Extent, as applied to *North Dakota Specific* Natural Hazards - Updated 4 February 2026

Purpose: This guidance is for use in developing ND Local and Tribal Multi-Hazard Mitigation Plans and for fulfilling the requirements of a Risk Assessment which addresses each hazard by their *a) type, b) location, c) extent, d) history, and e) future probability*, as described in FEMA's Local Mitigation Planning Policy Guide, and Local Mitigation Planning Handbook.

- Within FEMA's Local Mitigation Policy Guide, **Extent** is defined as the range of anticipated intensities of the identified hazards. The information must relate to each of the plan participants or the planning area, depending on the hazard. Extent is most commonly expressed using various scientific scales." – FEMA Local Mitigation Planning Policy Guide (pg. 19, effective April 11, 2025)

- Within the *Plan Review Tool*, located in Appendix A of the Local Mitigation Policy Guide, Element B addresses Risk Assessment requirements. And for review element **B1-c asks**, "Does the plan describe the extent for each identified hazard?".

- This requirement is further explained in Section 4.2, p. 19, where element **B1-c states**, "The plan must provide the extent of the hazards that can affect the planning area. When describing extent using charts or scales (e.g., Saffir-Simpson scale for hurricane wind speed; Enhanced Fujita scale for tornado), the plan must document how the scale applies to each jurisdiction.

Be sure to address how the selected scale applies to the planning area. Remember that ***extent*** *defines the characteristics of the hazard regardless of the people, property, and other assets it affects. While* ***impact*** *means the consequence of the hazard on governments and assets (IS-350).*

Main ND Natural Hazard Types and Sub-Types to consider:

The following discussion of hazard types and of hazard specific Extent/Intensity sources or scales refers primarily to inland hazards and those most common to the Northern Great Plains states, excluding Coastal Marine or Hurricane hazards. Hazard definitions are based on official FEMA (National Risk Index: NRI), NOAA (National Centers for Environmental Information: NCEI, and National Weather Service: NWS), USGS, USDA (Natural Resources Conservation Service:NRCS), and/or other sources as appropriate.

Detailed examples of most ND specific hazard types and sub-types can be found in the 2024-2029 ND Enhanced Mitigation MAOP. Please review those hazard types pertinent to your Local or Tribal Risk assessment.

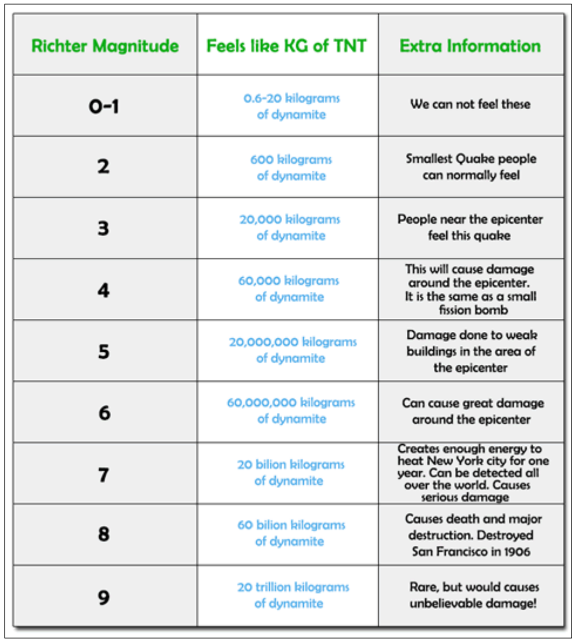
1. Geologic Hazards

ND has wide variety of geologic hazards with exposure to any one hazard sub-type usually varying greatly across the state.

- **Avalanche:** This hazard is usually not applicable to North Dakota, due to the generally low to mid-relief nature of the terrain, low to moderate levels of wintertime snow accumulations, and a low incidence and/or perceived risk of a damaging collapse of accumulated snow down a mountainside.

- **Earthquake:** Historically rare in ND. ***Extent:*** Can be referenced in terms of either Magnitude or Intensity, USGS Podcast. ND Quake Map at: https://www.dmr.nd.gov/ndgs/documents/Publication_List/pdf/geoinv/GI_94_2012.pdf
    - **Magnitude**: based on Intensity measured at the source. Richter Scale. See figure at the right.
    - **Intensity**: based on the disturbance felt at locations. Modified Mercalli Intensity Scale. See figure below.

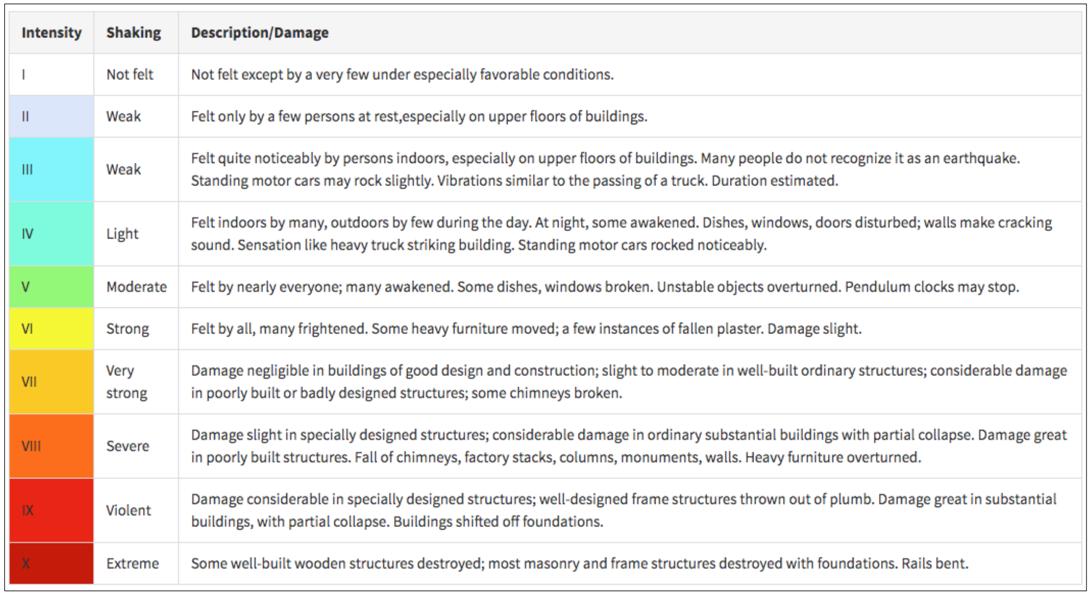
Figure 1.1, Understanding the Richter Scale



Richter Magnitude	Feels like KG of TNT	Extra Information
0-1	0.6-20 kilograms of dynamite	We can not feel these
2	600 kilograms of dynamite	Smallest Quake people can normally feel
3	20,000 kilograms of dynamite	People near the epicenter feel this quake
4	60,000 kilograms of dynamite	This will cause damage around the epicenter. It is the same as a small fission bomb
5	20,000,000 kilograms of dynamite	Damage done to weak buildings in the area of the epicenter
6	60,000,000 kilograms of dynamite	Can cause great damage around the epicenter
7	20 bilion kilograms of dynamite	Creates enough energy to heat New York city for one year. Can be detected all over the world. Causes serious damage
8	60 bilion kilograms of dynamite	Causes death and major destruction. Destroyed San Francisco in 1906
9	20 trillion kilograms of dynamite	Rare, but would causes unbelievable damage!

Source: Richter Scale (SMS-Tsunami Warning.com, 2024).

Figure 1.2, Modified Mercalli Intensity Scale



Intensity	Shaking	Description/Damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest,especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Source: Modified Mercalli Intensity Scale (USGS, n.d.)

- **Radon:** Radon is likely the most common geologic hazard sub-type in soils across ND, though exposure at any one location and soil depth can vary from location to location.
  Extent Scale: check **local test results**, measured in picocuries per liter, though there is no known safe level (EPA Radon, EPA: ND Radon Zone MAP). (ref. NDGS: measured by prevalence through short or long- term testing. Currently, there is no higher resolution ND GIS database and/or map available.)

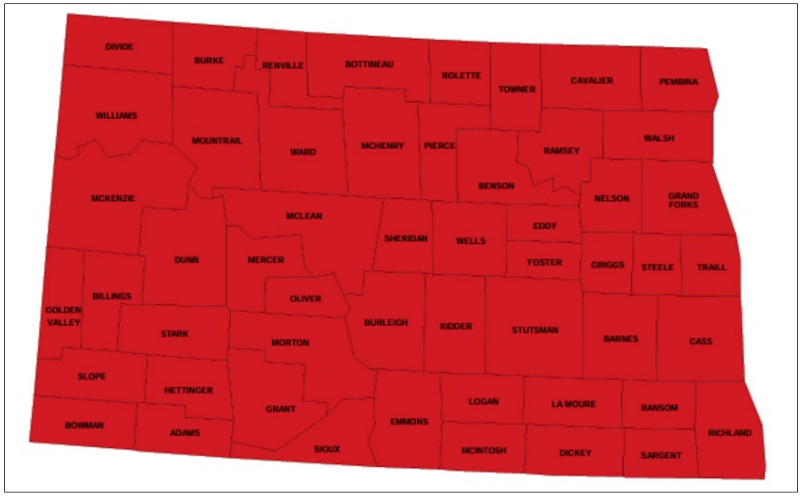
- **Expansive Soils:** A very common hazard across all of North Dakota, this is especially prevalent in the eastern third of the state.
  ***Extent Scale**:* Expressed as a characteristic of the *relative clay-mineral content* in the soil. In engineering and agriculture applications this may be the Shrink-Swell Class, a Linear Extensibility Percent (LE/LEP), or a Coefficient of Linear Extensibility (CL/COLE).

Figure 1.5, Shrink-Swell Class

Shrink-Swell Class	LEP	COLE
Low	<3	<0.03
Moderate	3 - 6	0.03 - 0.06
High	6 - 9	0.06 - 0.09
Very High	≥9	≥0.09

Source: National Soil Survey Handbook (USDA/NRCS, 2024, p. 388 of 1250)

Figure 1.3, EPA Map of Radon Zones in North Dakota



Source: https://www.epa.gov/sites/default/files/2014-08/documents/north_dakota.pdf

Figure 1.4, EPA Radon Zone Colors

Zone	Zone 1 (red)	Zone 2 (orange)	Zone 3 (yellow)
Color	🟥	🟧	🟨
Description	**Highest Potential** Predicted average screening level > 4 pCi/L (picocuries per liter)	**Moderate Potential** Predicted average screening level between 4 and 2 pCi/L (picocuries per liter)	**Low Potential** Predicted average screening level < 2 pCi/L (picocuries per liter)

Source: EPA Map of Radon Zones - North Dakota (EPA, 2026)

Expansive/contractive soils can produce soil heaving/cracking during protracted wet/dry conditions. According to Wikipedia (Shrink-swell capacity, 2025), cracking soils can break critical plant root structure leading to crop failures. Bridges, roadbeds, building foundations, and pipelines can fail due to the heaving, settling, or cracking of soils.

Detailed soil data for each county is available at Web Soil Survey - Home (usda.gov). Most of these county scaled documents have a one or two paragraph summary of general soil types across that county, suitable for a MHMP. **Contact your local NRCS-USDA** soils people for guidance on this or other soil-related hazard measures used in your area. The **Brenna Formation** in very soft glacial lake clay in the shallow subsurface of the Red River Valley that can be expansive with low load-bearing capacity (Anderson, 2024). So far, the NDGS has mapped the Brenna Formation in all of the counties in the Red River Valley, which include Pembina, Walsh, Grand Forks, Traill, Cass, and Richland Counties.

