 | $350,000 | $494 | 3 | $5,206 | 0 |
| Grant | 12 | $2,447,500 | $9,968 | 27 | $242,103 | 17 |
| Gregory | 2 | $525,000 | $792 | 3 | $167,335 | 0 |
| Haakon | 13 | $1,250,100 | $12,343 | 2 | $0 | 0 |
| Hamlin | 71 | $17,731,400 | $52,122 | 431 | $5,159,410 | 155 |
| Hand | 3 | $700,000 | $1,194 | 6 | $77,210 | 4 |
| Hanson | 8 | $1,496,500 | $6,817 | 10 | $166,928 | 7 |
| Hughes | 55 | $13,239,600 | $61,232 | 87 | $693,582 | 9 |
| Hutchinson | 11 | $2,002,400 | $8,569 | 12 | $277,682 | 0 |
| Hyde | 0 | $0 | $0 | 1 | $0 | 0 |
| Jerauld | 1 | $350,000 | $494 | 0 | $0 | 0 |
| Jones | 0 | $0 | $0 | 0 | $0 | 0 |
| Kingsbury | 1 | $350,000 | $494 | 37 | $382,290 | 2 |
| Lake | 228 | $41,687,500 | $238,492 | 303 | $7,970,816 | 62 |
| Lawrence | 111 | $25,496,000 | $158,943 | 40 | $279,219 | 1 |
| Lincoln | 351 | $116,739,200 | $474,636 | 227 | $6,676,182 | 46 |
| Lyman | 8 | $921,200 | $14,721 | 10 | $383,909 | 4 |
| Marshall | 2 | $490,000 | $811 | 12 | $144,193 | 6 |

| County | # of Policies | Total Coverage | Total Premium | Total Claims Since 1978 | Total Paid Since 1978 | RL Claims |
|---|---|---|---|---|---|---|
| McCook | 28 | $3,859,900 | $34,994 | 22 | $447,310 | 11 |
| McPherson | 0 | $0 | $0 | 0 | $0 | 0 |
| Meade | 73 | $13,505,300 | $86,809 | 22 | $52,781 | 5 |
| Miner | 2 | $420,000 | $686 | 0 | $0 | 0 |
| Minnehaha | 112 | $23,948,400 | $134,183 | 192 | $2,319,203 | 103 |
| Moody | 24 | $2,769,000 | $47,363 | 71 | $840,422 | 30 |
| Pennington | 344 | $80,312,700 | $411,062 | 137 | $490,194 | 14 |
| Potter | 0 | $0 | $0 | 0 | $0 | 0 |
| Roberts | 38 | $7,835,400 | $38,803 | 68 | $645,757 | 12 |
| Sanborn | 5 | $1,597,600 | $2,853 | 14 | $46,952 | 0 |
| Spink | 28 | $4,265,800 | $32,336 | 77 | $1,016,507 | 25 |
| Stanley | 129 | $37,354,500 | $114,618 | 118 | $2,555,208 | 3 |
| Sully | 1 | $350,000 | $494 | 5 | $22,793 | 0 |
| Todd | 3 | $205,200 | $3,117 | 4 | $1,937 | 0 |
| Tripp | 1 | $60,000 | $827 | 0 | $0 | 0 |
| Turner | 9 | $1,377,800 | $5,987 | 18 | $341,115 | 6 |
| Union | 298 | $99,089,000 | $184,265 | 430 | $5,282,237 | 24 |
| Walworth | 0 | $0 | $0 | 0 | $0 | 0 |
| Yankton | 81 | $18,374,100 | $106,557 | 64 | $1,603,545 | 11 |
| Ziebach | 1 | $210,000 | $413 | 3 | $3,427 | 0 |
| **State Total:** | **2,912** | **$692,862,700** | **$3,088,741** | **3,927** | **$56,271,948** | **860** |

Source: FEMA NFIP Policy and Claims Report for South Dakota; produced January 2022 by SD OEM

# Appendix 3C

# State and Facilities in Flood and Wildfire Zones

**Table 3C1 State Buildings at Risk to Flood Hazards by County – Hazus and FEMA NFHL**

| Flood Type | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| 1% Chance Hazus | Turner County | 2116 | DEPT OF TRANSPORATION | HURLEY LOADER SHED 448 SQ FT | 28306 SD Highway 19, Hurley, South Dakota, 57036 |
| 1% Chance Hazus | Turner County | 2114 | DEPT OF TRANSPORATION | HURLEY WOODFRAME SALT SHED | 28306 SD Highway 19, Hurley, South Dakota, 57036 |
| 1% Chance Hazus | Walworth County | 3009 | DEPT OF TRANSPORATION | SELBY 50X95 TRUCK MAINT SHOP | US-83, Selby, South Dakota, 57472 |
| 1% Chance Hazus | Walworth County | 3021 | DEPT OF TRANSPORATION | SELBY ABRASIVE SHED | US-83, Selby, South Dakota, 57472 |
| 1% Chance Hazus | Walworth County | 3002 | DEPT OF TRANSPORATION | SELBY MAINT SHOP | US-83, Selby, South Dakota, 57472 |
| 1% Chance Hazus | Walworth County | 3210 | DEPT OF TRANSPORATION | SELBY MAINT SHOP SITE | US-83, Selby, South Dakota, 57472 |
| 1% Chance Hazus | Walworth County | 3055 | DEPT OF TRANSPORATION | SELBY POLE BUILDING | US-83, Selby, South Dakota, 57472 |
| 1% Chance Hazus | Walworth County | 3089 | DEPT OF TRANSPORATION | SELBY SALT STORAGE SHED | US-83, Selby, South Dakota, 57472 |
| 1% Chance Hazus | Walworth County | 3203 | DEPT OF TRANSPORATION | SELBY SCALE SITE JCT OF US 12 | US-83, Selby, South Dakota, 57472 |
| 1% Chance NFHL | Pennington County | 699 | BUREAU OF ADMINISTRATION | FEDERAL PROPERTY WAREHOUSE | 604 Box Elder Rd W, Box Elder, South Dakota, 57719 |
| 1% Chance NFHL | Minnehaha County | 4471 | DEPT OF GAME, FISH & PARKS | BIG SIOUX RECREATION AREA | 410 W Park St, Brandon, South Dakota, 57005 |
| 1% Chance NFHL | Pennington County | 4516 | DEPT OF GAME, FISH & PARKS | GFP CLEGHORN HATCHERY | 4725 Jackson Blvd, Rapid City, South Dakota, 57702 |
| 1% Chance NFHL | Lawrence County | 4580 | DEPT OF GAME, FISH & PARKS | GFP MCNENNY HAT | 19619 Trout Loop, Spearfish, South Dakota, 57783 |
| 1% Chance NFHL | Lawrence County | 4261 | DEPT OF HEALTH | LAWRENCE CO HEALTH | 9 Kirk Rd, Deadwood, South Dakota, 57732 |
| 1% Chance NFHL | Brown County | 4100 | DEPT OF HUMAN SERVICES | HUMAN SERVICES | 404 Moccasin Dr, Aberdeen, South Dakota, 57401 |
| 1% Chance NFHL | Yankton County | 7431 | DEPT OF LABOR & REGULATIONS | CAREER LEARNG CENTER-SOUTHEAST JOB LINK | 1200 W 21st St, Yankton, South Dakota, 57078 |
| 1% Chance NFHL | Minnehaha County | 492 | DEPT OF LABOR & REGULATIONS | SIOUX FALLS ONE STOP CENTER | 811 E 10th St, Sioux Falls, South Dakota, 57103 |
| 1% Chance | Pennington | 7924 | DEPT OF PUBLIC SAFETY | RAPID CITY REGIONAL OFFICE | 2050 W Main St, Ste 1, Rapid City, South |

| Flood Type | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| NFHL | County | | | | Dakota, 57702 |
| 1% Chance NFHL | Brown County | 1254 | DEPT OF REVENUE | DEPT OF REVENUE FIELD OFFICE | 419 Moccasin Dr, Aberdeen, South Dakota, 57401 |
| 1% Chance NFHL | Codington County | 1267 | DEPT OF REVENUE | DEPT OF REVENUE FIELD OFFICE | 715 S Maple, Watertown, South Dakota, 57201 |
| 1% Chance NFHL | Brown County | 5123 | DEPT OF REVENUE | LOTTERY | 404 Moccasin Dr, Aberdeen, South Dakota, 57401 |
| 1% Chance NFHL | Minnehaha County | 650 | DEPT OF SOCIAL SERVICES | DIVISION OF SOCIAL WELFARE | 811 E 10th St, Sioux Falls, South Dakota, 57103 |
| 1% Chance NFHL | Brown County | 1015 | DEPT OF TRANSPORATION | ABERDEEN SALT STORAGE SHED | 2555 Highway 12 W, Aberdeen, South Dakota, 57401 |
| 1% Chance NFHL | Lawrence County | 4108 | DEPT OF TRANSPORATION | DEADWOOD ABRASIVE STORAGE SHED | 57 Crescent Dr, Deadwood, South Dakota, 57732 |
| 1% Chance NFHL | Lawrence County | 4073 | DEPT OF TRANSPORATION | DEADWOOD MAINT SHOP | 57 Crescent Dr, Deadwood, South Dakota, 57732 |
| 1% Chance NFHL | Lawrence County | 4237 | DEPT OF TRANSPORATION | DEADWOOD MAINT SHOP SITE | 57 Crescent Dr, Deadwood, South Dakota, 57732 |
| 1% Chance NFHL | Lawrence County | 4078 | DEPT OF TRANSPORATION | DEADWOOD STORAGE SHED | 57 Crescent Dr, Deadwood, South Dakota, 57732 |
| 1% Chance NFHL | Fall River County | 4014 | DEPT OF TRANSPORATION | EDGEMONT MAINT SHOP | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| 1% Chance NFHL | Fall River County | 4207 | DEPT OF TRANSPORATION | EDGEMONT MAINT SHOP SITE | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| 1% Chance NFHL | Fall River County | 4044 | DEPT OF TRANSPORATION | EDGEMONT SALT SAND STORAGE SHED | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| 1% Chance NFHL | Fall River County | 4208 | DEPT OF TRANSPORATION | EDGEMONT STOCKPILE SITE | 28576 Old Highway 18, Edgemont, South Dakota, 57735 |
| 1% Chance NFHL | Fall River County | 4090 | DEPT OF TRANSPORATION | EDGEMONT STOCKPILE SITE BUILDING | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| 1% Chance NFHL | Fall River County | 4016 | DEPT OF TRANSPORATION | EDGEMONT STORAGE SALT SHED | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| 1% Chance NFHL | Fall River County | 4060 | DEPT OF TRANSPORATION | EDGEMONT STORAGE SHED | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| 1% Chance NFHL | Minnehaha County | 2003 | DEPT OF TRANSPORATION | VALLEYSPRINGS REST AREA SHED | 57068, Valley Springs, South Dakota |
| 1% Chance | McCook | 143 | UNIFIED JUDICIAL SYSTEM | COURTHOUSE - MCCOOK CO | 130 W Essex Ave, Salem, South Dakota, |

