3.3.1 Drought

Drought is a natural climatic condition which occurs in virtually all climates, the consequence of a natural reduction in the amount of precipitation experienced over a long period of time, usually a season or more in length. High temperatures, prolonged winds, and low relative humidity can exacerbate the severity of drought. This hazard is of particular concern in Jefferson County due to the presence of farms as well as water-dependent industries and recreation areas across the Eastern Panhandle. A prolonged drought could severely impact these sectors of the local economy, as well as residents who depend on wells for drinking water and other personal uses.

Location and Extent

Droughts are regional climatic events, so when these events occur in the Eastern Panhandle, impacts are often felt across the state or the region. The spatial extent for areas of impact can range from county level to the entire mid-Atlantic Region. Areas with extensive agricultural land use can experience particularly significant impacts.

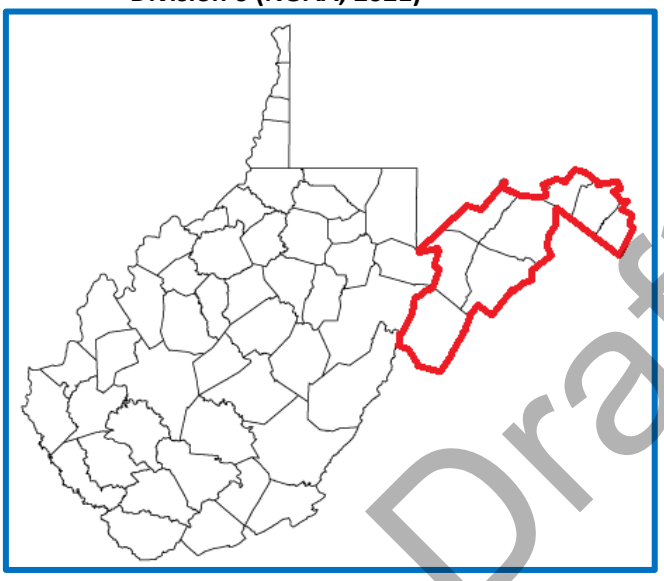
Locations of droughts nationwide are monitored continuously by USGS, and the National Drought Mitigation Center at the University of Nebraska-Lincoln in concurrence with the NOAA monitors conditions throughout the state. Maps showing locations currently experiencing drought conditions are posted on various websites (including http://waterwatch.usgs.gov) and show locations where stream flow is below normal and where drought conditions exist or are emerging.

The State of West Virginia Emergency Operations plan defines four types of droughts: meteorological, agricultural, hydrological, and socio-economic drought (State of West Virginia, 2016).

- Meteorological drought is often defined by a period of substantially diminished precipitation for a duration and/or intensity that persists long enough to produce a significant hydrologic imbalance.
- Agricultural droughts occur when there is inadequate precipitation and/or soil moisture to sustain crop or forage production systems. The water deficit results in serious damage and economic loss to plant or animal agriculture, usually proceeded by a meteorological drought.
- Hydrologic drought is defined in terms of reduction of stream flows, reduction in lake or reservoir storage and lowering of groundwater levels. This results from a shift in normal weather patterns over an area causing the amount of precipitation to fall significantly below the long-term average.
- Socio-economic droughts occur when physical water shortages start to affect the health, well-being and quality of human life, or when the drought starts to affect the supply and demand of an economic product.

Past Occurrence

Figure 3.3.1-1: Northeastern WV as Defined by NOAA WV Climate Division 6 (NOAA, 2021)



Minor droughts occur frequently in Jefferson County, but extended periods of severe drought that creates major disruption and economic loss are rare. The decades with the most severe droughts are 1916-1925, 1926-1935, 1966-1975, and 1996-2005. This is based on data from the National Oceanic and Atmospheric Administration (NOAA) WV Climate Division 6, which encompasses Jefferson County, as well as six other counties in Northeastern WV, as seen in Figure 1 (ESRL NOAA, 2021)

The most recent severe drought in Jefferson County occurred in 1999. Every month in 1999 had a mean PDSI value of -3.00 or less. (ESRL NOAA, 2016). The drought of 1999 started in the late summer of 1998. Below average rainfall continued for the fall and into the start of winter. In fact, in November of 1998 rainfall for most weather stations in the area was less than 1". There was little relief with some snow in January and February, but the drought expanded into the spring of 1999. An extreme drought continued into the summer of 1999 and with little moisture in the air, this means hotter temperatures. Crops were hit hard, livestock was affected, the water supply and the rivers ran nearly dry.

Average rainfall for a summer is about 12". Rainfall for the entire summer of 1999, that's June, June, and August was about what you would typically see in a month outside of a drought year. Rainfall was about 8 to 10" below average for that summer.

In the summer of 1999, the Clinton Administration declared all of West Virginia and 33 counties of Virginia an agricultural drought disaster area. Losses to farmers just in West Virginia totaled $80 million.

With the persistent and severity of the drought, rivers ran low as well as the tributaries. According to the National Weather Service report, "The Shenandoah River dropped to less than 22% of its normal flow and

the water level near Strasburg was at the lowest recorded in July since records began 72 years ago."