- **Erosion:** Soil Erosion can be considered as a distinct hazard type, where common, and/or as a consequence of other hazard types. Contact your local USDA-NRCS soils people for guidance on soil-related hazard measures in your Area Of Interest (AOI) and check the USDA Web Soil Survey for your area.

  ***Extent Scale**:* Expressed in terms of mass of soil material removed from a given area over a given time, with typical units expressed as tons/acre/year.

  A Mean-annual Erosion Potential (MEP), a Wind Erodibility Index (WEI), or a Water Erosion Potential (WEP) are examples used by the USDA and can be expressed in a table. **Note:* the table, at the right, is for a hypothetical "average sized" ND county. Make sure and check your exposure to various types of erosion, based on your locale.

  Figure 1.6, Example of *potential* Soil Erosion Rating Categories

Rating Value (annual: MEP, WEI, WEP, etc.)	**Acres Affected**	**Percent**
Low - x tons/acre/year	601,926	70.5%
Moderate - xx tons/acre/year	175,028	20.5%
High - xxx tons/acre/year	71,719	8.4%
Null or Not Rated	5,123	0.6%
Totals for Area of Interest (AOI)	853,796*	100.0%

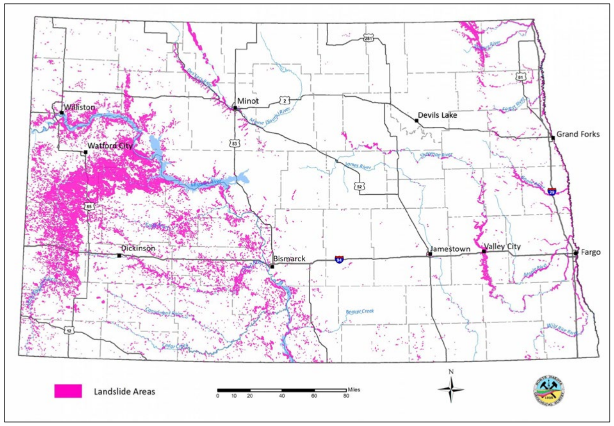
  After: Wind Erodibility and other Soil Erosion Factor Tables (USDA, 2019)

  Water related erosion can be exacerbated by periods of intense rainfall, rapid river rises, or overland flooding. Both wind and water erosion can increase during and after periods of drought or following wildland fire scarring, as natural vegetative cover is removed.

- **Landslide:** Erosion, Landslides, and land subsidence can often go hand in hand. *For example*, where riverbank erosion is common, undercutting of the stream bank can cause landslides along that portion of the river, while subsurface soil evacuation near a river can cause sinkhole formation further in from a riverbank. Landslides can occur in any area of high slope, whether natural such as hillsides or built areas such as roadways.

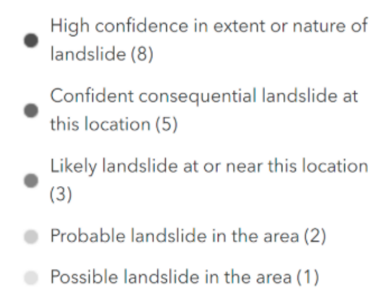
  Extent Scale: see **prevalent areas** https://www.dmr.nd.gov/dmr/ndgs/landslides. These areas are primarily based on geologic factors and steepness of slope (NDGS, 2026), including both active and inactive landslides.

Figure 1.7, Common ND Landslide Areas



Source: ND Landslides (NDGS. 2026)

Figure 1.8, Landslide Confidence



● High confidence in extent or nature of landslide (8)

● Confident consequential landslide at this location (5)

● Likely landslide at or near this location (3)

● Probable landslide in the area (2)

● Possible landslide in the area (1)

Source: USGS, 2026 [USGS arcgis link]

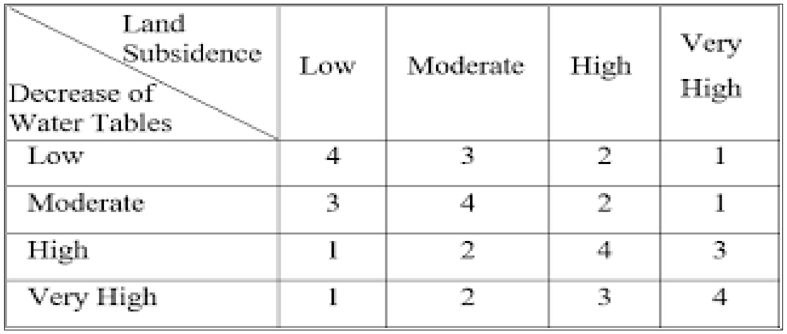
The USGS uses a similar process, nationwide, and has developed an 8-point, 5-category "confidence" scale for Landslide ***susceptibility***, as shown at the left. This scale and related ArcGIS map is available online at: https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=ae120962f459434b8c904b456c82669d

- **Subsidence:** According to the USGS, land subsidence is a gradual settling or sudden sinking of the Earth's surface due to subsurface movement of earth material. In North Dakota, land subsidence caused by abandoned coal mining has formed significant depressions which range in size from a few feet across, to tens and hundreds of feet across. ***Extent Scale:*** May be expressed by 1) a **percent** of land surface subject to subsidence or 2) an area averaged **rate** of subsidence, due to the ongoing removal of subsurface soil, minerals, water, or oil.

  Example of subsidence Percent. For instance, in mainly western ND the prevalence of Abandoned Mine Lands (AML) is most often the result of abandoned underground coal mines.

  The percentage of a land surface affected by or vulnerable to collapse depends on the location of these mines. (ref. ND Public Service Commission/Abandoned Land Mines: https://tinyurl.com/yknzkwb7, or link under image at upper right)

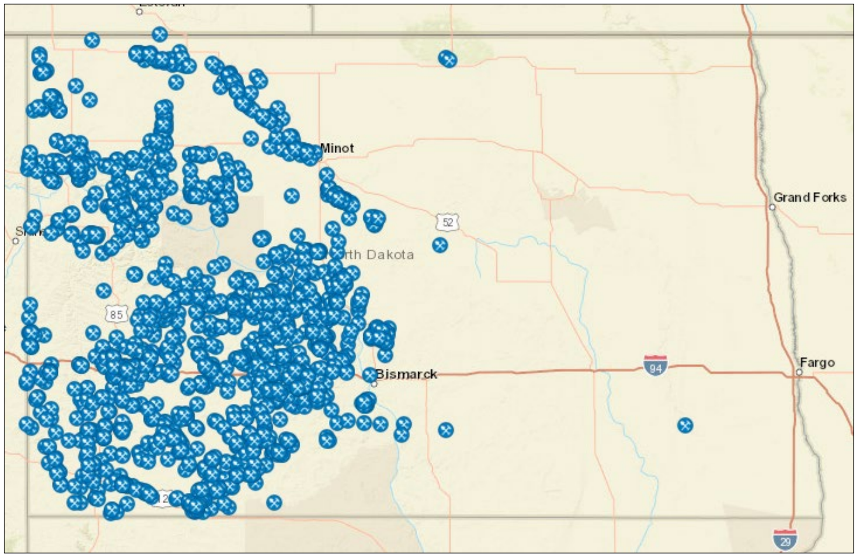
Figure 1.10, Sample Matrix Correlation Matrix of Land Subsidence and the Decrease of Water Table in Indonesia



Land Subsidence Decrease of Water Tables	Low	Moderate	High	Very High
Low	4	3	2	1
Moderate	3	4	2	1
High	1	2	4	3
Very High	1	2	3	4

Source: Land Subsidence and Water Table Changes (Firdaus, 2018)

Figure 1.9, Abandoned Mine Lands in North Dakota



*Source:*https://ndgov.maps.arcgis.com/apps/mapviewer/index.html?webmap=0c4eb5ce19a84a069c1d04b449c39d43

Example of Subsidence Rate: In contrast, the recent or ongoing removal of subsoil material due to subsurface water flows, stream bank erosion, the pumping of ground water for human, industrial, or agricultural use (Ohehen, 2025), or the pumping of shallow gas and oil reserves can result in faster or slower subsidence, based on the rate of material removal.

The table at the right depicts a relative rate of subsidence based on a rate of change in a water table in Indonesia (Firdaus, 2018), though ND site specific rates would depend on local geologic conditions.

2. Dam Failure

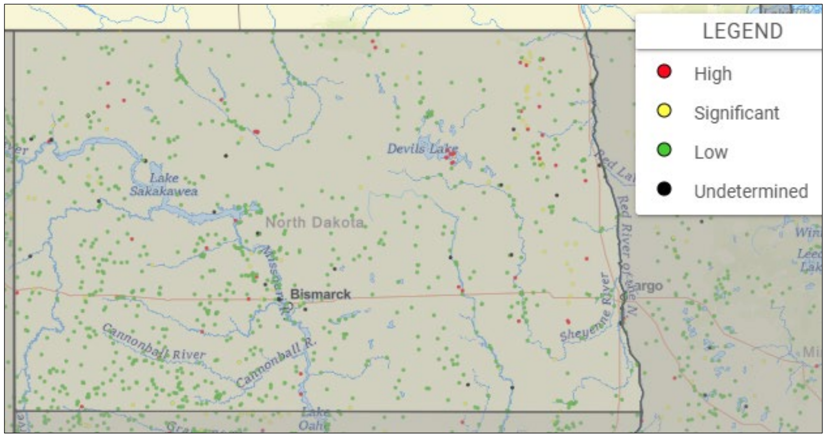
At a minimum, Dam Failure Hazard is assessed for all dams that are rated as having a medium (significant) or high hazard classification and that may affect the jurisdiction. This includes dams upstream of or within the MHMP's coverage area (county or tribal jurisdiction). In addition to hazard classification, one should consider both dam condition and the likelihood of failure when assessing this hazard's overall risk. For instance, a dam with a partially eroded or otherwise damaged spillway under conditions of heavy rainfall and/or snowmelt runoff induced flooding may be at an increased likelihood of failure until that flooding subsides or the dam or spillway is repaired.

Figure 2.1, Dam Failure Hazard Potential Classification

Hazard Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
High	Probable. One or more expected.	Yes (but not necessary for this hazard level).
Medium/ Significant	None expected	Yes
Low	None expected	Low. Generally limited to owner.

Source: Hazard Potential Classification, FEMA P-333 (FEMA, 2004).

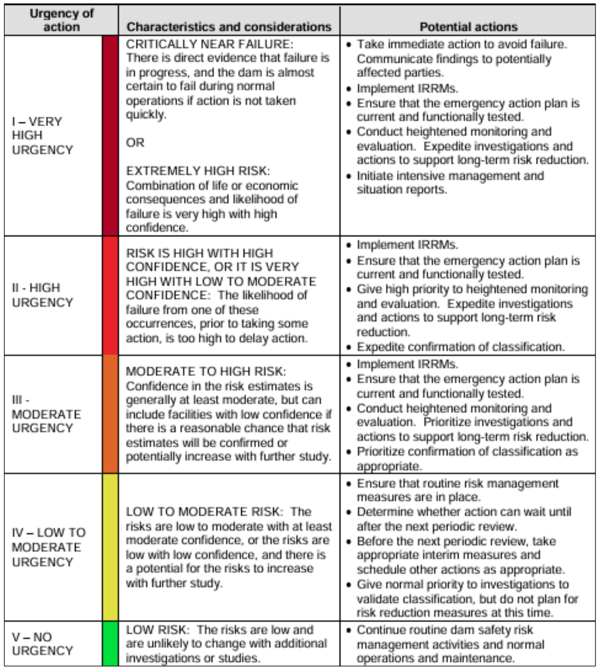
Figure 2.2, Dams of North Dakota



Source: USACE/NID, 2026 [https://nid.sec.usace.army.mil/nid/#/]

Extent: Based on a combination of **Hazard Potential Class**, Dam Condition, and Likelihood. Hazard Class for all federal and state regulated dams is in the **National Inventory of Dams** (NID, 2026).