| Flood Type | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| NFHL | County | | | | 57058 |
| | | | | **Total** | **36** |
| 0.2% Chance NFHL | Hughes County | 40 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | THORPE BUILDING | 701 E Sioux Ave, Pierre, South Dakota, 57501 |
| 0.2% Chance NFHL | Minnehaha County | 5100 | DEPT OF HEALTH | BOARD OF MED & OSTEOP | 101 S Mall Ave, Sioux Falls, South Dakota, 57104 |
| 0.2% Chance NFHL | Moody County | 9107 | DEPT OF MILITARY | 00001 FLANDREAU ARMORY | 710 W Community Dr, Flandreau, South Dakota, 57028 |
| 0.2% Chance NFHL | Meade County | 9122 | DEPT OF MILITARY | STURGIS FMS (METAL STORAGE BUILDING) | 701 14th St, Sturgis, South Dakota, 57785 |
| 0.2% Chance NFHL | Lawrence County | 464 | DEPT OF REVENUE | GAMING COMMISSION | 87 Sherman St, Deadwood, South Dakota, 57732 |
| 0.2% Chance NFHL | Lawrence County | 634 | DEPT OF SOCIAL SERVICES | DEPT OF SOCIAL SERVICES | 20 Cliff St, Deadwood, South Dakota, 57732 |
| 0.2% Chance NFHL | Codington County | 5171 | OFFICE OF THE ATTORNEY GENERAL | WATERTOWN CRIMINAL INVESTIGATION DIVISIO | 801 Jenson Ave SE, Watertown, South Dakota, 57201 |
| 0.2% Chance NFHL | Lawrence County | 140 | UNIFIED JUDICIAL SYSTEM | COURTHOUSE - LAWRENCE CO | 78 Sherman St, Deadwood, South Dakota, 57732 |
| | | | | **Total** | **8** |
| Levee NFHL | Minnehaha County | 702 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | SDN COMMUNICATIONS | 2900 W 10th St, Sioux Falls, South Dakota, 57104 |
| Levee NFHL | Minnehaha County | 4555 | DEPT OF GAME, FISH & PARKS | GFP REGIONAL OFFICE | 4500 S Oxbow Ave, Sioux Falls, South Dakota, 57106 |
| Levee NFHL | Minnehaha County | 476 | DEPT OF HEALTH | BOARD OF PHARMACY | 3701 W 49th St, Sioux Falls, South Dakota, 57106 |
| Levee NFHL | Minnehaha County | 463 | DEPT OF HEALTH | EMPIRE OFFICE BUILDING | 4305 S Louise Ave, Sioux Falls, South Dakota, 57106 |
| Levee NFHL | Minnehaha County | 384 | DEPT OF HEALTH | HEALTH DEPARTMENT | 1200 N West Ave, Sioux Falls, South Dakota, 57104 |
| Levee NFHL | Minnehaha County | 5190 | DEPT OF HUMAN SERVICES | DISABILITY DETERMINATION SERVICES | 3109 W 41st St, #100, Sioux Falls, South Dakota, 57105 |
| Levee NFHL | Minnehaha County | 659 | DEPT OF HUMAN SERVICES | REHABILITATION CENTER | 2900 W 11th St, #101, Sioux Falls, South Dakota, 57104 |
| Levee NFHL | Minnehaha County | 9125 | DEPT OF MILITARY | SIOUX FALLS FOSS FIELD COMPLEX | 801 W National Guard Dr, Sioux Falls, South Dakota, 57104 |
| Levee NFHL | Minnehaha | 357 | DEPT OF PUBLIC SAFETY | DRIVER LICENSE EXAM | 2501 W Russell St, Sioux Falls, South |

| Flood Type | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| | County | | | | Dakota, 57104 |
| Levee NFHL | Minnehaha County | 8969 | DEPT OF REVENUE | DEPT OF REVENUE FIELD OFFICE | 809 N Elmwood Ave, Sioux Falls, South Dakota, 57104 |
| | | | | **Total** | **10** |
| | | | | **Grand Total** | **54** |