The lack of precipitation was simply devastating for local and state agriculture. Crops just didn't have a chance to grow, or they died in the fields with the lack of rain. Even trees were shedding leaves early. This excerpt is from the National Weather Service report, " Corn that should have been 6 feet high was only waist-high at best and did not germinate." Some farmers had to reduce their herd sizes in order to stretch hay and water supplies.

Because of the drought the spring wildfire season basically extended into the summer. The Virginia Department of Forestry reported a record fire season January through July of 1999 with 1,320 fires burning 6,146 acres across the state.

This historic drought ended in the fall of 1999 for the Shenandoah Valley, but drought conditions persisted for West Virginia through the winter, and ending the following spring.

Between June 1998 and June 1999, the area received about 12 inches less rainfall than average. The local agricultural economy was impacted significantly, and Jefferson Utilities enacted emergency water restrictions. President Bill Clinton declared a disaster declaration for the entire state of West Virginia (Tuckwiller, 1999).

The U.S. Drought Monitor (USDM) identifies areas in drought and labels them by intensity. The map uses four categories of drought, from D1—the least intense—to D4, the most. It also highlights areas with no drought and uses the D0 category to indicate abnormally dry areas that could be entering or recovering from drought.

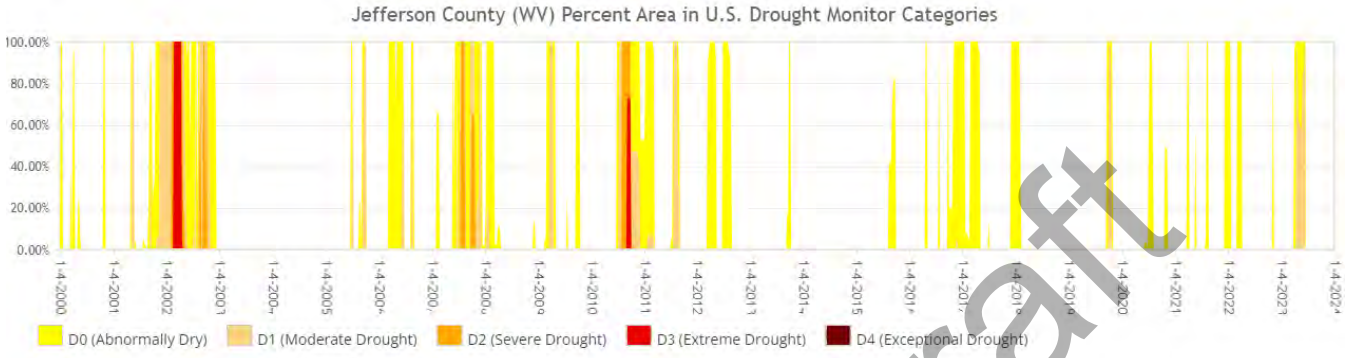
U.S. Drought Monitor reports three periods of extreme drought (D3) between 2000 and 2023, occurring in 2002, 2007 and 2010. The NCEI reports four droughts between 1997 and 2007, occurring in 1997, 1998, 1999, and 2007. This roughly gives a total of six significant droughts between 1997 and 2023. NCEI does not have records for the drought of 2002 in Jefferson County, the year the majority of the country experienced droughts. In March of 2002, there was an extreme drought (D3) throughout the East Coast region. Other parts of the country experienced droughts at different times throughout the year.

According to data from the U.S. Drought Monitor, of the 953 weeks on record, 218 have experienced some type of drought; that is 22.8% of the time Jefferson County is experiencing a drought condition. Drought conditions are not spread out evenly throughout the year, or even over a period of years. As the graph above indicates, there can be several years with no drought conditions, and then more than one year with consistent drought conditions.

On October 3, 2019, West Virginia Governor Jim Justice declared a State of Emergency for all 55 West Virginia counties due to a prolonged shortage of rainfall that caused moderate drought conditions across much of the state and severe drought conditions in southern West Virginia (State of West Virginia Executive Department, 2019). The emergency declaration proclaimed the drought reflected both

meteorological and agricultural drought characteristics, and included some restrictions on water usage, as well as some voluntary measures.

Figure 3.3.1-2: Jefferson County Drought Percentage Status from January 2000 to January 2022



From the beginning of 2023 to the end of March, Jefferson County did not experience drought conditions. However, between the approximate 2-month period from the beginning of April to the beginning of June in 2023, nearly the entirety (96%-100%) of Jefferson County was exposed to D0: Abnormally Dry to D1: Moderate Drought conditions, according to the U.S. Drought Monitor. In comparison, since the start of 2023, the Continental United States faced mixed conditions across the landscape. In January of 2023, 60-70% of the country experienced a range of D0: Abnormally Dry to D:4 Exceptional Drought conditions. Between April and May 2023, the estimated percentage of "Not Dry" areas varied between 40 to 59.

The United States Department of Agriculture (USDA) Risk Management Agency (RMA) operates and manages the Federal Crop Insurance Corporation program. Since Jefferson County farms are eligible for crop insurance, it is possible to determine agricultural losses in Jefferson County. Table 1 displays the crop loss insurance payments by year in Jefferson County since 2010. The most losses occurred in 2010, with corn suffering the most substantial losses as defined by indemnity amount. In 2010, Jefferson County received $1,556,397 million in indemnity.