Figure 2.3, Joint Federal Risk Categories



Urgency of action	Characteristics and considerations	Potential actions
I – VERY HIGH URGENCY 🟥	CRITICALLY NEAR FAILURE: There is direct evidence that failure is in progress, and the dam is almost certain to fail during normal operations if action is not taken quickly. OR EXTREMELY HIGH RISK: Combination of life or economic consequences and likelihood of failure is very high with high confidence.	• Take immediate action to avoid failure. Communicate findings to potentially affected parties. • Implement IRRMs. • Ensure that the emergency action plan is current and functionally tested. • Conduct heightened monitoring and evaluation. Expedite investigations and actions to support long-term risk reduction. • Initiate intensive management and situation reports.
II - HIGH URGENCY 🟥	RISK IS HIGH WITH HIGH CONFIDENCE, OR IT IS VERY HIGH WITH LOW TO MODERATE CONFIDENCE: The likelihood of failure from one of these occurrences, prior to taking some action, is too high to delay action.	• Implement IRRMs. • Ensure that the emergency action plan is current and functionally tested. • Give high priority to heightened monitoring and evaluation. Expedite investigations and actions to support long-term risk reduction. • Expedite confirmation of classification.
III - MODERATE URGENCY 🟧	MODERATE TO HIGH RISK: Confidence in the risk estimates is generally at least moderate, but can include facilities with low confidence if there is a reasonable chance that risk estimates will be confirmed or potentially increase with further study.	• Implement IRRMs. • Ensure that the emergency action plan is current and functionally tested. • Conduct heightened monitoring and evaluation. Prioritize investigations and actions to support long-term risk reduction. • Prioritize confirmation of classification as appropriate.
IV – LOW TO MODERATE URGENCY 🟨	LOW TO MODERATE RISK: The risks are low to moderate with at least moderate confidence, or the risks are low with low confidence, and there is a potential for the risks to increase with further study.	• Ensure that routine risk management measures are in place. • Determine whether action can wait until after the next periodic review. • Before the next periodic review, take appropriate interim measures and schedule other actions as appropriate. • Give normal priority to investigations to validate classification, but do not plan for risk reduction measures at this time.
V – NO URGENCY 🟩	LOW RISK: The risks are low and are unlikely to change with additional investigations or studies.	• Continue routine dam safety risk management activities and normal operations and maintenance.

Source: Federal Guidelines for Dam Risk Management, FEMA P-1025 (FEMA, 2015)

See state map image above.

a) **Hazard Potential Class:** based on downstream impacts Federal Guidelines for Dam Safety: Hazard Potential Classification – FEMA P-333 (at the upper right); See also: ND Dam Safety Standards, Table 6.1, p.26 and Definitions, p.66.

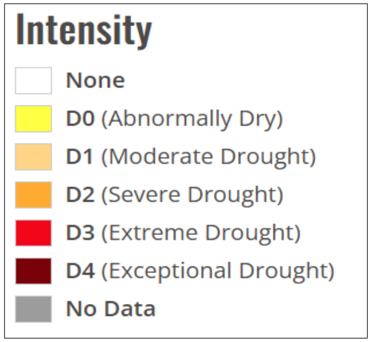
b) **Dam Condition**: based on Inspection Reports (contact NDDWR, Dam Safety).

c) **Failure Likelihood:** primarily weather event driven, based on Joint Federal Risk Categories, Table 1, at the right. (National Dam Safety Program Hazard Classifications (pg. 30), Inundation Mapping, etc.)

3. Drought

There are many types of drought, including meteorological, hydrological, agricultural, ecological, and socioeconomic, among others (NIDIS, 2026). And these can range from shorter term of a few weeks to a longer term of seasons to years. However, the **U.S. Drought Monitor**, which has been in use nationwide since January to 2000, has developed an intensity scale which incorporates local impacts from a broad variety of sectors.

Figure 3.1, Drought Classification



Intensity

⬜ None

🟨 **D0** (Abnormally Dry)

🟧 **D1** (Moderate Drought)

🟧 **D2** (Severe Drought)

🟥 **D3** (Extreme Drought)

🟫 **D4** (Exceptional Drought)

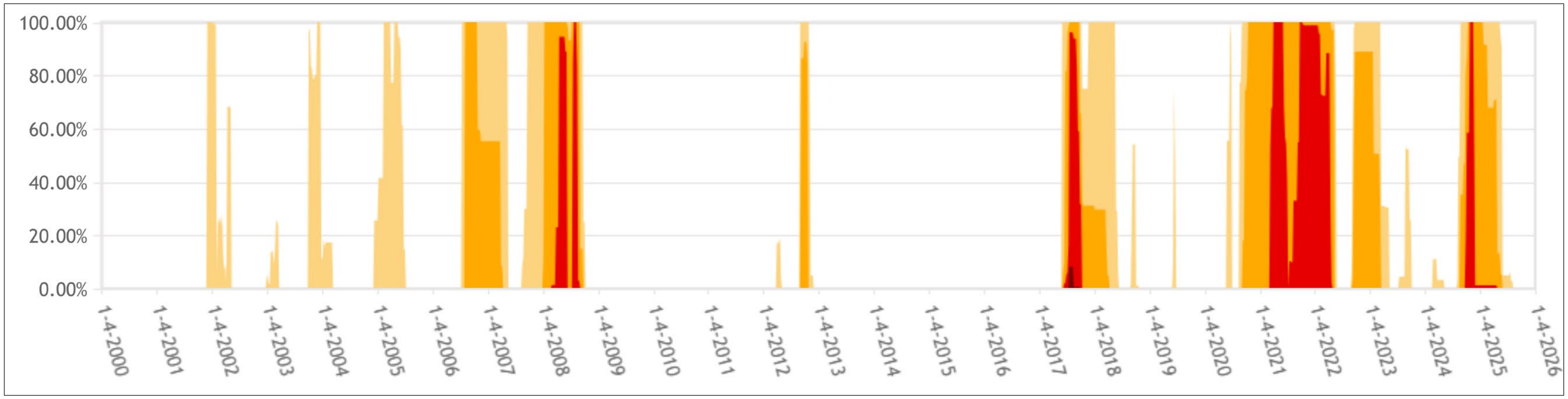
⬛ No Data

Source: U.S. Drought Monitor, Classification (USDM, 2026)

Extent Scale: based on **drought category** as per Weekly U.S. Drought Monitor. see USDM Scale, at the right. Alternate references include the monthly and historical Palmer Drought Severity Index, or the daily Standard Precipitation Index.

Examples of the intensity classification scale is at the right and a timeseries of drought periods, ranging from D1 through D4, is below. The USDA's Secretarial disaster declaration process includes Fast Track Secretarial disaster designations for severe drought. The Fast Track Secretarial disaster designations provide for a nearly automatic designation when, during the growing season, any portion of a county meets the D2 (Severe Drought) drought intensity value for 8 consecutive weeks – or a higher drought intensity value for any length of time as reported in the U.S. Drought Monitor.

Figure 3.2, Williams County (ND) Percent Area in U.S. Drought Monitor Categories, D1 through D4



Source: U.S. Drought Monitor, Timeseries (USDM, 2026)

4. Flood Hazards

Within North Dakota, most flooding occurs either along stream and river channels as a result of large scale-snowmelt or excessive rainfall, or it occurs across the landscape as a result of localized excessively heavy rainfall or heavy rainfall over snowmelt runoff.

Riverine Floods are floods that occur within or along regular river or stream channels. These can be the result of excessive rainfall and/or snowmelt over the jurisdiction in which the flooding is occurring, or precipitation which has occurred days earlier and far upstream of the jurisdiction. Rivers may have dams and reservoirs located along their main channels or their tributaries which are designed to store and control excess runoff for short periods of time. These may become overwhelmed or damaged by excessive runoff and related hazards. See Dam Failure Hazard (above) for more details.

- **River Flood *Extent Scale:* River Flood Stages -** for locations with an official NWS river/lake forecast point, this is expressed as Minor, Moderate, or Major flood stage. Extent may also be based on probability of occurrence, forecast flood level, and/or inundation.
    1. Do you have a river or a body of water with an official river (or lake) forecast point? If so,
        a. Use to reference any historic and/or recently observed flood levels.
        b. Check for associated flood impacts up to and including these levels.
    2. **Probability of Occurrence is also given as the Recurrence Interval.** FEMA Flood Maps typically depict a 100 year (recurrence interval) floodplain, which equates to a 1% probability (1/100) in any given year.
    3. On occasion, an emergency Forecast Flood Level may be determined for locations which have a river gage, but aren't official forecast points, with forecasts largely based on other recent floods.
    4. Flood Inundation can also be expressed as a depth of water over a given area or length or road.

Figure 3.1, Extent for Riverine Flooding (example, near Bismarck ND)

Stage	Water Level*	Description
Action	12.5 Feet	**Use Caution!** High water is possible. Expect minor impacts and a nuisance to those near rivers. Some actions may be needed to protect property.
Minor	14.5 Feet	**Take Action!** Some property flooding and threat to public. Roads, trails, parks, and private property near a river may become flooded.
Moderate	16 Feet	**Take Action!** Flooding of structures and main roadways. Residences and roads near streams may become flooded. Evacuations may be necessary. Disruptions to daily life.
Major	18 Feet	**Take Action!** Extensive flooding of structures and main roads. Critical Infrastructure may become flooded. Evacuations may be necessary. Significant disruptions are likely.

Water Level example for the Missouri River at Bismarck

Source: NWS Glossary: Flood Categories (NWS, 2026)

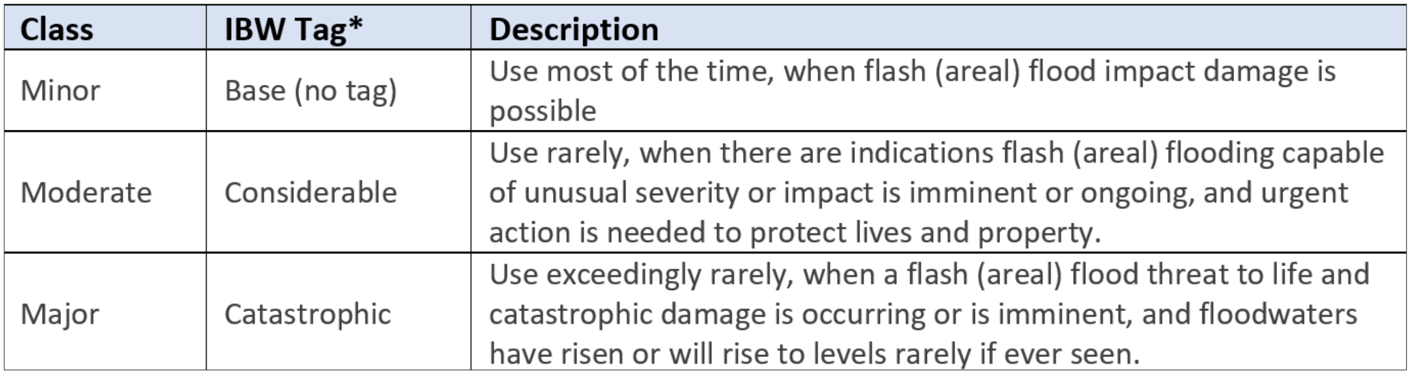
Flash Floods and Areal Floods are two types of overland flood hazard that can occur just about anywhere that excessively heavy rain or heavy rain on spring snowmelt runoff occurs. According to the National Weather Service (2021b), their primary difference is in the speed of flood onset. Excessively heavy rain is rainfall and/or water runoff that exceeds the capacity for local soil infiltration and the normal storm water runoff capacity of an area. This can be the result of either an excessively high rainfall rate or total rainfall quantity. A Flash Flood is a specific kind of overland flooding that occurs within 6 hours of the causative event (heavy rainfall, levee breach, dam failure, etc.) and with primary impacts expected to occur within the next 0-12 hours (up to a day). An Areal Flood is a more general category with a longer onset and/or offset period. It may continue from an initial Flash Flood episode, where water is slow to subside, or it may encompass the whole flood episode where either excessive rainfall, snowmelt, or riverine breakout flow more slowly inundates an area.