Source: Hazus-MH, FEMA NFHL, South Dakota OEM, Wood GIS Analysis

**Table 3C2 State Buildings at Risk to Wildfire Hazard**

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| **Very High** | Pennington County | 497 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | STATE RADIO TOWER SITE-SETH BULLOCK | 251 Forest St, Hill City, South Dakota, 57745 |
| **Very High** | Custer County | 1107 | DEPT OF GAME, FISH & PARKS | CSP BARN | 13329 US-16A, Custer, South Dakota, 57730 |
| **Very High** | Custer County | 1124 | DEPT OF GAME, FISH & PARKS | CSP GAME LODGE | 13329 US-16A, Custer, South Dakota, 57730 |
| **Very High** | Custer County | 1145 | DEPT OF GAME, FISH & PARKS | CSP NORBECK WELCOME CENTER | 13329 US-16A, Custer, South Dakota, 57730 |
| **Very High** | Custer County | 4620 | DEPT OF GAME, FISH & PARKS | GFP CUSTER STATE PARK | 13329 US-16A, Custer, South Dakota, 57730 |
| **Very High** | Custer County | 9781 | DEPT OF PUBLIC SAFETY | EXCEL | 25292 Badger Clark Rd, Custer, South Dakota, 57730 |
| **Very High** | Custer County | 9784 | DEPT OF PUBLIC SAFETY | GYMNASIUM | 25292 Badger Clark Rd, Custer, South Dakota, 57730 |
| **Very High** | Custer County | 9782 | DEPT OF PUBLIC SAFETY | QUEST | 25292 Badger Clark Rd, Custer, South Dakota, 57730 |
| **Very High** | Custer County | 9783 | DEPT OF PUBLIC SAFETY | SHOP | 25292 Badger Clark Rd, Custer, South Dakota, 57730 |
| **Very High** | Custer County | 4255 | DEPT OF TRANSPORATION | HERMOSA STOCKPILE SITE | 57744, Hermosa, South Dakota |
| **Very High** | Pennington County | 4245 | DEPT OF TRANSPORATION | PENNINGTON CO EXCESS LAND | 57751, Keystone, South Dakota |
| **Very High** | Pennington County | 4247 | DEPT OF TRANSPORATION | PENNINGTON CO EXCESS LAND | 57751, Keystone, South Dakota |
| **Very High** | Pennington County | 4217 | DEPT OF TRANSPORATION | RIMROCK GRAVEL STOCKPILE SITE | 57702, Rapid City, South Dakota |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| **Very High** | Custer County | 116 | UNIFIED JUDICIAL SYSTEM | COURTHOUSE - CUSTER CO | 411 Mt Rushmore Rd, Custer, South Dakota, 57730 |
| | | | | **Total** | **14** |
| High | Custer County | 496 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | BEAR MT SRC TOWER SITE | FS Rd, Custer, South Dakota, 57730 |
| High | Pennington County | 7973 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | GOLDEN WEST SKYLINE | 3850 Skyline Dr, Rapid City, South Dakota, 57701 |
| High | Hand County | 1201 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | HAND CO TOWER SITE | 57362, Miller, South Dakota |
| High | Pennington County | 4405 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | KBHE PUBLIC BROADCAST & SRC | 3650 Skyline Dr, Rapid City, South Dakota, 57701 |
| High | Custer County | 73 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | STATE RADIO & PUBLIC BROADCASTING | 57730, Custer, South Dakota |
| High | Custer County | 4459 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | STATE RADIO AND PUBLIC BROADCASTING | 57730, Custer, South Dakota |
| High | Pennington County | 65 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | STATE RADIO SKYLINE DR @ KBHE | Skyline Dr, Rapid City, South Dakota, 57701 |
| High | Fall River County | 61 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | STATE RADIO TOWER SITE | 45 Battle Mountain Rd, Hot Springs, South Dakota, 57747 |
| High | Marshall County | 7654 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | STATE RADIO TOWER SITE | Hillhead, South Dakota |
| High | McPherson County | 4392 | BUEREAU OF INFORMATION AND TELECOMMUNICATIONS | STATE RADIO TOWER SITE | SD Highway 10 & 355th Ave, Leola, South Dakota, 57456 |
| High | Lawrence County | 5191 | DEPT OF AG & NATURAL RESOURCES | DENR GILT EDGE SITE | 11898 Gilt Edge Rd, Deadwood, South Dakota, 57732 |
| High | Custer County | 9771 | DEPT OF CORRECTIONS | ADMINISTRATION & WARDS | 12279 Brady Dr, Custer, South Dakota, 57730 |
| High | Custer County | 9772 | DEPT OF CORRECTIONS | LAUNDRY | 12279 Brady Dr, Custer, South Dakota, 57730 |
| High | Custer County | 9774 | DEPT OF CORRECTIONS | PENITENTIARY UNIT | 12279 Brady Dr, Custer, South Dakota, 57730 |
| High | Custer County | 9773 | DEPT OF CORRECTIONS | POWER HOUSE & SHOP | 12279 Brady Dr, Custer, South Dakota, 57730 |
| High | Custer County | 4092 | DEPT OF GAME, FISH & PARKS | CUSTER ABRASIVE STORAGE BUILDING | 115 Centennial Dr, Custer, South Dakota, 57730 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| High | Custer County | 4067 | DEPT OF GAME, FISH & PARKS | CUSTER MAINT SHOP | 115 Centennial Dr, Custer, South Dakota, 57730 |
| High | Custer County | 4214 | DEPT OF GAME, FISH & PARKS | CUSTER MAINT SHOP SITE | 115 Centennial Dr, Custer, South Dakota, 57730 |
| High | Custer County | 4101 | DEPT OF GAME, FISH & PARKS | CUSTER SIGN SHOP | 115 Centennial Dr, Custer, South Dakota, 57730 |
| High | Custer County | 4069 | DEPT OF GAME, FISH & PARKS | CUSTER STORAGE SHED | 115 Centennial Dr, Custer, South Dakota, 57730 |
| High | Custer County | 4015 | DEPT OF GAME, FISH & PARKS | CUSTER SYLVAN LAKE LOADER SHED | 115 Centennial Dr, Custer, South Dakota, 57730 |
| High | Hughes County | 4587 | DEPT OF GAME, FISH & PARKS | FARM ISLAND SHOP | 1301 Farm Island Rd, Pierre, South Dakota, 57501 |
| High | Pennington County | 4516 | DEPT OF GAME, FISH & PARKS | GFP CLEGHORN HATCHERY | 4725 Jackson Blvd, Rapid City, South Dakota, 57702 |
| High | Pennington County | 4506 | DEPT OF GAME, FISH & PARKS | GFP CO | 333 Main St, Hill City, South Dakota, 57745 |
| High | Custer County | 4507 | DEPT OF GAME, FISH & PARKS | GFP CO & TRAPPE | 12168 US-16, Custer, South Dakota, 57730 |
| High | Lawrence County | 4580 | DEPT OF GAME, FISH & PARKS | GFP MCNENNY HAT | 19619 Trout Loop, Spearfish, South Dakota, 57783 |
| High | Lawrence County | 4511 | DEPT OF GAME, FISH & PARKS | GFP STATE FARM | 2130 Christensen Dr, Spearfish, South Dakota, 57783 |
| High | Hand County | 6104 | DEPT OF GAME, FISH & PARKS | LAKE LOUISE RECREATION AREA | 35250 191st St, Miller, South Dakota, 57362 |
| High | Edmunds County | 843 | DEPT OF HEALTH | BOWDLE HEALTH CARE CENTER | 8001 5th St, Bowdle, South Dakota, 57428 |
| High | Custer County | 4273 | DEPT OF HEALTH | CUSTER CO DOH | 447 Crook St, Ste 2, Custer, South Dakota, 57730 |
| High | Lawrence County | 4261 | DEPT OF HEALTH | LAWRENCE CO HEALTH | 9 Kirk Rd, Deadwood, South Dakota, 57732 |
| High | Oglala Lakota County | 7508 | DEPT OF LABOR | DEPT OF LABOR | 57770, Pine Ridge, South Dakota |
| High | Pennington County | 9086 | DEPT OF MILITARY | 00001 AIRCRAFT MAINTENANCE HANGAR | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9008 | DEPT OF MILITARY | 00001 CSMS #2 LOCATION HWY 16 B | 1205 US-16-TRUCK E, Rapid City, South Dakota, 57701 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| High | Hughes County | 9101 | DEPT OF MILITARY | 00001 PIERRE READINESS CENTER | 57501, Pierre, South Dakota |
| High | Pennington County | 9087 | DEPT OF MILITARY | 00002 AIRCRAFT MAINTENANCE HANGAR #2 | 4750 Guard Rd, Rapid City, South Dakota, 57703 |
| High | Pennington County | 9036 | DEPT OF MILITARY | 00003 RAPID CITY AIRPORT ARMORY | 4750 Guard Rd, Rapid City, South Dakota, 57703 |
| High | Pennington County | 9001 | DEPT OF MILITARY | 00I23 CREDIT UNION | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9040 | DEPT OF MILITARY | 100 DUKE CORNING ARMORY | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9058 | DEPT OF MILITARY | 105 OMS #2 | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9013 | DEPT OF MILITARY | 122 STARBASE BUILDING | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9014 | DEPT OF MILITARY | 123 STARBASE BUILDING | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9007 | DEPT OF MILITARY | 140 STORAGE | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9070 | DEPT OF MILITARY | 159 ORDINANCE STORAGE | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9002 | DEPT OF MILITARY | 160 BUILDING | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9042 | DEPT OF MILITARY | 170 BUILDING | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9010 | DEPT OF MILITARY | 180 BUILDING | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9012 | DEPT OF MILITARY | 201 VISITOR CENTER | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9060 | DEPT OF MILITARY | 250 GENERALS QUARTER | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9066 | DEPT OF MILITARY | 350 COYOTE DEN | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9011 | DEPT OF MILITARY | 360 DVQ | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9018 | DEPT OF MILITARY | 370 BOQ | 2823 W Main St, Rapid City, South Dakota, 57702 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| High | Pennington County | 9019 | DEPT OF MILITARY | 380 BOQ | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9016 | DEPT OF MILITARY | 420 JFHQ | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9003 | DEPT OF MILITARY | 450 CONFERENCE CENTER | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9043 | DEPT OF MILITARY | 456 USP&FO WAREHOUSE | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9083 | DEPT OF MILITARY | 550 HEALTH CLINIC | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9084 | DEPT OF MILITARY | 554 CHAPEL | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9004 | DEPT OF MILITARY | 560 PHYSCIAL FITNESS CENTER | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9006 | DEPT OF MILITARY | 570 RATION BREAKDOWN | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9061 | DEPT OF MILITARY | 580 HOUSE | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9005 | DEPT OF MILITARY | 660 PCS WAREHOUSE STORAGE BUILDING | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9009 | DEPT OF MILITARY | 670 STORAGE BUILDING | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9037 | DEPT OF MILITARY | 801 BARRACKS | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9017 | DEPT OF MILITARY | 802 BARRACKS | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Pennington County | 9015 | DEPT OF MILITARY | 803 BARRACKS | 2823 W Main St, Rapid City, South Dakota, 57702 |
| High | Hughes County | 9100 | DEPT OF MILITARY | PIERRE TS RG | 57501, Pierre, South Dakota |
| High | Pennington County | 708 | DEPT OF PUBLIC SAFETY | GREAT PLAINS DISPATCH (WILDLAND FIRE) | 8123 S Highway 16, Rapid City, South Dakota, 57702 |
| High | Hughes County | 3214 | DEPT OF PUBLIC SAFETY | PUBLIC SAFETY SITE SD34 | 57501, Pierre, South Dakota |
| High | Pennington County | 7924 | DEPT OF PUBLIC SAFETY | RAPID CITY REGIONAL OFFICE | 2050 W Main St, Ste 1, Rapid City, South Dakota, 57702 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| High | Beadle County | 1213 | DEPT OF TRANSPORATION | BEADLE COUNTY BORROW PIT | 57350, Huron, South Dakota |
| High | Pennington County | 7922 | DEPT OF TRANSPORATION | COAL GASIFICATION PLANT | S SD-79, Rapid City, South Dakota, 57702 |
| High | Tripp County | 3248 | DEPT OF TRANSPORATION | COLOME STOCKPILE SITE | 57528, Colome, South Dakota |
| High | Custer County | 4227 | DEPT OF TRANSPORATION | CUSTER STOCKPILE SITE | 57730, Custer, South Dakota |
| High | Lawrence County | 4108 | DEPT OF TRANSPORATION | DEADWOOD ABRASIVE STORAGE SHED | 57 Crescent Dr, Deadwood, South Dakota, 57732 |
| High | Lawrence County | 4073 | DEPT OF TRANSPORATION | DEADWOOD MAINT SHOP | 57 Crescent Dr, Deadwood, South Dakota, 57732 |
| High | Lawrence County | 4237 | DEPT OF TRANSPORATION | DEADWOOD MAINT SHOP SITE | 57 Crescent Dr, Deadwood, South Dakota, 57732 |
| High | Lawrence County | 4078 | DEPT OF TRANSPORATION | DEADWOOD STORAGE SHED | 57 Crescent Dr, Deadwood, South Dakota, 57732 |
| High | Campbell County | 3105 | DEPT OF TRANSPORATION | HERREID ABRASIVE AND SALT DOME | 10613 US Highway 83, Herreid, South Dakota, 57632 |
| High | Campbell County | 3103 | DEPT OF TRANSPORATION | HERREID NEW COLD STORAGE BUILDING | 10613 US Highway 83, Herreid, South Dakota, 57632 |
| High | Campbell County | 3100 | DEPT OF TRANSPORATION | HERREID NEW SHOP | 10613 US Highway 83, Herreid, South Dakota, 57632 |
| High | Campbell County | 3251 | DEPT OF TRANSPORATION | HERREID SHOP SITE | 10613 US Highway 83, Herreid, South Dakota, 57632 |
| High | Pennington County | 4087 | DEPT OF TRANSPORATION | HILL CITY SALT STORAGE SHED | 24032 Highway 385, Hill City, South Dakota, 57745 |
| High | Beadle County | 1233 | DEPT OF TRANSPORATION | HURON STOCKPILE SITE | 57350, Huron, South Dakota |
| High | Hyde County | 1283 | DEPT OF TRANSPORATION | HYDE HIGHMORE R/W | 57345, Highmore, South Dakota |
| High | Pennington County | 4099 | DEPT OF TRANSPORATION | KEYSTONE WYE ABRASIVE SHED | US-16, Keystone, South Dakota, 57751 |
| High | Pennington County | 4019 | DEPT OF TRANSPORATION | KEYSTONE WYE LOADER SHED | US-16, Keystone, South Dakota, 57751 |
| High | Pennington County | 4018 | DEPT OF TRANSPORATION | KEYSTONE WYE TRUCK STRG BLDG | US-16, Keystone, South Dakota, 57751 |
| High | Oglala Lakota County | 4232 | DEPT OF TRANSPORATION | OGLALA STCKPL SITE | 57764, Oglala, South Dakota |
| High | Pennington County | 4230 | DEPT OF TRANSPORATION | R/CITY SO YARD/79S STOCKPILE SITE | 5801 S SD-79, Rapid City, South Dakota, 57702 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| High | Pennington County | 4008 | DEPT OF TRANSPORATION | RAPID CITY HWY44 STORAGE SHED | 11485 W Highway 44, Rapid City, South Dakota, 57702 |
| High | Pennington County | 4051 | DEPT OF TRANSPORATION | RAPID CITY SALT STORAGE SHED/SOUTH | 5801 S SD-79, Rapid City, South Dakota, 57702 |
| High | Pennington County | 4002 | DEPT OF TRANSPORATION | RAPID CITY SIGN STORAGE SHED | 5801 S SD-79, Rapid City, South Dakota, 57702 |
| High | Pennington County | 4053 | DEPT OF TRANSPORATION | RAPID CITY SOUTH YARD ABRASIVE SHED | 5801 S SD-79, Rapid City, South Dakota, 57702 |
| High | Pennington County | 4031 | DEPT OF TRANSPORATION | RAPID CITY STORAGE SHED/SOUTH | 5801 S SD-79, Rapid City, South Dakota, 57702 |
| High | Marshall County | 1225 | DEPT OF TRANSPORATION | VEBLIN STOCKPILE SITE | 57270, Veblen, South Dakota |
| High | Todd County | 3112 | DEPT OF TRANSPORATION | WHITE RIVER 50X90 COLD STRG BLDG | 26522 US-83, White River, South Dakota, 57579 |
| High | Todd County | 3099 | DEPT OF TRANSPORATION | WHITE RIVER ABRASIVE DOME | 26522 US-83, White River, South Dakota, 57579 |
| High | Todd County | 3008 | DEPT OF TRANSPORATION | WHITE RIVER MAINT SHOP | 26522 US-83, White River, South Dakota, 57579 |
| High | Todd County | 3202 | DEPT OF TRANSPORATION | WHITE RIVER MAINT SHOP SITE | 26522 US-83, White River, South Dakota, 57579 |
| High | Todd County | 3050 | DEPT OF TRANSPORATION | WHT RIVER SLT STORAGE SHED | 26522 US-83, White River, South Dakota, 57579 |
| | | | | **Total** | **101** |
| Moderate | Walworth County | 9112 | | 00001 MOBRIDGE READINESS CENTER | 1213 Lake Front Dr, Mobridge, South Dakota, 57601 |
| Moderate | Union County | 5013 | | ADAMS HOMESTEAD & NATURE PRESERVE | 272 Westshore Dr, North Sioux City, South Dakota, 57049 |
| Moderate | Fall River County | 9702 | | ADMINISTRATION BUILDING | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Meade County | 423 | | AFB HOSP PED CLINIC 28TH MED GRP | 2900 Doolittle Dr, Ellsworth Afb, South Dakota, 57706 |
| Moderate | Lawrence County | 4602 | | AGRICULTURE | 11361 Nevada Gulch Rd, Lead, South Dakota, 57754 |
| Moderate | Pennington County | 4515 | | AGRICULTURE/FORESTRY | 3305 1/2 W South St, Rapid City, South Dakota, 57702 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Hughes County | 3090 | | AIRPLANE HANGER JCP LEASING | 4300 Airport Rd, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 3076 | | AIRPORT WAREHOUSE | 4300 Airport Rd, Pierre, South Dakota, 57501 |
| Moderate | Pennington County | 648 | | ARCHAEOLOGICAL RESEARCH CENTER | 217 Kansas City St, Rapid City, South Dakota, 57701 |
| Moderate | Fall River County | 9708 | | BARN | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Butte County | 4076 | | BELLE FOURCHE COLD STORGE SHED | 10921 SD-34, Belle Fourche, South Dakota, 57717 |
| Moderate | Butte County | 4085 | | BELLE FOURCHE COVER ALL SALT SAND | 10921 SD-34, Belle Fourche, South Dakota, 57717 |
| Moderate | Butte County | 4071 | | BELLE FOURCHE HEATED TRUCK STORGE | 10921 SD-34, Belle Fourche, South Dakota, 57717 |
| Moderate | Butte County | 4009 | | BELLE FOURCHE LAB BUILDING | 10921 SD-34, Belle Fourche, South Dakota, 57717 |
| Moderate | Butte County | 4075 | | BELLE FOURCHE MAINT SHOP | 10921 SD-34, Belle Fourche, South Dakota, 57717 |
| Moderate | Butte County | 4007 | | BELLE FOURCHE SALT STORAGE SHED | 10921 SD-34, Belle Fourche, South Dakota, 57717 |
| Moderate | Butte County | 4228 | | BELLE FOURCHE SHOP SITE | 10921 SD-34, Belle Fourche, South Dakota, 57717 |
| Moderate | Lawrence County | 7950 | | BHSU E Y BERRY LIBRARY | 1200 University St, Spearfish, South Dakota, 57799 |
| Moderate | Lawrence County | 7403 | | BLACK HILLS EDUCATION CONNECTION | 208 E Colorado Blvd, Spearfish, South Dakota, 57783 |
| Moderate | Fall River County | 9713 | | BOILER PLANT | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9718 | | CANYON COTTAGES | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Pennington County | 7520 | | CAREER LEARNING CENTER | 730 E Watertown St, Rapid City, South Dakota, 57701 |
| Moderate | Hughes County | 196 | | CENTRAL PRINTING PLANT | E 4th St, Pierre, South Dakota, 57501 |
| Moderate | Deuel County | 1038 | | CLEAR LAKE COLD STORAGE SHED | 510 Highway 22 W, Clear Lake, South Dakota, 57226 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Deuel County | 1036 | | CLEAR LAKE COLD/SALT BRINE STORAGE BLDG | 510 Highway 22 W, Clear Lake, South Dakota, 57226 |
| Moderate | Deuel County | 1098 | | CLEAR LAKE NEW MAINTENANCE SHOP | 510 Highway 22 W, Clear Lake, South Dakota, 57226 |
| Moderate | Deuel County | 1021 | | CLEAR LAKE SALT STORAGE SHED | 510 Highway 22 W, Clear Lake, South Dakota, 57226 |
| Moderate | Deuel County | 1215 | | CLEAR LAKE SHOP SITE | 510 Highway 22 W, Clear Lake, South Dakota, 57226 |
| Moderate | Codington County | 1266 | | CODINGTON SURPLUS LAND | 57263, South Shore, South Dakota |
| Moderate | Pennington County | 8989 | | COMMERCE PARK SUBDIVISION | 1444 Fountain Plaza Dr, Rapid City, South Dakota, 57702 |
| Moderate | Hughes County | 89 | | COMMUNICATION VAN - ATTORNEY GENERAL | 1302 US-14, Pierre, South Dakota, 57501 |
| Moderate | Corson County | 689 | | CORSON COUNTY SRC SITE | 57642, McLaughlin, South Dakota |
| Moderate | Fall River County | 123 | | COURTHOUSE - FALL RIVER CO | 906 N River St, Hot Springs, South Dakota, 57747 |
| Moderate | Hughes County | 132 | | COURTHOUSE - HUGHES CO | 104 E Capitol Ave, Pierre, South Dakota, 57501 |
| Moderate | Kingsbury County | 138 | | COURTHOUSE - KINGSBURY CO | 101 2nd St SE, De Smet, South Dakota, 57231 |
| Moderate | Lawrence County | 140 | | COURTHOUSE - LAWRENCE CO | 78 Sherman St, Deadwood, South Dakota, 57732 |
| Moderate | Pennington County | 151 | | COURTHOUSE - PENNINGTON CO | 315 Saint Joseph St, Rapid City, South Dakota, 57701 |
| Moderate | Ziebach County | 167 | | COURTHOUSE - ZEIBACH CO | 68 S Main St, Dupree, South Dakota, 57623 |
| Moderate | Hughes County | 373 | | CULTURAL HERITAGE CENTER | 900 Governors Dr, Pierre, South Dakota, 57501 |
| Moderate | Pennington County | 4103 | | DAHL FINE ARTS CENTER | 703 Kansas City St, Rapid City, South Dakota, 57701 |
| Moderate | Kingsbury County | 9155 | | DE SMET ARMORY | 403 3rd St SW, De Smet, South Dakota, 57231 |
| Moderate | Kingsbury County | 4451 | | DE SMET HIGH SCHOOL | 405 3rd St SW, De Smet, South Dakota, 57231 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Kingsbury County | 1085 | | DE SMET MAINT ABRASIVE BUILDING | 20455 SD-25, De Smet, South Dakota, 57231 |
| Moderate | Kingsbury County | 1054 | | DE SMET MAINT SHOP | 20455 SD-25, De Smet, South Dakota, 57231 |
| Moderate | Kingsbury County | 1217 | | DE SMET MAINT SHOP SITE | 20455 SD-25, De Smet, South Dakota, 57231 |
| Moderate | Kingsbury County | 1053 | | DE SMET SALT BRINE SHED | 20455 SD-25, De Smet, South Dakota, 57231 |
| Moderate | Kingsbury County | 1065 | | DE SMET SALT STORAGE SHED | 20455 SD-25, De Smet, South Dakota, 57231 |
| Moderate | Lawrence County | 7503 | | DEPT OF LABOR | 1300 North Ave, Spearfish, South Dakota, 57783 |
| Moderate | Pennington County | 7521 | | DEPT OF LABOR | 2330 N Maple Ave, Ste 1, Rapid City, South Dakota, 57701 |
| Moderate | Pennington County | 586 | | DEPT OF REVENUE FIELD OFFICE | 1520 Haines Ave, Ste 3, Rapid City, South Dakota, 57701 |
| Moderate | Lawrence County | 634 | | DEPT OF SOCIAL SERVICES | 20 Cliff St, Deadwood, South Dakota, 57732 |
| Moderate | Todd County | 642 | | DEPT OF SOCIAL SERVICES | Marge Ln, Mission, South Dakota, 57555 |
| Moderate | Deuel County | 4270 | | DEUEL CO PHA / CO. MEMORIAL HOSP. | 701 3rd Ave S, Clear Lake, South Dakota, 57226 |
| Moderate | Deuel County | 840 | | DEUEL COUNTY MEMORIAL HOSPITAL | 701 3rd Ave S, Clear Lake, South Dakota, 57226 |
| Moderate | Hughes County | 99986 | | Division of Banking | 1601 N Harrison Ave, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 99993 | | DMP - Banking Building | 1601 N Harrison Ave, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 99990 | | DMP - CHC Changing Times | 900 Governors Dr, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 99989 | | DMP - CHC Main Panel | 900 Governors Dr, Pierre, South Dakota, 57501 |
| Moderate | Pennington County | 355 | | DRIVER LICENSE EXAM | 1301 E Catron Blvd, Rapid City, South Dakota, 57701 |
| Moderate | Hughes County | 17 | | EAST TRUCK BYPASS SHOP | 1500 N Garfield Ave, Pierre, South Dakota, 57501 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Fall River County | 4409 | | EDGEMONT HIGH SCHOOL | 57735, Edgemont, South Dakota |
| Moderate | Fall River County | 4014 | | EDGEMONT MAINT SHOP | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| Moderate | Fall River County | 4207 | | EDGEMONT MAINT SHOP SITE | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| Moderate | Fall River County | 4044 | | EDGEMONT SALT SAND STORAGE SHED | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| Moderate | Fall River County | 4208 | | EDGEMONT STOCKPILE SITE | 28576 Old Highway 18, Edgemont, South Dakota, 57735 |
| Moderate | Fall River County | 4090 | | EDGEMONT STOCKPILE SITE BUILDING | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| Moderate | Fall River County | 4016 | | EDGEMONT STORAGE SALT SHED | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| Moderate | Fall River County | 4060 | | EDGEMONT STORAGE SHED | 28278 Dewey Rd, Edgemont, South Dakota, 57735 |
| Moderate | Hughes County | 3001 | | EMERGENCY MANAGEMENT STORAGE | 3100 Airport Rd, Pierre, South Dakota, 57501 |
| Moderate | Fall River County | 9724 | | ENCLOSED WALKWAY - BLDG 2/3 | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 4249 | | FALLRIVER CO EXCESS LAND | 57747, Hot Springs, South Dakota |
| Moderate | Fall River County | 4250 | | FALLRIVER CO EXCESS LAND | 57747, Hot Springs, South Dakota |
| Moderate | Fall River County | 4251 | | FALLRIVER CO EXCESS LAND | 57747, Hot Springs, South Dakota |
| Moderate | Pennington County | 699 | | FEDERAL PROPERTY WAREHOUSE | 604 Box Elder Rd W, Box Elder, South Dakota, 57719 |
| Moderate | Meade County | 9032 | | FT MEADE RTI COMPLEX | 54 Sheridan St, Fort Meade, South Dakota, 57741 |
| Moderate | Marshall County | 2205 | | FT SISSETON STATE PARK CMD OFCR RESIDENC | 11907 434th Ave, Lake City, South Dakota, 57247 |
| Moderate | Lawrence County | 464 | | GAMING COMMISSION | 87 Sherman St, Deadwood, South Dakota, 57732 |
| Moderate | Hughes County | 1029 | | GEORGE S MICKELSON CRIMINAL JUSTICE CENT | 1302 US-14, Pierre, South Dakota, 57501 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Pennington County | 4535 | | GFP CO | 15555 Lonesome Dove St, Box Elder, South Dakota, 57719 |
| Moderate | Butte County | 4505 | | GFP CO | 19127 US Highway 85, Belle Fourche, South Dakota, 57717 |
| Moderate | Gregory County | 4533 | | GFP CO & TRAPPE | 122 E 5th St, Burke, South Dakota, 57523 |
| Moderate | Meade County | 4512 | | GFP CO PILOT TR | 20680 132nd Ave, Sturgis, South Dakota, 57785 |
| Moderate | Lawrence County | 4588 | | GFP HARDY CAMP | 22107 US-85, Lead, South Dakota, 57754 |
| Moderate | Pennington County | 5011 | | GFP OUTDOOR CAMPUS WEST | 4130 Adventure Trl, Rapid City, South Dakota, 57702 |
| Moderate | Meade County | 4593 | | GFP PARK DISTRICT | 20680 132nd Ave, Sturgis, South Dakota, 57785 |
| Moderate | Fall River County | 4590 | | GFP PARK DISTRICT - FALL RIVER CONS OFFI | 646 Jennings Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9714 | | GUEST HOUSE | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Custer County | 4107 | | HERMOSA 60X85 HEATED TRK STRG | 14311 Broken Spoke Pl, Hermosa, South Dakota, 57744 |
| Moderate | Custer County | 4096 | | HERMOSA ABRASIVE SHED | 14311 Broken Spoke Pl, Hermosa, South Dakota, 57744 |