- **Flash Flood *Extent Scale:* Inundation or depth** based on soil saturation and rainfall rate using Flash Flood Guidance.
    - *How much rainfall needs to occur in one hour, three hours, and six hours to produce a flash flood event?*

- **Areal Flood *Extent Scale:* Inundation or depth** based on saturation, rainfall, and inundation using Flash Flood Guidance.

  For additional references check the NWS Bismarck and NWS Grand Forks flood event websites, or contact your local NWS Service Hydrologists.
    - *This occurs at rainfall or excessive snowmelt above flash flood levels.*
    - *Overland (Areal) Flooding will occur if rainfall or snowmelt exceeds the levels identified in Flash Flooding.*

Figure 3.2, Extent for Flash or Areal/Overland Flooding



Class	IBW Tag*	Description
Minor	Base (no tag)	Use most of the time, when flash (areal) flood impact damage is possible
Moderate	Considerable	Use rarely, when there are indications flash (areal) flooding capable of unusual severity or impact is imminent or ongoing, and urgent action is needed to protect lives and property.
Major	Catastrophic	Use exceedingly rarely, when a flash (areal) flood threat to life and catastrophic damage is occurring or is imminent, and floodwaters have risen or will rise to levels rarely if ever seen.

*Note: IBW: Impact-Based Warning Tags apply for Flash Flooding

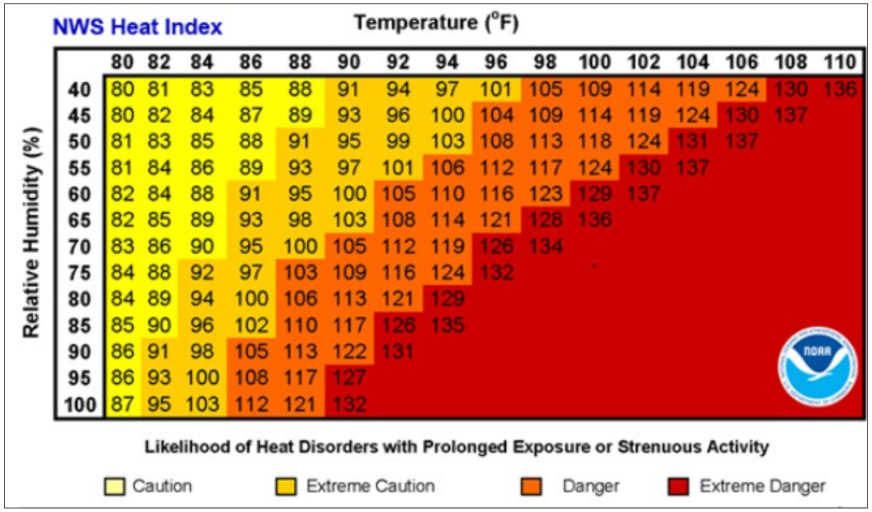
Source: NWS Flash Flood Warning IBW Factsheet (NWS, 2019)

5. Severe Summer Weather Hazards

Across North Dakota, most Severe Summer Weather Hazard events have a highly variable areal coverage which may encompass parts of a township, a county, a group of counties, and at times large portions of the state. Such storms are rarely, if ever, influenced by surface features such as river or lakes, hills or valleys, or forests or cities. Instead, they are largely driven by low-level moist air in-flow, which can increase airmass buoyancy; low to mid-level shear, which can produce cyclonic (counterclockwise spin) in the air and lead to strong storm helicity; and strong jet stream winds, which can help build stringer and longer lasting storms. Thus, summer storms can range from a singular thunderstorm, a supercell thunderstorm with tornadic potential, an organized cluster or line of storms, and Squall lines with embedded tornadic supercells. And in most cases, these storm system will evolve from one type of storm early in the day, to other types of damaging storms through the remainder of the evening or overnight period.

- **Excessive Heat *Extent Scales:*** currently based on temperature and humidity **Heat Index**, for general use, see table at right.

Figure 5.1, NWS Heat Index



NWS Heat Index

Temperature (°F)

Relative Humidity (%)

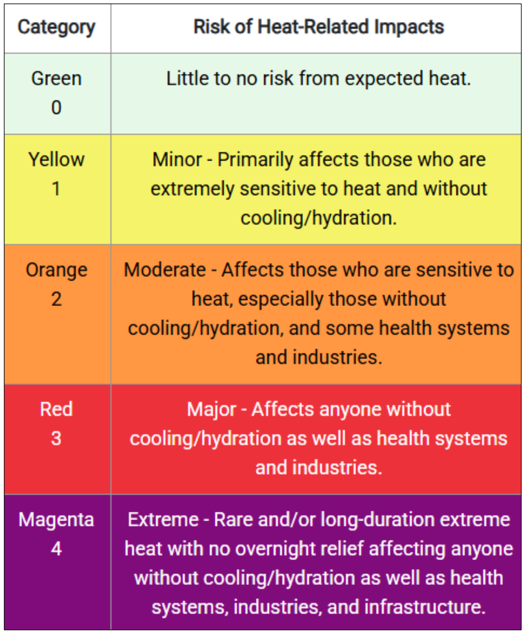
	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
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 Strenuous Activity

☐ Caution ☐ Extreme Caution ☐ Danger ☐ Extreme Danger

Source: https://www.weather.gov/safety/heat-tools

Figure 5.2, Heat Risk Index



Category	Risk of Heat-Related Impacts
Green 0	Little to no risk from expected heat.
Yellow 1	Minor - Primarily affects those who are extremely sensitive to heat and without cooling/hydration.
Orange 2	Moderate - Affects those who are sensitive to heat, especially those without cooling/hydration, and some health systems and industries.
Red 3	Major - Affects anyone without cooling/hydration as well as health systems and industries.
Magenta 4	Extreme - Rare and/or long-duration extreme heat with no overnight relief affecting anyone without cooling/hydration as well as health systems, industries, and infrastructure.

Source: https://www.wpc.ncep.noaa.gov/heatrisk/

Other references may include Wet-Bulb Globe Temperature (WBGT), for outdoor sports, workers, and First Responders.

Heat Risk is a test approach (scroll on map to ND location of choice). This uses a risk which is better scaled to each portion of the country, and the time of the year. See chart at the left.

Contact the local forecast office to identify locally measured highest and lowest recorded temperatures.

- **Lightning:** Lightning is present with all thunderstorms, and it’s presence is the reason for the sound we hear as thunder – the sound of thunder being caused by the rapid expansion of the air column around a lightning bolt. As such, lightning is also the most common of the Severe Summer Weather Hazards for each region of the state. When *Thunder Roars Go Indoors!*

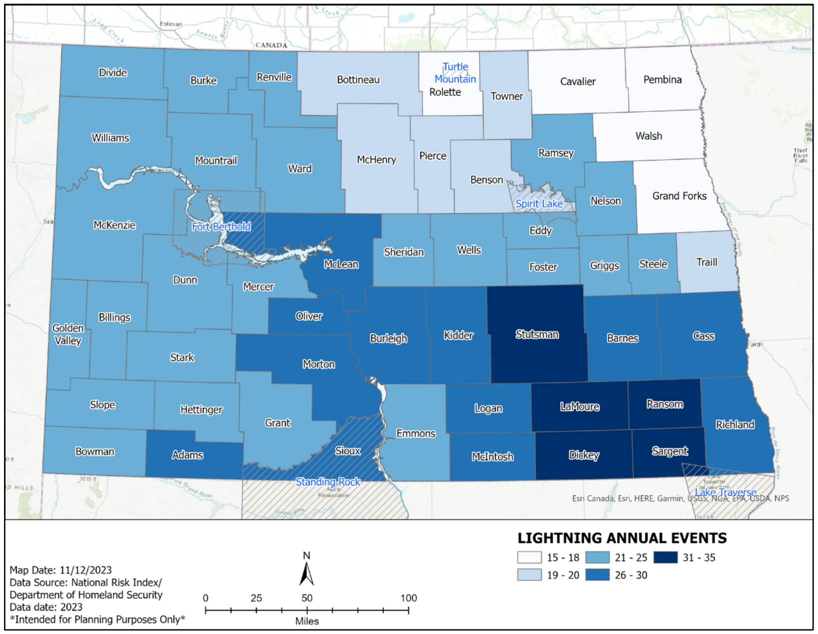
  Extent Scale: Based on CG: Cloud-to-Ground Lightning forecast (*potential* **LAL**): Lightning Activity Level, table at the right.
  - Daily LAL Forecast: Daily Fire Weather Forecast and/or online Point-and-Click (BIS example).
  - Past Week’s actual CG Lightning Occurrence: Daily Record Maps (BIS example)
  - Historic Strike Frequency: NOAA-NCEI CG Lightning Strikes, 1/1/1991 to 12/31/2012 (ltd access), see below.

Figure 5.3, Thunderstorm Probability and Related Lightning Activity Level (LAL)

Thunderstorm Probability	Thunderstorm Category	Rain Intensity	LAL	Lightning Characteristics (CG: Cloud-to-Ground)
None	None	Variable	**1**	None
10%	Isolated	Light Rain occasionally reaching the ground	**2**	1 to 5 CG lightning strikes in 5-minute period
20%	Widely Scattered	Light to moderate rain reaching the ground	**3**	6 to 10 CG lightning strikes in a 5-minute period
30-50%	Scattered	Moderate rain is common	**4**	Frequent, 11 to 15 CG strikes in 5-minute period
60-70%	Numerous	Moderate to heavy rainfall	**5**	Frequent and intense, 15+ CG strikes in 5-minute period
20% (Dry)	Dry Lightning	Little to no rain	**6**	Like LAL 3 but without rain, w/higher wildland fire threat

Source: Compiled from NWS Glossary, 2023

Figure 5.4a, Annual Cloud-to-Ground Lightning Events in ND, 1991-2012



Source: FEMA NRI/NOAA-NCEI Lightning Database, 2023

The NCEI Lightning Events database forms the basis for the annual frequency map shown at the far left. Numbers in the legend are for an average 4x4 km square area within each county, which is about 6.2 square miles. The conversion to number of strikes per square mile is in the table near left. This shows a range from about 2.5 to 5.7 CG strikes per square mile, per year, across the state. With the average lightning strike carrying 30,000 amps of current.