| Moderate | Custer County | 4062 | | HERMOSA STORAGE SHED | 14311 Broken Spoke Pl, Hermosa, South Dakota, 57744 |
| Moderate | Pennington County | 4066 | | HIGHWAY PATROL | 2220 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Hughes County | 369 | | HILLSVIEW PLAZA | 3800 SD Highway 34, Pierre, South Dakota, 57501 |
| Moderate | Fall River County | 4236 | | HOT SPRINGS MAINT SHED SITE | 27660 US-385, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 4074 | | HOT SPRINGS MAINT SHOP | 27660 US-385, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 4043 | | HOT SPRINGS SALT SAND STORAGE SHED | 27660 US-385, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 4027 | | HOT SPRINGS SALT STORAGE SHED | 27660 US-385, Hot Springs, South Dakota, 57747 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Fall River County | 4021 | | HOT SPRINGS STORAGE COLD SHED | 27660 US-385, Hot Springs, South Dakota, 57747 |
| Moderate | Turner County | 2116 | | HURLEY LOADER SHED 448 SQ FT | 28306 SD Highway 19, Hurley, South Dakota, 57036 |
| Moderate | Turner County | 2114 | | HURLEY WOODFRAME SALT SHED | 28306 SD Highway 19, Hurley, South Dakota, 57036 |
| Moderate | Lyman County | 3004 | | I90 WBL LYMAN CO REST AREA STORAGE | Vivian, South Dakota |
| Moderate | Walworth County | 6106 | | INDIAN CREEK RECREATION AREA | 12905 288th Ave, Mobridge, South Dakota, 57601 |
| Moderate | Dewey County | 3085 | | ISABEL COLD STORAGE BUILDING 50X90 | Hillsview Rd, Isabel, South Dakota, 57633 |
| Moderate | Dewey County | 3104 | | ISABEL NEW ABRASIVE DOME | Hillsview Rd, Isabel, South Dakota, 57633 |
| Moderate | Dewey County | 3030 | | ISABEL NEW SHOP | Hillsview Rd, Isabel, South Dakota, 57633 |
| Moderate | Dewey County | 3250 | | ISABEL NEW SHOP SITE | Hillsview Rd, Isabel, South Dakota, 57633 |
| Moderate | Hughes County | 5117 | | KEBACH BUILDING | 3442 E SD Highway 34, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 6 | | KEBACH BUILDING/SDWP MINIMUM UNIT H | 3442 E SD Highway 34, Pierre, South Dakota, 57501 |
| Moderate | Kingsbury County | 1287 | | KINGSBURY EXCESS LAND | 57231, De Smet, South Dakota |
| Moderate | Hughes County | 91 | | KLEIN BUILDING | 221 S Central Ave, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 12 | | KNEIP BUILDING | 700 Governors Dr, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 99988 | | Kneip Building 3rd Floor | 700 Governors Dr, Pierre, South Dakota, 57501 |
| Moderate | Jackson County | 4403 | | KZSD PUBLIC BROADCAST & SRC | 22760 Buzzard Butte Rd, Long Valley, South Dakota, 57547 |
| Moderate | Fall River County | 9715 | | LAUNDRY/COMMISSARY | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Lawrence County | 493 | | LAWRENCE CO DEPT OF HEALTH | 930 N 10th St, Spearfish, South Dakota, 57783 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Lawrence County | 4274 | | LAWRENCE CO DOH | 930 N 10th St, Spearfish, South Dakota, 57783 |
| Moderate | Lawrence County | 4204 | | LAWRENCE CO EXCESS LAND | 57783, Spearfish, South Dakota |
| Moderate | Hughes County | 39 | | MACKAY BUILDING - STATE LIBRARY | 800 Governors Dr, Pierre, South Dakota, 57501 |
| Moderate | Fall River County | 9711 | | MAINTENANCE GARAGE | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9712 | | MAINTENANCE SHOP | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9701 | | MEN'S BUILDING | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Todd County | 3081 | | MISSION ABRASIVE SHED 3600 SQ | 756 W 2nd St, Mission, South Dakota, 57555 |
| Moderate | Todd County | 3038 | | MISSION COLD STORAGE BUILDING | 756 W 2nd St, Mission, South Dakota, 57555 |
| Moderate | Todd County | 3070 | | MISSION MAINT SHOP | 756 W 2nd St, Mission, South Dakota, 57555 |
| Moderate | Todd County | 3234 | | MISSION MAINT SHOP SITE | 756 W 2nd St, Mission, South Dakota, 57555 |
| Moderate | Todd County | 3236 | | MISSION PORT OF ENTRY SITE | US-83 & US-18, Mission, South Dakota, 57555 |
| Moderate | Hughes County | 450 | | NEW HEALTH LAB | 615 E 4th St, Pierre, South Dakota, 57501 |
| Moderate | Charles Mix County | 5188 | | NORTH POINT RECREATION AREA | 38180 297th St, Lake Andes, South Dakota, 57356 |
| Moderate | Butte County | 4010 | | NORTHERN PLAINS SQUAD OFFICE | 10921 SD-34, Belle Fourche, South Dakota, 57717 |
| Moderate | Fall River County | 4003 | | OELRICHS MAINT SHOP | 29201 Highway 385, Oelrichs, South Dakota, 57763 |
| Moderate | Fall River County | 4229 | | OELRICHS MAINT SHOP SITE | 29201 Highway 385, Oelrichs, South Dakota, 57763 |
| Moderate | Fall River County | 4045 | | OELRICHS SALT SAND STORAGE SHED | 29201 Highway 385, Oelrichs, South Dakota, 57763 |
| Moderate | Fall River County | 4070 | | OELRICHS SALT STORAGE SHED | 29201 Highway 385, Oelrichs, South Dakota, 57763 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Fall River County | 4068 | | OELRICHS STORAGE SHED | 29201 Highway 385, Oelrichs, South Dakota, 57763 |
| Moderate | Pennington County | 4046 | | PARTS CENTRAL BUILDING | 415 Main St, Rapid City, South Dakota, 57701 |
| Moderate | Jackson County | 4252 | | PENNINGTON CO EXCESS LAND | 57750, Interior, South Dakota |
| Moderate | Day County | 6105 | | PICKEREL LAKE RECREATION AREA | 12980 446th Ave, Grenville, South Dakota, 57239 |
| Moderate | Hughes County | 3000 | | PIERRE AIRPORT HANGER | 4300 Airport Rd, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 58 | | PIERRE EXAM STATION (RENTED) | 314 S Central Ave, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 59 | | PROSPECT BUILDING - BUSINESS SERVICES | 215 E Prospect Ave, Pierre, South Dakota, 57501 |
| Moderate | Fall River County | 4408 | | PUBLIC BROADCASTING | 57735, Edgemont, South Dakota |
| Moderate | Pennington County | 4469 | | PUBLIC BROADCASTING MICROWAVE SITE | 57761, New Underwood, South Dakota |
| Moderate | Fall River County | 9717 | | PUMP HOUSE #1 | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9710 | | PUMP HOUSE #2 | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Hughes County | 7517 | | R CENTER BUILDING | 3415 Airport Rd, Pierre, South Dakota, 57501 |
| Moderate | Pennington County | 9167 | | RANGE ROAD READINESS CENTER | 3740 Range Rd, Rapid City, South Dakota, 57702 |
| Moderate | Pennington County | 4102 | | RAPID CITY 2ND ABRASIVE SHED | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 4082 | | RAPID CITY ABRASIVE BUILDING | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 4035 | | RAPID CITY COLD STORAGE SHED | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 4037 | | RAPID CITY MAINT SHOP BLDG A | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 4040 | | RAPID CITY MTRLS LAB SHED | 2300 Eglin St, Rapid City, South Dakota, 57703 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Pennington County | 4036 | | RAPID CITY REG OFFICE | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 4244 | | RAPID CITY REGION OFFICE SITE | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 4038 | | RAPID CITY REPAIR SHOP BLDG B | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 4104 | | RAPID CITY SALT BRINE SHED | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 5186 | | RAPID CITY SCHOOL WAREHOUSE | 3801 S Highway 79, Rapid City, South Dakota, 57701 |
| Moderate | Pennington County | 4039 | | RAPID CITY SLT STORAGE SHED?BLDG D | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 7406 | | RAPID CITY UNIVERSITY CENTER | 4300 Cheyenne Blvd, Box Elder, South Dakota, 57719 |
| Moderate | Pennington County | 4048 | | RC AREA SPECIALTY CREW BLDG F | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 4105 | | RC REG COMPLEX-NEW STRG BLDG | 2300 Eglin St, Rapid City, South Dakota, 57703 |
| Moderate | Hughes County | 45 | | REAL ESTATE COMMISSION | 221 W Capitol Ave, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 300 | | S D FEDERAL SURPLUS AGENCY | 118 W Capitol Ave, Pierre, South Dakota, 57501 |
| Moderate | Hughes County | 198 | | SAINT CHARLES | E Capitol Ave & S Euclid Ave, Pierre, South Dakota, 57501 |
| Moderate | Pennington County | 4503 | | SDDA REGIONAL OFFICE | 3305 W South St, Rapid City, South Dakota, 57702 |
| Moderate | Walworth County | 3009 | | SELBY 50X95 TRUCK MAINT SHOP | US-83, Selby, South Dakota, 57472 |
| Moderate | Walworth County | 3021 | | SELBY ABRASIVE SHED | US-83, Selby, South Dakota, 57472 |
| Moderate | Walworth County | 3002 | | SELBY MAINT SHOP | US-83, Selby, South Dakota, 57472 |
| Moderate | Walworth County | 3210 | | SELBY MAINT SHOP SITE | US-83, Selby, South Dakota, 57472 |
| Moderate | Walworth County | 3055 | | SELBY POLE BUILDING | US-83, Selby, South Dakota, 57472 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Walworth County | 3089 | | SELBY SALT STORAGE SHED | US-83, Selby, South Dakota, 57472 |
| Moderate | Walworth County | 3203 | | SELBY SCALE SITE JCT OF US 12 | US-83, Selby, South Dakota, 57472 |
| Moderate | Fall River County | 9728 | | SEWER VAULT HOUSE | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Meade County | 494 | | SLY HILL STATE RADIO SITE | 1114 Foothills Rd, Sturgis, South Dakota, 57785 |
| Moderate | Pennington County | 631 | | SOCIAL SERVICE CHILD SUPPORT | 510 N Campbell St, Rapid City, South Dakota, 57701 |
| Moderate | Lawrence County | 9144 | | SPEARFISH ARMORY | University St, Spearfish, South Dakota, 57799 |
| Moderate | Fall River County | 9721 | | STAFF GARAGE - ARMBRUSTER | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9706 | | STAFF GARAGE - RICHARDSON | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9726 | | STAFF GARAGE - WALKER | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9719 | | STAFF HOUSE - ARMBRUSTER | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9722 | | STAFF HOUSE - PAYTON | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9705 | | STAFF HOUSE - RICHARDSON | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9720 | | STAFF HOUSE - WALKER | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Pennington County | 604 | | STATE RADIO - BMD BUILDING | 2635 Dyess Ave, Unit A, Rapid City, South Dakota, 57701 |
| Moderate | Lawrence County | 74 | | STATE RADIO & PUBLIC BROADCAST | Terry Peak Lodge |
| Moderate | Campbell County | 692 | | STATE RADIO TOWER SITE | 57632, Herreid, South Dakota |
| Moderate | Pennington County | 417 | | STOCKGROWERS BUILDING | 426 St Joseph St, Rapid City, South Dakota, 57701 |
| Moderate | Meade County | 4028 | | STURGIS COLD STORAGE BUILDING | 1100 Otter Rd, Sturgis, South Dakota, 57785 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Meade County | 9122 | | STURGIS FMS (METAL STORAGE BUILDING) | 701 14th St, Sturgis, South Dakota, 57785 |
| Moderate | Meade County | 4234 | | STURGIS MAINT SHOP SITE | 1100 Otter Rd, Sturgis, South Dakota, 57785 |
| Moderate | Meade County | 4095 | | STURGIS MAINTENANCE SHOP | 1100 Otter Rd, Sturgis, South Dakota, 57785 |
| Moderate | Meade County | 4106 | | STURGIS NEW 40X60 ABRASIVE SHED | 1100 Otter Rd, Sturgis, South Dakota, 57785 |
| Moderate | Meade County | 4083 | | STURGIS SALT SAND STORAGE | 1100 Otter Rd, Sturgis, South Dakota, 57785 |
| Moderate | Meade County | 4047 | | STURGIS STORAGE SHED | 1100 Otter Rd, Sturgis, South Dakota, 57785 |
| Moderate | Meade County | 4065 | | STURGIS STORAGE SHED | 1100 Otter Rd, Sturgis, South Dakota, 57785 |
| Moderate | Meade County | 4000 | | STURGIS STORAGE SHED | 1100 Otter Rd, Sturgis, South Dakota, 57785 |
| Moderate | Hughes County | 15 | | SUTHERLAND BUILDING - PUBLIC SAFETY | 118 W Capitol Ave, Pierre, South Dakota, 57501 |
| Moderate | Fall River County | 9723 | | TUNNEL - BOILER PLANT/BLDG 1 | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Fall River County | 9725 | | TUNNEL - BOILER PLANT/BLDG 3 | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Pennington County | 4089 | | WALL ABRASIVE STORAGE BUILDING | 212 2nd Ave, Wall, South Dakota, 57790 |
| Moderate | Pennington County | 4059 | | WALL COLD STORAGE SHED | 212 2nd Ave, Wall, South Dakota, 57790 |
| Moderate | Pennington County | 4025 | | WALL HIGH SCHOOL | 401 South Blvd W, Wall, South Dakota, 57790 |
| Moderate | Pennington County | 4013 | | WALL MAINT SHOP | 212 2nd Ave, Wall, South Dakota, 57790 |
| Moderate | Pennington County | 4216 | | WALL MAINT SHOP SITE | 212 2nd Ave, Wall, South Dakota, 57790 |
| Moderate | Pennington County | 4012 | | WALL SALT STORAGE SHED | 212 2nd Ave, Wall, South Dakota, 57790 |
| Moderate | Pennington County | 4041 | | WALL SALT/EQUIP STORAGE SHED | 212 2nd Ave, Wall, South Dakota, 57790 |

| Wildfire Hazard | Subregion | Building | State Agency | Building Name | Address |
|---|---|---|---|---|---|
| Moderate | Pennington County | 4049 | | WASTA ABRASIVE SHED | 30 Highway 1416, Wasta, South Dakota, 57791 |
| Moderate | Pennington County | 4224 | | WASTA MAINT SHOP SITE | US-14 E, Wasta, South Dakota, 57791 |
| Moderate | Fall River County | 9707 | | WATER TOWER | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| Moderate | Pennington County | 5163 | | WDT BADLANDS BUILDING | Mickelson Dr, Rapid City, South Dakota, 57703 |
| Moderate | Pennington County | 9173 | | WEST CAMP RAPID RUSSELL CABIN | 1001 S 44th St, Rapid City, South Dakota, 57702 |
| Moderate | Pennington County | 9172 | | WEST CAMP RAPID RUSSELL HOUSE | 1001 S 44th St, Rapid City, South Dakota, 57702 |
| Moderate | Fall River County | 9703 | | WOMEN/COUPLES/NCU/SCU/DIETARY BUILDING | 2500 Minnekahta Ave, Hot Springs, South Dakota, 57747 |
| | | | | **Total** | **211** |

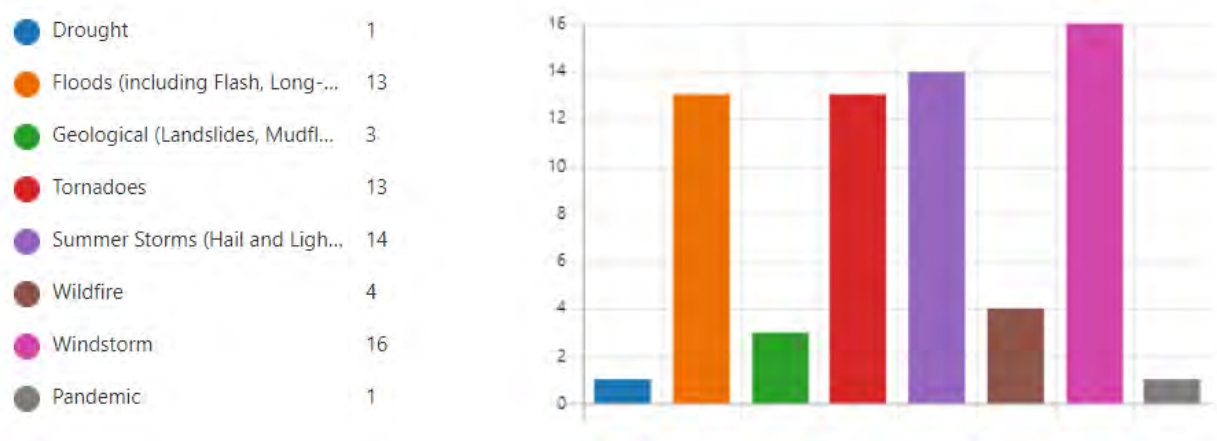
Source: USDA Wildfire Risk to Communities, South Dakota OEM, Wood GIS Analysis