Figure 5.4b, CG Strikes [convert sq km to sq mi]

4x4 sq km	*1 sq mi*
12-18	*2.5 - 3.0*
19-20	*3.1 - 3.3*
21-25	*3.4 - 4.0*
26-30	*4.1 - 4.9*
31-35	*5.0 - 5.7*

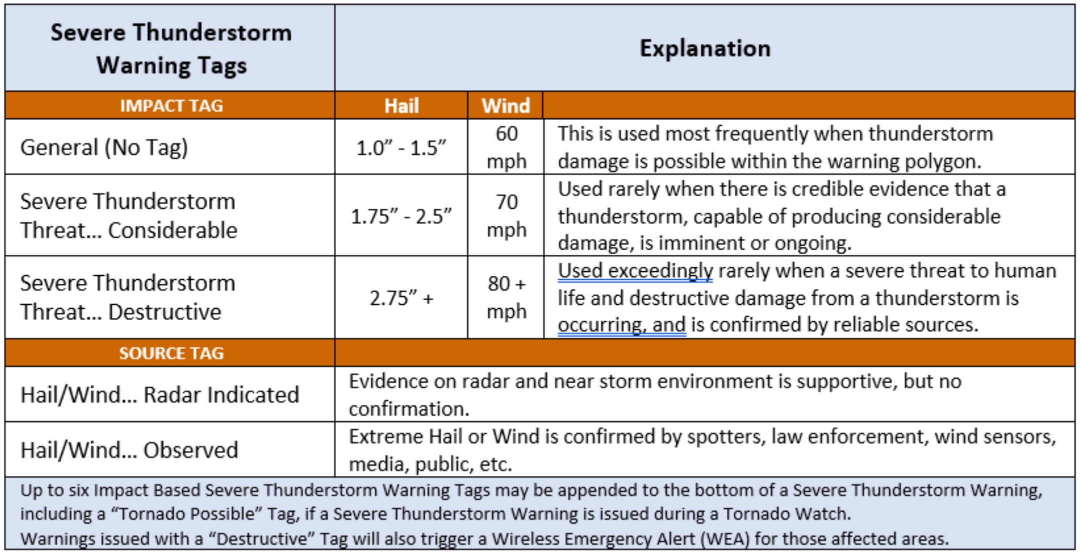
For Damage and Casualty Reports: the NCEI Storm Events Database, 1996 thru present does have some reports of reported damage, injuries, or fatalities. But these are scarce, as most lightning strikes go unreported. So, *not a very good resource for total lightning events.*

For Wildfires: Positive lightning strikes tend to occur outside the heavy rain and therefore are more prone to fire-starts in dry conditions.

- **Hail *Extent Scale:*** based on **Hail Size** (national SPC Outlook, local GHWO). See chart at the right.
    - *Cross compare with NCEI data pulled for each specific jurisdiction.*
    - *Also analyze impacts to crops or structures, as the intensity of impact is highly influenced by hail size.*
    - *Larger hail will do more damage, but smaller-sized hail that is wind driven may be more impactful to crops and structures.*

- **Thunderstorm Wind *Extent Scale:* Wind gusts** GTE 50 kts/58 mph (Events as recorded in StormData). Forecasts sources: national SPC Outlook, local GHWO. Wind speed can be measured, estimated, and/or based on damage (weather.gov) due to gusts GTE 50 kts.
    - *Wind gusts of 58 mph (50 kts) or greater.*

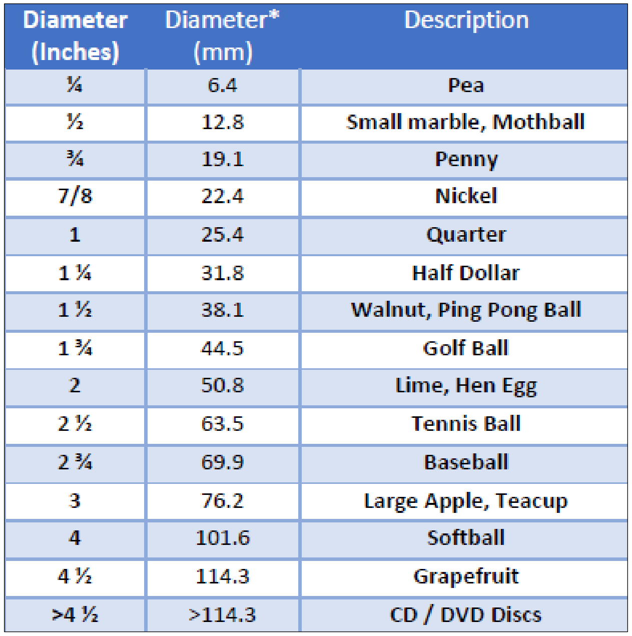
Figure 5.6, Severe Thunderstorm Warning Tags



Severe Thunderstorm Warning Tags	Explanation		
IMPACT TAG	Hail	Wind	
General (No Tag)	1.0" - 1.5"	60 mph	This is used most frequently when thunderstorm damage is possible within the warning polygon.
Severe Thunderstorm Threat… Considerable	1.75" - 2.5"	70 mph	Used rarely when there is credible evidence that a thunderstorm, capable of producing considerable damage, is imminent or ongoing.
Severe Thunderstorm Threat… Destructive	2.75" +	80 + mph	Used exceedingly rarely when a severe threat to human life and destructive damage from a thunderstorm is occurring, and is confirmed by reliable sources.
SOURCE TAG			
Hail/Wind… Radar Indicated	Evidence on radar and near storm environment is supportive, but no confirmation.		
Hail/Wind… Observed	Extreme Hail or Wind is confirmed by spotters, law enforcement, wind sensors, media, public, etc.		
Up to six Impact Based Severe Thunderstorm Warning Tags may be appended to the bottom of a Severe Thunderstorm Warning, including a "Tornado Possible" Tag, if a Severe Thunderstorm Warning is issued during a Tornado Watch. Warnings issued with a "Destructive" Tag will also trigger a Wireless Emergency Alert (WEA) for those affected areas.			

Source: Impact Based Warning Examples, n.d., https://www.weather.gov/impacts/examples

Figure 5.5, NWS Hail Size References



Diameter (Inches)	Diameter* (mm)	Description
¼	6.4	Pea
½	12.8	Small marble, Mothball
¾	19.1	Penny
7/8	22.4	Nickel
1	25.4	Quarter
1 ¼	31.8	Half Dollar
1 ½	38.1	Walnut, Ping Pong Ball
1 ¾	44.5	Golf Ball
2	50.8	Lime, Hen Egg
2 ½	63.5	Tennis Ball
2 ¾	69.9	Baseball
3	76.2	Large Apple, Teacup
4	101.6	Softball
4 ½	114.3	Grapefruit
>4 ½	>114.3	CD / DVD Discs

*Source: NWS, 2021a. *metric conversion of table added.*

Impact-Based Warnings. Impact-Based Warning (IBW) have been introduced for several categories of Severe Summer Weather, including Hail, Damaging Wind, and Tornadoes. These tags are used as part of the forecast and warning process to alert Emergency Managers, Public Safety Officials, Media, and the Public to the potential for increased impacts with more intensely severe storms. Though not directly tied to an extent scale, they do reflect the possibility for more intense storms with commensurably greater impacts, during the warning process.

- **Tornado:** The intensity/magnitude of a tornado can be difficult to ascertain by observations of its apparent size, shape, or color shading. Even its radar signature can be variable, as this is highly dependent on the tornadoes proximity to the radar. Instead, a tornadoes intensity is determined after the fact, by the damage it produced, or in rare instances, when it actually passes near a wind sensor and that wind sensor survives. The impact. Dr. Ted Fujita is credited with having developed the first operational tornado rating system, called the F-scale. The first tornado damage survey conducted by Dr. Fujita was the Historic 20 June 1957 Fargo Tornado - a serious ND connection!

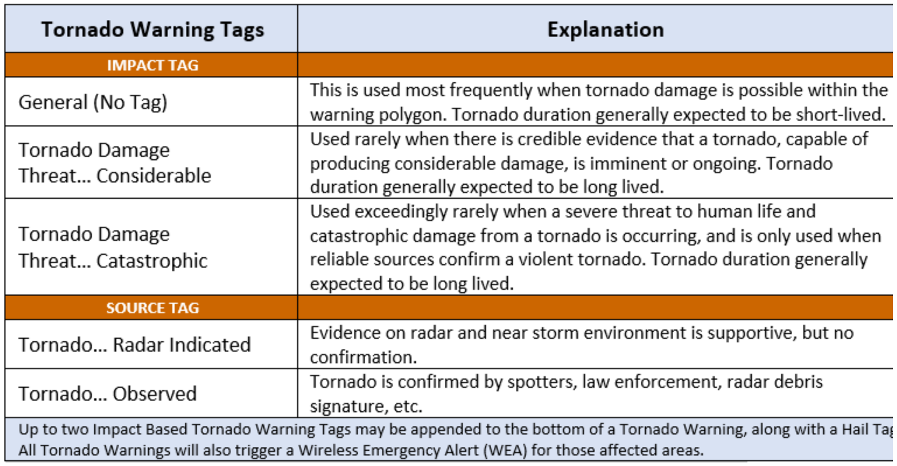
  Dr. Fujita later developed his damage scale, which was used to rate historic tornadoes worldwide, dating back to 1950, and forward through 2006. An expanded and Enhanced Fujita Scale, the EF-scale, was developed in the early 2000s, and has been in use across the U.S. since 2007.

Figure 5.7, Tornado Intensity Rating Scales

Original Fujita Scale (F-Scale) **Used 1950-2006**			Enhanced Fujita Scale (EF-Scale) **Used Since 2007**	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	**EF Number**	3 Second Gust (mph)
0	40-72	45-78	**0**	65-85
1	73-112	79-117	**1**	86-110
2	113-157	118-161	**2**	111-135
3	158-207	162-209	**3**	136-165
4	208-260	210-261	**4**	166-200
5	261-318	262-317	**5**	Over 200

Source: https://www.spc.noaa.gov/faq/tornado/ef-scale.html

Figure 5.8, Tornado Warning Tags



Tornado Warning Tags	**Explanation**
IMPACT TAG	
General (No Tag)	This is used most frequently when tornado damage is possible within the warning polygon. Tornado duration generally expected to be short-lived.
Tornado Damage Threat... Considerable	Used rarely when there is credible evidence that a tornado, capable of producing considerable damage, is imminent or ongoing. Tornado duration generally expected to be long lived.
Tornado Damage Threat... Catastrophic	Used exceedingly rarely when a severe threat to human life and catastrophic damage from a tornado is occurring, and is only used when reliable sources confirm a violent tornado. Tornado duration generally expected to be long lived.
SOURCE TAG	
Tornado... Radar Indicated	Evidence on radar and near storm environment is supportive, but no confirmation.
Tornado... Observed	Tornado is confirmed by spotters, law enforcement, radar debris signature, etc.
Up to two Impact Based Tornado Warning Tags may be appended to the bottom of a Tornado Warning, along with a Hail Ta All Tornado Warnings will also trigger a Wireless Emergency Alert (WEA) for those affected areas.	

Source: Impact Based Warning Examples, n.d., https://www.weather.gov/impacts/examples

Extent Scale: This is based on **damage**, using the Fujita Scale, 1950-2006, and the Enhanced Fujita Scale since 2007.

Known/Reported Tornado Events are recorded in StormData. Historic information is available on the ND Severe Weather History webpage at https://www.weather.gov/bis/ndtorhistory. This includes maps of the state showing the highest wind gust, hail size, tornado, and number of tornadoes for each county. There is also a link to a pdf file of county scaled statistics located therein.