# Appendix 3D

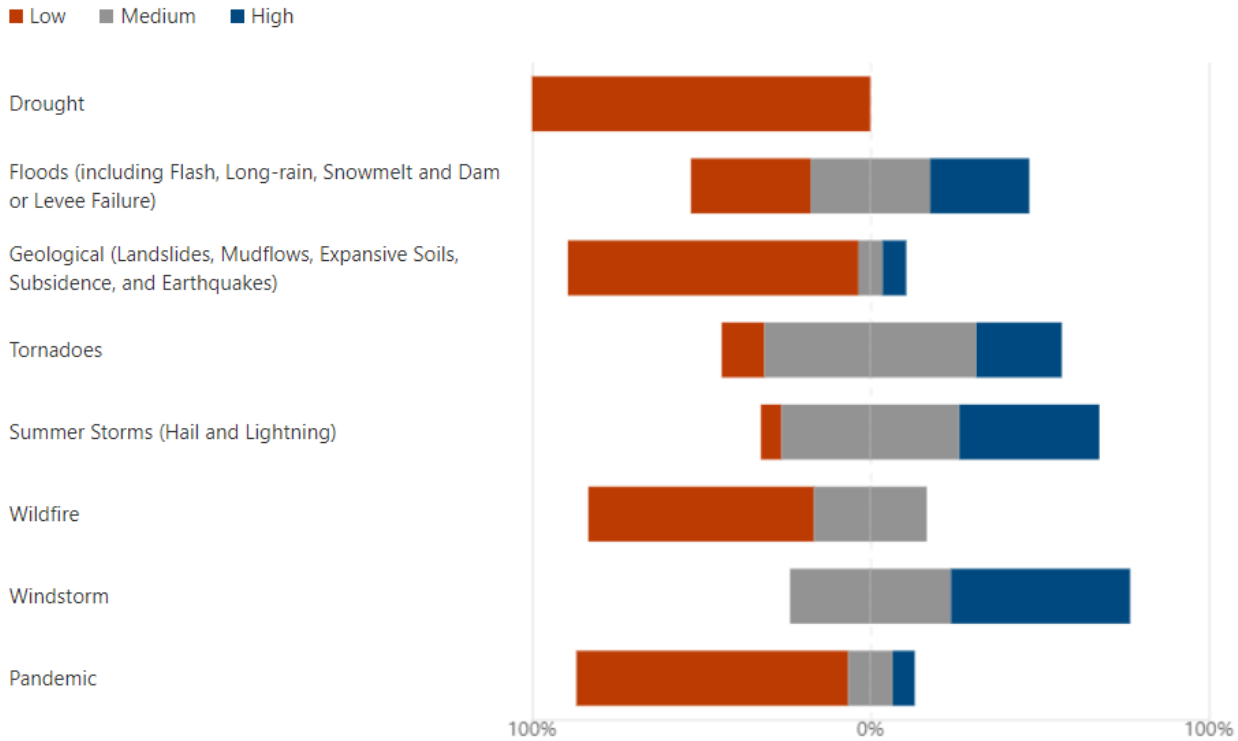
# South Dakota Rural Electric Cooperatives Survey Results

The State of South Dakota is in the process of updating the Hazard Identification and Risk Assessment (HIRA) section of the South Dakota Hazard Mitigation Plan. The State HMP allows Rural Electric Cooperatives to be eligible for certain FEMA hazard mitigation funds that can be used to increase resiliency of critical infrastructure and lifelines. Please complete a 12 question survey regarding natural hazard risk and vulnerability; the summary level information will be used to inform the HIRA update as it relates to Rural Electric Cooperatives. Please complete this survey by November 12, 2021.

1. Which of the following natural hazards have adversely affected/damaged critical electric infrastructure in the cooperative service territory in the past? (Choose all that apply)

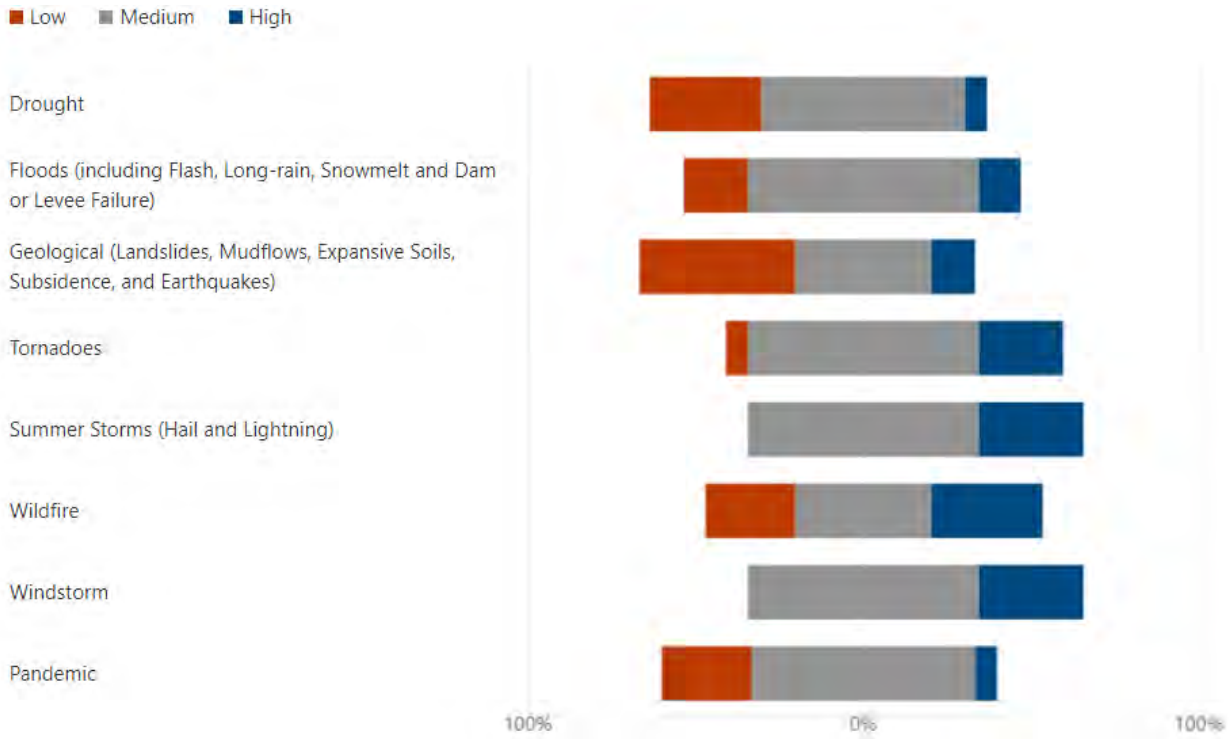



2. What natural hazards have the potential to impact critical electric infrastructure in the cooperative service territory in the future? (Low, Medium or High)



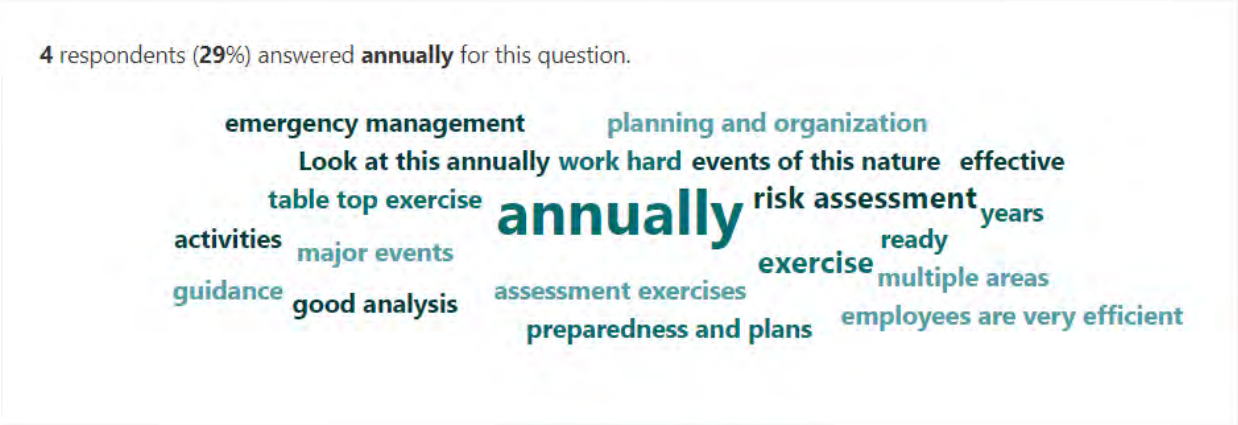
3. How concerned are you about the possibility of the rural electric cooperative critical electric infrastructure being impacted by a natural hazard?

4. What level of local capability exists to contend with the hazard in your cooperative service territory? (Low, Medium or High)

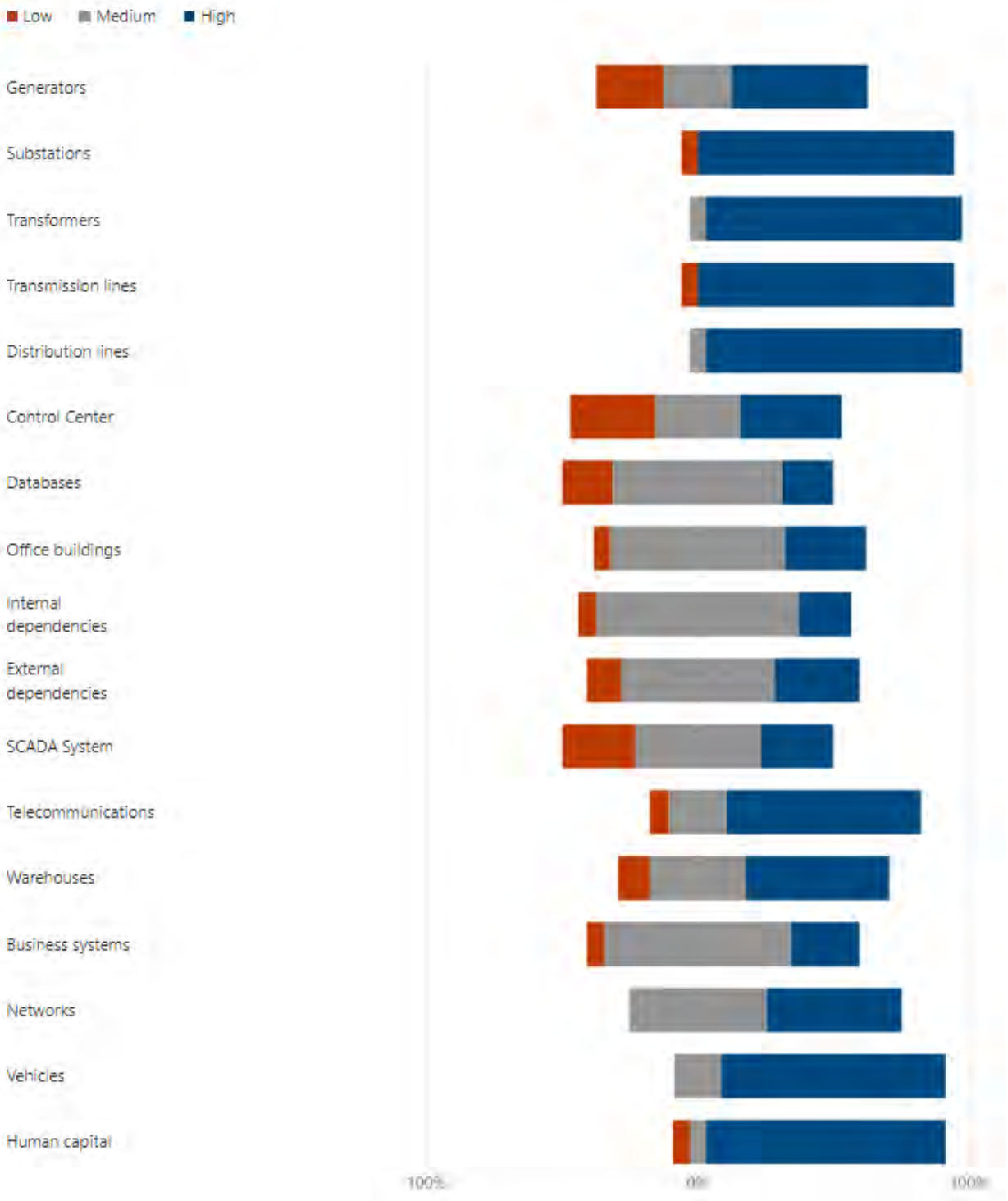


5. Has the rural electric cooperative conducted a hazard analysis and risk assessment? (If yes, please indicate how recently?)