High Wind (summer): These are non-convective winds that can occur any time of the year. ***Extent:*** Based on ***Sustained Winds*** *Greater-Than-or-Equal-to (GTE) 40 mph, or* ***Wind Gusts*** *GTE 58 mph*. Wind speeds can be estimated from impacts using the Beaufort Wind Scale. *A wind scale graphic is included in the Winter Weather Hazard section, below.*

The NWS issues a High Wind Warning when sustained winds of 40 mph or greater are occurring or are expected in the next 12-24 hours. The NWS produces a 7-day Graphical Hazardous Weather Outlook (GHWO) for High Winds across ND, with a national outlook out to 3 days (WSSI).

6. Severe Winter Weather Hazards

Across North Dakota, most Severe Winter Weather Hazard events have a large areal coverage which may encompass most of a county, a group of counties, and at times the entire state. Because of differences in terrain, preexisting snow cover, and differential ground or near-surface air temperatures, the same large-scale weather system may produce blizzard conditions in one part of the state or a county, heavy snow or an ice storm in other portions, or areas of high winds with no appreciable precipitation in still others - often as part of the same Winter Weather storm system.

- **Blizzard:** A blizzard is like the tornado of the winter season, with its potential for a rapid onset, extreme wind conditions, and visibilities driven to zero. ***Extent Scale:*** The hazard condition is based on **wind speed, low visibility, and duration.** Blizzard conditions are ***when wind speed GTE to 35 mph produce reduced visibility that is frequently less than a quarter mile in falling and/or blowing snow, for a duration of three hours or greater***. While the quantity of snowfall is not a requirement for this hazard there needs to be some fresh falling snow and/or an appreciable amount of fresh snowpack to generate the prolonged low visibilities in falling and/or blowing snow.
    - A **Ground Bizzard** is still a Blizzard, but with low visibilities based primarily on an existing blowable snowpack.
    - Most historic occurrences are recorded as Blizzards in StormData, some *may* be listed as part of a more generic Winter Storm.
    - Forecasts and warnings come through local NWS offices, and through graphical outlook sources: national WSSI, local GHWO).
    - *Similar blizzard-like conditions within a much shorter term convective snow event is now called a* ***snow squall*** *- see below.*

- **Heavy Snow:** Heavy snow is considered hazardous when it becomes difficult to keep roadways and walkways passable. ***Extent Scale:*** This is typically based on total **snow accumulation** in either 12 or 24 hour periods (natl. WSSI, local GHWO).
    - *Six inches in 12 hours and 8 inches in 24 is considered heavy snow for most of the Northern Plains states, including North Dakota.*
    - *Note that faster snowfall rates or greater total snowfall amounts can lead to much more severe impacts!*

- **Ice Storm:** Freezing Rain becomes an Ice Storm when the accumulation becomes dangerous to transportation, and/or the weight of ice accretion on power lines and tree branches leads to breakage. ***Extent Scale:*** This is typically based on **ice accumulation** in either 12 or 24 hours periods (national WSSI, local GHWO).
    - *A quarter of an inch ice accumulation on power lines and/or tree branches and surrounding surfaces in general. This is the base level for an Ice Storm Warning.*
    - *Half an inch and or a quarter inch of ice accumulation combined with wind is highly impactful and produces more extreme damage, though no extremity scale or "Level 2" Ice Storm Warning has yet been developed.*

- **Winter Storm:** This composite category is used across the Northern Plains, as needed. Especially if a particular winter storm transitions quickly between storm types, like ice to snow to near-blizzard conditions. ***Extent Scale:*** Used to describe a **combination of** *three or more Advisory or Warning conditions for snow, ice, visibility, wind, and/or windchill* in 12 or 24 hours (national WSSI, local GHWO).
    - *Any combination of three or more Advisory or Warning conditions with impacts below the trigger points described for all other forms of severe winter weather. Where the combination of these factors creates dangerous conditions.*

- **Snow Squall (convective):** This is effectively a short-term blizzard; one caused by convective winter storms and handled much like a severe thunderstorm warning. The primary danger is the occurrence of brief whiteout conditions along heavy traffic corridors and/or a rapid production of icy road conditions.

Extent Scale: Based on **snowfall rate, wind, visibility, w/brief duration** (Safety). The local NWS Graphical Hazardous Weather Outlook (GHWO) incorporates a few more of the winter hazards applicable to North Dakota. The national Winter Storm Severity Index (WSSI) is more general. And both use collaborated guidance as incorporated in the National Digital Forecast Database (NDFD).

- *Snow Squalls are short/intense winter storms events, not quite a blizzard because of the shorter duration and spotty nature.*
- *Impact-Based Snow Squall Warnings have two potential Impact Levels: General and Significant. The Significant Tag will trigger a WEA. See figure, below.*

Figure 6.1, Snow Squall Infographic

Source: weather.gov [https://www.weather.gov/wrn/winter_hazard_infographics]

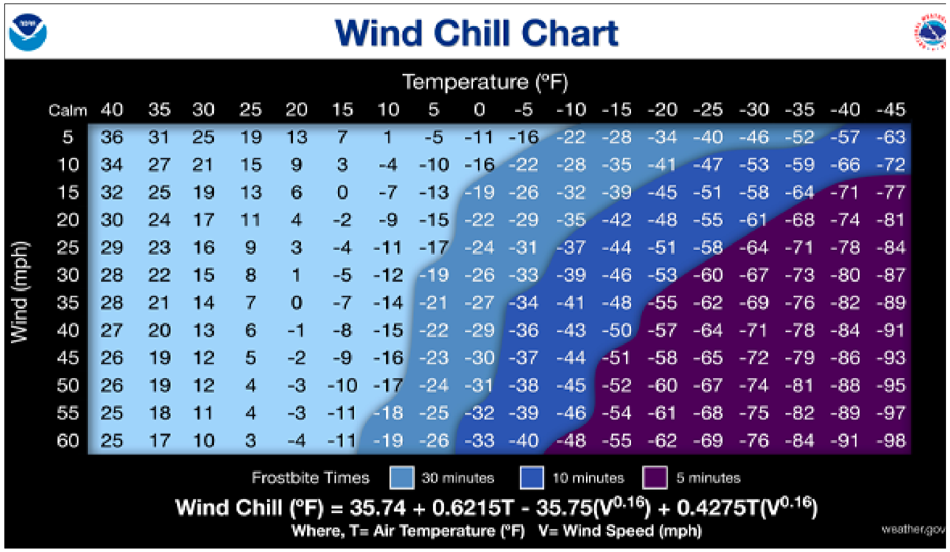
Figure 6.2, Snow Squall Warning Tags

Snow Squall Warning Tags	Explanation
IMPACT TAG	
General (No Tag)	This is used most frequently for snow squall conditions, where other actions may reduce the threat for safe travel.
Significant (Triggers WEA)*	This is used only when snow squalls pose a substantial threat to safe travel, such that WEA is warranted to alert areas in the squall's path.
SOURCE TAG	
Radar Indicated	Radar detects a possible snow squall, but conditions have not yet been confirmed.
Observed	Snow squall conditions have been confirmed by one or more reliable sources.
Up to two Impact Based Warning Tags may be appended to the bottom of a Snow Squall Warning. *The "Significant" Tag is the only tag which will trigger a Wireless Emergency Alert (WEA) for those affected areas.	

Source: Impact-Based Snow Squall Warnings - Factsheet (NWS, 2023)

- **High Wind (winter):** These are non-convective winds that can occur any time of the year. ***Extent Scale:*** Based on ***Sustained Winds*** *Greater-Than-or-Equal-to (GTE) 40 mph, or* ***Wind Gusts*** *GTE 58 mph*. Wind speeds can be estimated from impacts using the Beaufort Wind Scale, at right.
  - The NWS issues a High Wind Warning when sustained winds of 40 mph or greater are occurring or are expected in the next 12-24 hours. The NWS produces a 7-day Graphical Hazardous Weather Outlook (GHWO) for High Winds across ND, with a national outlook out to 3 days (WSSI).
- **Extreme Cold:** This is an apparent temperature which for cold weather is a factor of the actual air temperature and the enhanced cooling impacts of wind and is calculated for any wind speed or for temperatures when there is no appreciable wind. ***Extent Scale:*** based on a **cooling rate** table Wind Chill/Extreme Cold (below), for people exposed to cold. For livestock, pets, etc. contact local veterinarian, animal specialists.
  - *-40 degrees is the trigger point for a wind chill warning in ND*
  - *-25 or -30 degrees is the trigger point for a wind chill advisory for multiple counties for multiple hours in length.*

Figure 6.4, Wind Chill Chart



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

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

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Source: https://www.weather.gov/safety/cold-wind-chill-chart

Figure 6.3, Beaufort Wind Chart – used to estimate sustained (2-minute average) wind speeds

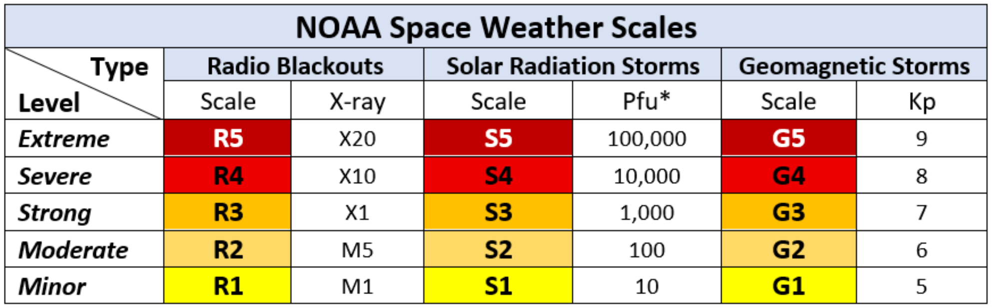
Beaufort Number	MPH		Terminology	Description
	Range	Average		
0	0	0	Calm	Calm. Smoke rises vertically.
1	1-3	2	Light air	Wind motion visible in smoke.
2	4-7	6	Light breeze	Wind felt on exposed skin. Leaves rustl
3	8-12	11	Gentle breeze	Leaves and smaller twigs in constant m
4	13-18	15	Moderate breeze	Dust and loose paper is raised. Small br begin to move.
5	19-24	22	Fresh breeze	Smaller trees sway.
6	25-31	27	Strong breeze	Large branches in motion. Whistling he overhead wires. Umbrella use becomes
7	32-38	35	Near gale	Whole trees in motion. Some difficulty walking into the wind.
8	39-46	42	Gale	Twigs broken from trees. Cars veer on
9	47-54	50	**Severe gale**	**Light structure damage.**
10	55-63	60	**Storm**	**Trees uprooted. Considerable st damage.**
11	64-73	70	**Violent storm**	**Widespread structural damage.**
12	74-95	90	**Hurricane**	**Considerable and widespread d structures.**

Source: NWS Northern Indiana, https://www.weather.gov/media/iwx/webpages/skywarn/Beaufort_Wind_Chart.pdf

7. Space Weather

Space Weather hazards are those which originate as charged particles of various energy and mass erupting from the Sun and impinging on the Earth's magnetosphere, various layers of the atmosphere, biosphere, and potentially it's geosphere. The chart at the right of this page depicts the relative intensity (extent) levels for each of the primary solar storm types. For more detail on each of the storm types and their rating scales see the links provided below.

Figure 7.1, NOAA Space Weather Scales



NOAA Space Weather Scales

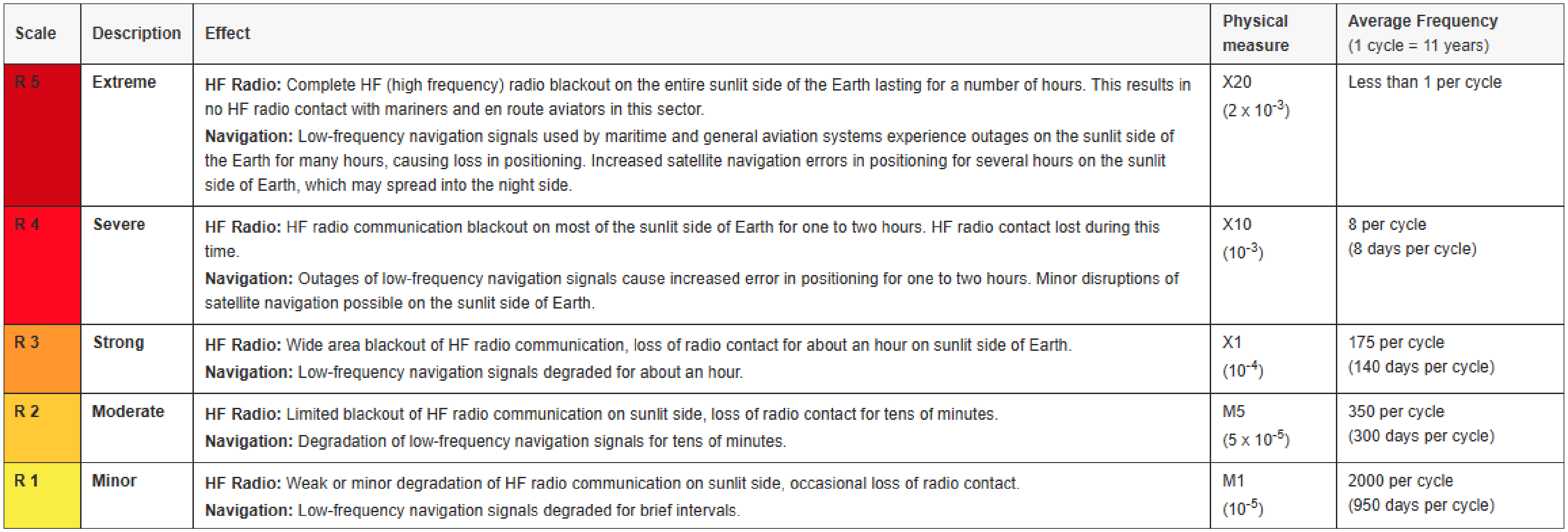
Type Level	Radio Blackouts		Solar Radiation Storms		Geomagnetic Storms	
	Scale	X-ray	Scale	Pfu*	Scale	Kp
Extreme	**R5**	X20	**S5**	100,000	**G5**	9
Severe	**R4**	X10	**S4**	10,000	**G4**	8
Strong	**R3**	X1	**S3**	1,000	**G3**	7
Moderate	**R2**	M5	**S2**	100	**G2**	6
Minor	**R1**	M1	**S1**	10	**G1**	5

**Pfu: Particle flux unit, number of particles with an energy GTE 10 MeV*

Source: NOAA Space Weather Prediction Center (NOAA/SWPC, 2026)

- **Radio Blackouts:** These are a measure of the severity of solar x-ray bursts that can impact HF communications and navigation systems and induce power and communications blackouts at Earth. ***Extent Scale:*** Based primarily on impacts to HF Radio and navigational systems using R-Scale. See detailed description below.

Figure 7.2, R-Scale for Radio Blackouts



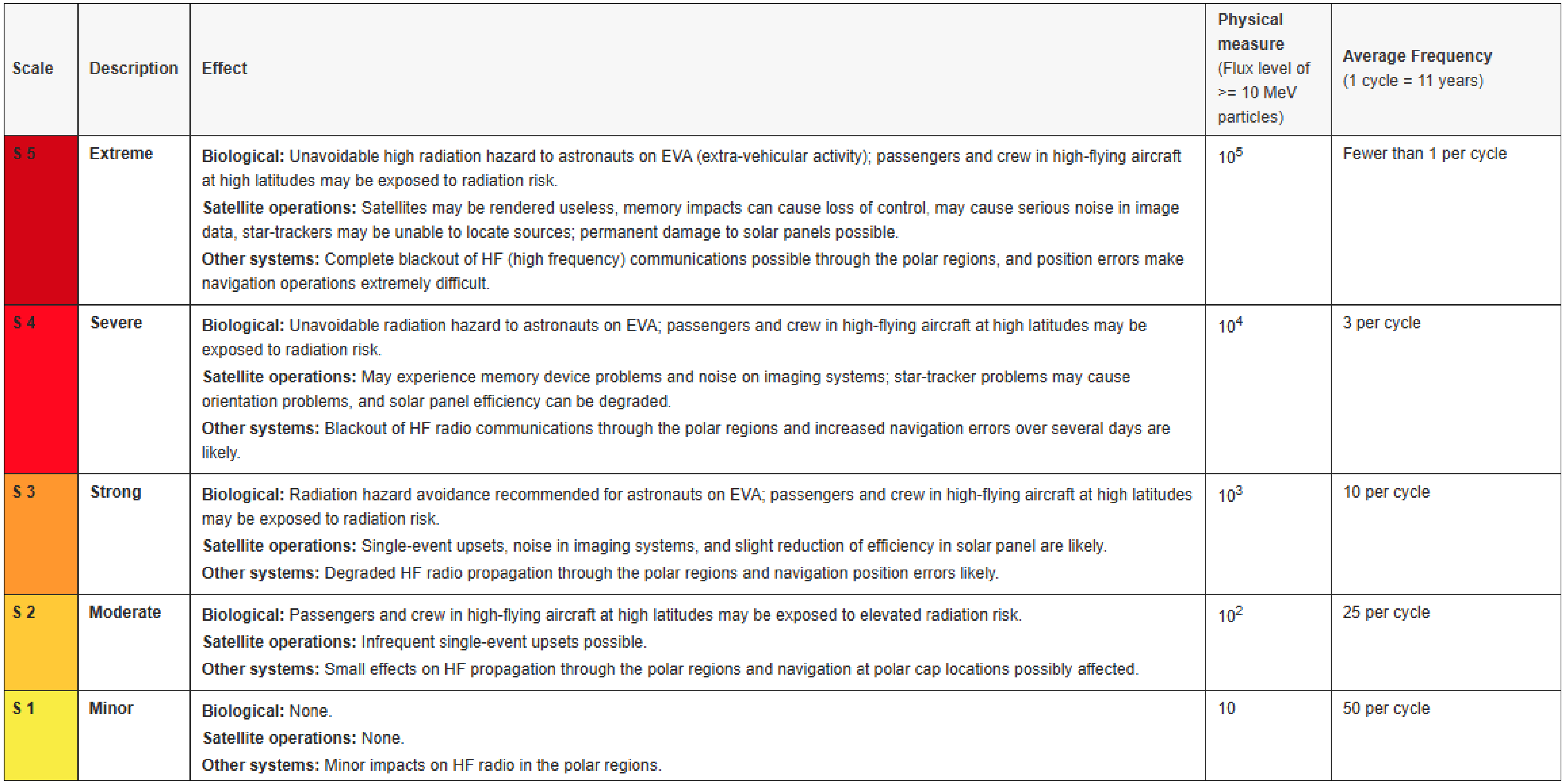
Scale	Description	Effect	Physical measure	Average Frequency (1 cycle = 11 years)
R 5	Extreme	**HF Radio:** Complete HF (high frequency) radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners and en route aviators in this sector. **Navigation:** Low-frequency navigation signals used by maritime and general aviation systems experience outages on the sunlit side of the Earth for many hours, causing loss in positioning. Increased satellite navigation errors in positioning for several hours on the sunlit side of Earth, which may spread into the night side.	X20 (2 x 10^{-3})	Less than 1 per cycle
R 4	Severe	**HF Radio:** HF radio communication blackout on most of the sunlit side of Earth for one to two hours. HF radio contact lost during this time. **Navigation:** Outages of low-frequency navigation signals cause increased error in positioning for one to two hours. Minor disruptions of satellite navigation possible on the sunlit side of Earth.	X10 (10^{-3})	8 per cycle (8 days per cycle)
R 3	Strong	**HF Radio:** Wide area blackout of HF radio communication, loss of radio contact for about an hour on sunlit side of Earth. **Navigation:** Low-frequency navigation signals degraded for about an hour.	X1 (10^{-4})	175 per cycle (140 days per cycle)
R 2	Moderate	**HF Radio:** Limited blackout of HF radio communication on sunlit side, loss of radio contact for tens of minutes. **Navigation:** Degradation of low-frequency navigation signals for tens of minutes.	M5 (5 x 10^{-5})	350 per cycle (300 days per cycle)
R 1	Minor	**HF Radio:** Weak or minor degradation of HF radio communication on sunlit side, occasional loss of radio contact. **Navigation:** Low-frequency navigation signals degraded for brief intervals.	M1 (10^{-5})	2000 per cycle (950 days per cycle)

Source: NOAA Space Weather Prediction Center (NOAA/SWPC, 2026)

- **Solar Radiation Storms:** These are a measure of the severity of solar proton events which can impact navigation and communications systems to a degree but are especially harmful to humans and other life forms at higher latitudes or traveling at higher altitudes.

Extent Scale: Based primarily on impacts to aircraft or space station passengers and crew members, along with HF Radio and satellite navigation systems using S-Scale.