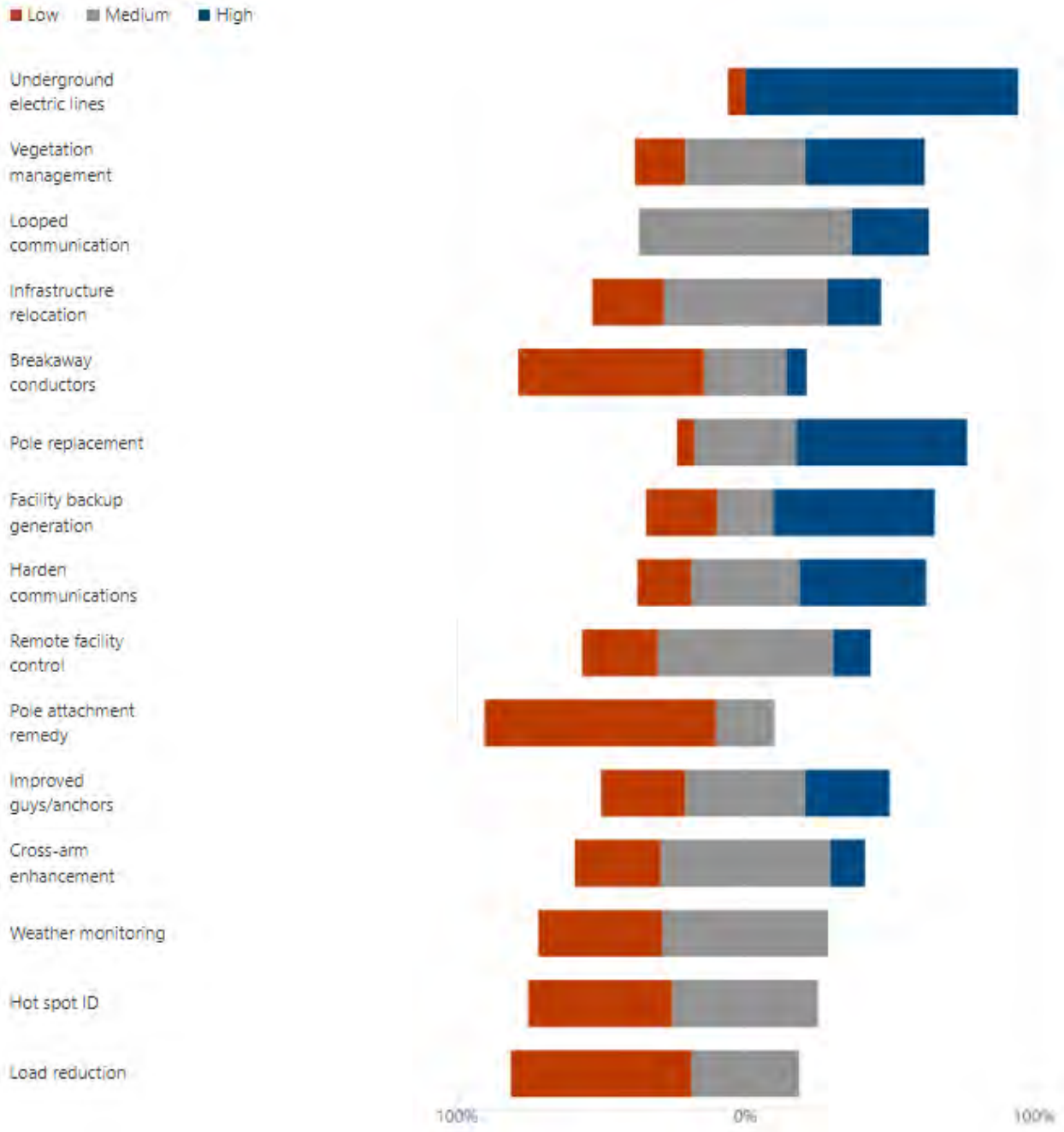
- 14 responses Total to this question
  - No
  - NA
  - Not Sure
  - We update our bi-annually
  - 2010
  - We annually do a table top exercise and a risk assessment to determine our preparedness and plans for events of this nature. With those activities we work hard to be ready for major events and our employees are very efficient and effective in emergency management, planning and organization.
  - No
  - I think in the last 5 years.
  - We have not but might be good. Could use guidance on what a good analysis might look like
  - No
  - No
  - Annually
  - Yes we have had risk assessment exercises is multiple areas. Look at this annually.
  - No



6. Please review the following list of potential critical assets to the electric infrastructure. Please rate (Low, Medium, High) the criticality of each type of infrastructure to the overall system.

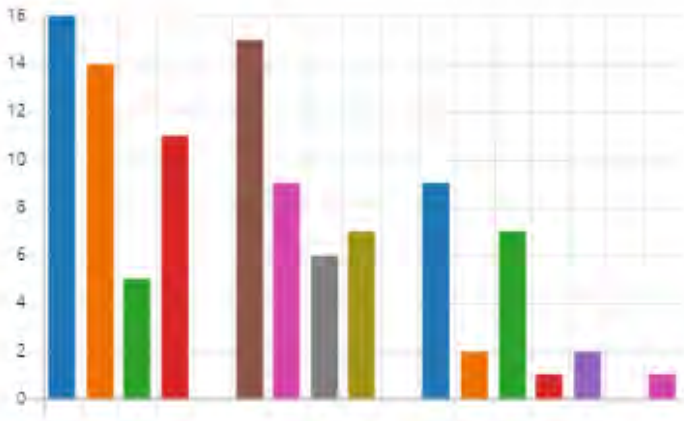


7. Please review the potential mitigation actions for rural electric cooperatives to reduce impacts of natural hazards on service or critical infrastructure. Please prioritize the importance of each (Low, Medium, High)



8. Please indicate mitigation actions your rural electric cooperative has taken to make critical electric infrastructure more resistant to natural hazards. (If "other" please indicate what that is)

| | |
|---|---|
| Underground electric lines | 16 |
| Vegetation management | 14 |
| Looped communication | 5 |
| Infrastructure relocation | 11 |
| Breakaway conductors | 0 |
| Pole replacement | 15 |
| Facility backup generation | 9 |
| Harden communications | 6 |
| Remote facility control | 7 |
| Pole attachment remedy | 0 |
| Improved guys/anchors | 9 |
| Cross-arm enhancement | 2 |
| Weather monitoring | 7 |
| Hot spot ID | 1 |
| Load reduction | 2 |
| None | 0 |
| Other | 1 |




9. Has your organization received FEMA grant funding to strengthen infrastructure?

| | |
|---|---|
| Yes | 13 |
| No | 4 |

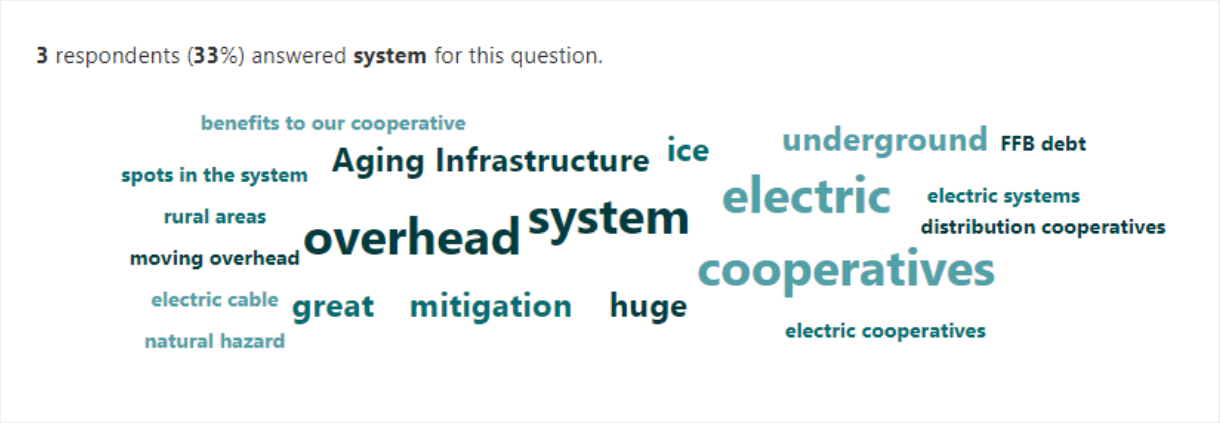
77% of people answered **Yes** for this question, and the majority answered "**Moderately concerned** " for Question 3.

77% of people answered **Yes** for this question, and the majority answered "**Yes**" for Question 10.

10. Would your organization be interested in leveraging FEMA grant funding for strengthening infrastructure?

| | |
|---|---|
| Yes | 16 |
| No | 0 |

11. Has your organization conducted any loss avoidance studies to quantify or demonstrate the value of infrastructure mitigation efforts?

12. Are there any other issues regarding the reduction of risk and loss associated with natural hazards and rural electric cooperatives that you think are important, such as aging infrastructure or climate trends?

- 9 total responses
  - No
  - Aging Infrastructure
  - One of the main hazards that you did not mention is ice/winter storms which are a major natural hazard that hits rural electric systems very hard due to the huge amount of overhead line exposure we have as a result of serving the vast sparsely populated rural areas.
  - No, encourage co-op's to bury electric cable if feasible.
  - Would be great to have a way to expand the program to include more moving overhead to underground
  - Most SD distribution cooperatives face the same challenge to replace an aging system. Climate in the Dakotas remains unchanged as weather cycles have been consistently horrible out on the Great Plains. However, it's never so bad that it cannot get worse.
  - Aging infrastructure and utilities failure to utilize mitigation money to improve system and avoid continuous weak spots in the system.
  - We are in a area with high icing tendencies. Overhead to underground conversion has had huge benefits to our cooperative.
  - Federal legislation to allow electric cooperatives to refinance FFB debt at today's lower interest rates would free up capital so more mitigation work could be completed.