Figure 7.3, S-Scale for Solar Radiation (Proton) Storms

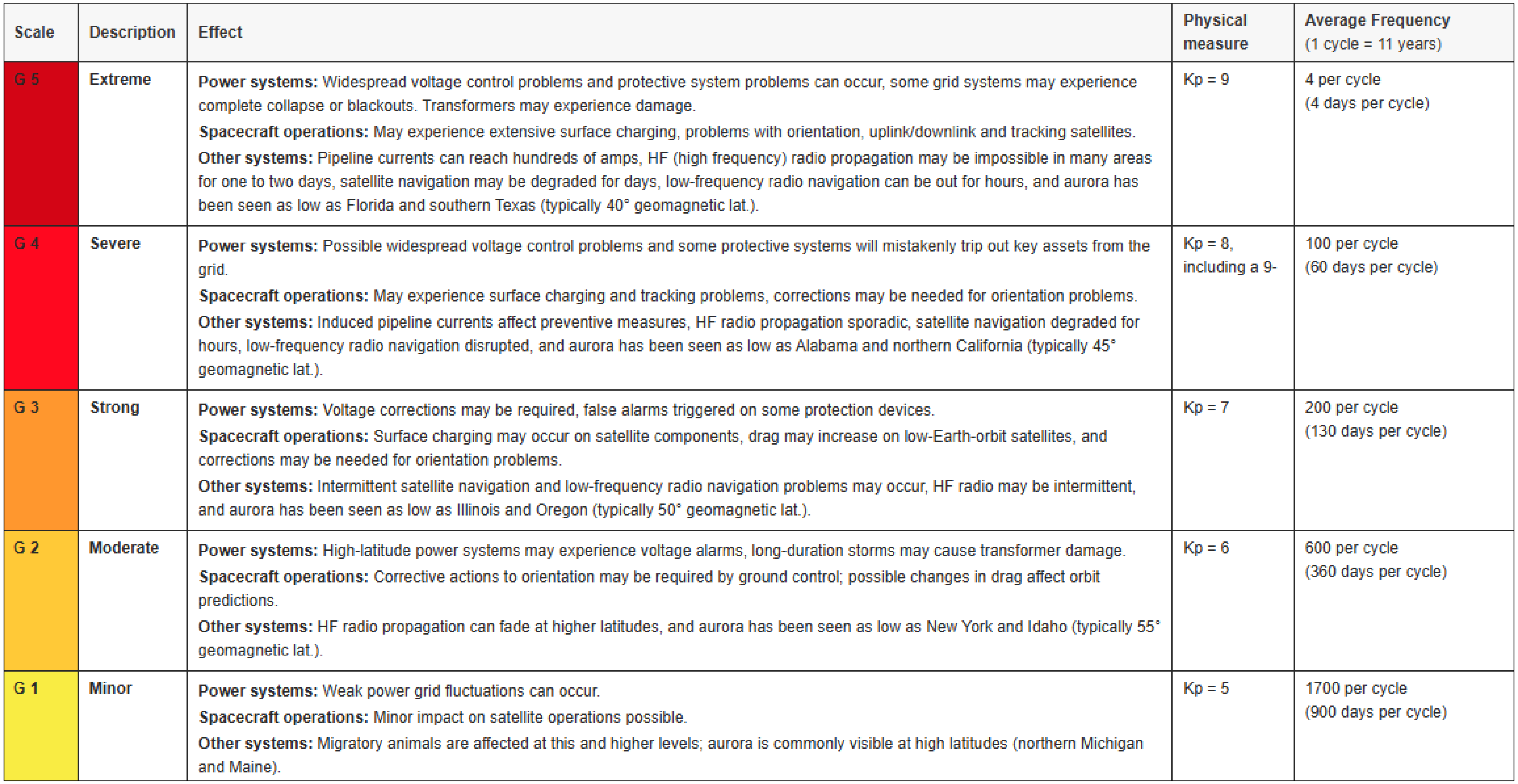


Scale	Description	Effect	**Physical measure** (Flux level of >= 10 MeV particles)	**Average Frequency** (1 cycle = 11 years)
S 5	Extreme	**Biological:** Unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. **Satellite operations:** Satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible. **Other systems:** Complete blackout of HF (high frequency) communications possible through the polar regions, and position errors make navigation operations extremely difficult.	10^5	Fewer than 1 per cycle
S 4	Severe	**Biological:** Unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. **Satellite operations:** May experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded. **Other systems:** Blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.	10^4	3 per cycle
S 3	Strong	**Biological:** Radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. **Satellite operations:** Single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely. **Other systems:** Degraded HF radio propagation through the polar regions and navigation position errors likely.	10^3	10 per cycle
S 2	Moderate	**Biological:** Passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk. **Satellite operations:** Infrequent single-event upsets possible. **Other systems:** Small effects on HF propagation through the polar regions and navigation at polar cap locations possibly affected.	10^2	25 per cycle
S 1	Minor	**Biological:** None. **Satellite operations:** None. **Other systems:** Minor impacts on HF radio in the polar regions.	10	50 per cycle

Source: NOAA Space Weather Prediction Center (NOAA/SWPC, 2026)

- **Geomagnetic Storms:** These are storms produced within the earth's magnetosphere often as a result of Coronal Mass Ejections (CMEs) that erupt from the Sun and transport large amounts of solar plasma into the Earth's system. These CMEs are often the most impactful, with accompanying impacts from either of the previous Solar Storm types, Radio Blackout and/or Solar Radiation Storms. ***Extent Scale:*** Based primarily on impacts to power systems, pipelines, and satellites using G-Scale.
  - *May 10 to 11, 2024, the strongest G-5 storm in 20 years (Love, 2025) occurred resulting in two days of internet outages/delays, widespread GPS outages, and Aurora displays (Northern and Southern Lights) extending nearly to the Tropics.*
  - Often have spectacular auroral displays: Aurora Dashboard (Experimental) | NOAA / NWS Space Weather Prediction Center

Figure 7.4, G-Scale for Geomagnetic Storms



Scale	Description	Effect	Physical measure	Average Frequency (1 cycle = 11 years)
G 5	Extreme	**Power systems:** Widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage. **Spacecraft operations:** May experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites. **Other systems:** Pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.).	Kp = 9	4 per cycle (4 days per cycle)
G 4	Severe	**Power systems:** Possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid. **Spacecraft operations:** May experience surface charging and tracking problems, corrections may be needed for orientation problems. **Other systems:** Induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.).	Kp = 8, including a 9-	100 per cycle (60 days per cycle)
G 3	Strong	**Power systems:** Voltage corrections may be required, false alarms triggered on some protection devices. **Spacecraft operations:** Surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems. **Other systems:** Intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.).	Kp = 7	200 per cycle (130 days per cycle)
G 2	Moderate	**Power systems:** High-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage. **Spacecraft operations:** Corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions. **Other systems:** HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.).	Kp = 6	600 per cycle (360 days per cycle)
G 1	Minor	**Power systems:** Weak power grid fluctuations can occur. **Spacecraft operations:** Minor impact on satellite operations possible. **Other systems:** Migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine).	Kp = 5	1700 per cycle (900 days per cycle)

Source: NOAA Space Weather Prediction Center (NOAA/SWPC, 2026)

8. Wildfire

According to the National Wildfire Coordinating Group (2014), a wildfire is generally an “unplanned, unwanted wildland fire, including unauthorized human-caused fires, and any other wildland fire in which the objective is to out the fire out”.

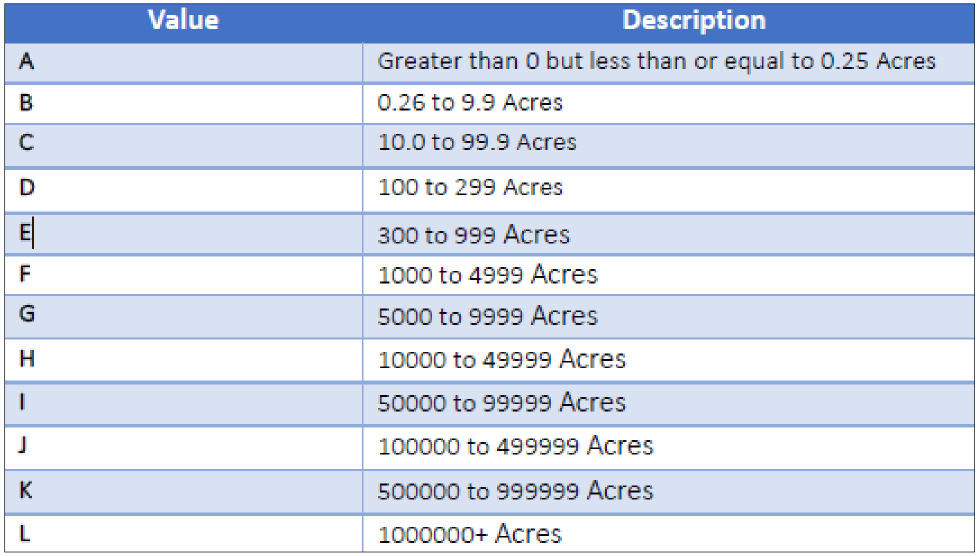
Extent Scale: Wildfire extent is determined by Fire **Size** (final, acres) measured in acres burned, NWCG Glossary: enter Size Class of Fire.

- ○ *Equates to Burn Area or essentially the footprint or physical extent of the wildland fire.*
- ○ *This can be calculated in total acres burned/impacted in a fire season, and in a single incident or occurrence.*

Additional fire hazard planning resources include:

- Pre-Fire/Wildfire Awareness - ND Burn Restrictions and Fire Danger Maps.
  - ○ Current Conditions - ND Daily Burn Restrictions https://experience.arcgis.com/experience/c5da309af17b4c48a3b953675a77f654
  - ○ Current - ND Adjective Fire Danger https://gis.des.nd.gov/NDDESFireIndex.png
  - ○ Post-Fire/Wildfire Reporting: ND Insurance… NFIRS, eNFIRS, ESO https://www.firemarshal.nd.gov/fire-rescue/reporting

Figure 8.1, NWCG Fire Class Code Standard Data Values



Value	Description
A	Greater than 0 but less than or equal to 0.25 Acres
B	0.26 to 9.9 Acres
C	10.0 to 99.9 Acres
D	100 to 299 Acres
E	300 to 999 Acres
F	1000 to 4999 Acres
G	5000 to 9999 Acres
H	10000 to 49999 Acres
I	50000 to 99999 Acres
J	100000 to 499999 Acres
K	500000 to 999999 Acres
L	1000000+ Acres

Source: NWCG, 2024. *https://www.nwcg.gov/node/388612*

Wind Hazard Addendum:

Wind Hazard: This refers to either **sustained winds** (2-minute average, over a 10-minute sample period) or **wind gusts** (either 3-second or instantaneous peaks). A longe duration sustained wind can produce similar damage to a much shorter duration but higher intensity wind gust.

For example, a thunderstorm outflow (smaller scale), squall line (medium scale), or a derecho (larger scale) wind episode can move across your area and produce a wind report of WNW at 32G75 mph… from the west-northwest at 32 mph sustained wind and brief gusts to 75 mph. The 75 mph gust is the primary damaging aspect of this storm. A wind report is WNW at 60G75 mph is significantly different, since both the sustained wind at 60 mph and the wind gust of 75 mph each have damaging potential. From the Beaufort wind scale, one sees that a sustained wind of 60 mph could uproot trees and produce significant structural damage, damage which could range from the high EF0 to low EF1 scale, and more representative of a 75-95 mph wind gust.

Extent/Intensity estimates, when direct measurement isn't available:

- Sustained wind can be estimated from damage, using the Beaufort Wind Scale.
- Wind gusts can be estimated from damage, using NWS Table A.7 Estimating Wind Speed from Damage, p. A-71.
    - *In the NWS, Strong Wind is considered nonhazardous, less than 40 mph sustained wind or less than 58 mph wind gusts.*
    - *While High Wind is at or above 40 mph (35 kts) sustained wind and/or Damaging Wind at or above 58 mph (50 kts) wind gusts.*

Terminology:

NWS High Wind refers to sustained winds of 35 knots (40 mph) or greater, with peaks and lulls lasting over a period of one hour or longer, or any wind gust of 50 knots (58 mph) or greater. These are common to large scale extratropical storm systems in both winter and summer seasons. The local NWS offices issue High Wind Watches and Warnings for this potential. Storm occurrence is based on measured wind speed (sustained or gusts) or estimates of wind speed based on damages as reported in NCEI Storm Data.

NWS Thunderstorm Wind/Damaging Wind refers specifically to convective season wind gusts of 50 knots (58 mph) or greater. The NWS Storm Prediction Center (SPC) issues Severe Thunderstorm Watches and local NWS offices issue Severe Thunderstorm Warnings for this potential. *Storm occurrence is based on measured wind speeds, estimates of wind speed, or wind damages commensurate with wind gusts of 50 knots (58 mph) or greater as reported in NCEI Storm Data.* A wind gust of 65 knots (75 mph) or greater is considered especially damaging for SPC Watch verification purposes. NWS Warnings adds damage tags for potential wind gusts of 70 mph (Considerable) and 80 mph (Destructive), above the base severe level of 58 mph.

FEMA-NRI Strong Wind refers to damaging convective season winds and is the equivalent of NWS Thunderstorm Wind. However, NRI Strong Winds are based on measured wind gusts "exceeding 58 mph" (50.4 kts: NRI Tech Document, 2025, p. 18-1), as extracted from NCEI Storm Data records, while the official NWS and NCEI category is based on wind gusts GTE 50 kts (57.5 mph). NWS also has a Strong Wind category which is considered non-severe.

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