Table 3.3.1-1: Crop Loss Insurance Compensation Due to Drought (USDA RMA, 2023)	
Crop Year	**Indemnity Amount**
2010	$1,556,397
2011	$602,457
2012	$72,921
2013	$4,136
2014	$27,535
2015	$68,049
2016	$60,191
2017	$43,296
2018	$0
2019	$4,791
2020	$144,266
2021	$51,012
2022	$40,050
2023 (Year to Date)	$4,582

Future Occurrence

It is difficult to forecast the severity or frequency of future drought events with any certainty. However, based on historical drought data between 1896 and 2021, northeastern WV had 93 months of moderate and severe drought (defined as a month with a mean PDSI of -3.00 or less), or spent 6.18 percent of that time in a moderate or severe drought (NOAA, 2021a). While some form of drought condition frequently exists in the region, the impact depends on the duration of the event, severity of conditions, and area affected.

Table 3.3.1-2: Severe Drought Events in Jefferson County 1997-2023 (NCEI, 2023)			
Date	**Crop Damage ($)**	**Type**	**Description and Source**
1997	$2,150,000	Severe	NCEI: A very dry month, containing one 7-day heat wave, exacerbated drought-like conditions across much of the fertile farmland of eastern West Virginia. The weather in July proved to be the death knell for much of the crop yields, including corn, hay, and pasture. The West Virginia Farm Service Agency reported the following damage statistics: Corn, hay, and pasture yields were 40 to 50 percent of normal. Estimated damage to the corn crop included 2500 to 3000 acres per county in the Potomac Highlands but as much as 10,000 acres in the eastern panhandle. Hay damage was estimated to be 40,000 acres per county; pasture lands an additional 80,000 acres per county. No significant damage to alfalfa was noted. Though some summer fruit was damaged by the drought, most of what survived was excellent.

Table 3.3.1-2: Severe Drought Events in Jefferson County 1997-2023 (NCEI, 2023)			
Date	**Crop Damage ($)**	**Type**	**Description and Source**
8/1/1998	0		NCEI: Drought conditions persisted for six months in a row across the Eastern Panhandle of West Virginia. Persistent high pressure over the Southeast U.S. forced most precipitation producing low-pressure systems to steer north of the region. In addition, record high temperatures baked the region during the first week of the month. Monthly precipitation totals from Jefferson County was 1.3 inches. Average precipitation for the month of December is around 3 inches. Most locations received less than half of their normal precipitation from July through December. A ban on open burning continued through mid-December in Jefferson County due to extreme fire danger.
10/1/1998	0		
11/1/1998	0		
12/1/1998	0		
5/1/1999	0		NCEI: Rainfall from two tropical storms and a handful of low-pressure systems made an impact in the drought that plagued the region since the summer of 1998. By the end of the month, conditions across the Eastern Panhandle were upgraded from an extreme to a moderate drought because rainfall was above average during September. Rainfall totals included 7.9 inches in Jefferson County. Effects of the drought still lingered in the agricultural community. Across the state by the end of the month, 81% of topsoil was reported short or very short of moisture. 32% of apples, 67% of corn, 69% of hay, 77% of pasture land, 30% of soybeans, and 33% of tobacco crops were in poor or very poor condition. By month's end, 28% of farmers were still hauling water for livestock, and 25% of wells were dry or had an extremely low water reserve.
6/1/1999	0		
7/1/1999	0		
8/1/1999	0		
9/1/1999	0		
2002	-	D3 Extreme Drought	U.S. Drought Monitor: Dryness and drought remained unchanged in the Northeast, and expanded or intensified in parts of the mid-Atlantic, Southeast, and the central and southern Appalachians. D3 conditions were extended to cover central North Carolina, the Virginia Blue Ridge and Northern Neck, eastern West Virginia, and the entire Delmarva Peninsula
7/24/2007	0	D2 Severe Drought	Severe drought conditions persisted through much of October in Jefferson County. Rainfall deficits reached a high of 10 inches below normal for the year, but a series of low-pressure systems moving across the Mid Atlantic helped to decrease those deficits by a few inches.
8/1/2007	0		
10/1/2007	0		
2010	-	D3 Extreme Drought	U.S. Drought Monitor: Across the panhandle of West Virginia, northwest Maryland and extreme southwest

Table 3.3.1-2: Severe Drought Events in Jefferson County 1997-2023 (NCEI, 2023)			
Date	**Crop Damage ($)**	**Type**	**Description and Source**
			Pennsylvania, extreme drought (D3) conditions were added. Precipitation for the most recent 30 and 90 days measure in at about 40% of normal, while the SPI, NLDAS soil moisture, and stream flows are all below the 5% threshold for indicating extreme drought. Across northern Virginia, abnormal dryness was expanded from the west toward the District of Columbia to reflect the field reports of deciduous trees dropping leaves and fruit earlier than normal due to lack of recent rainfall.

Range of Magnitude

Droughts can have varying effects, depending on the month in which they occur, as well as the severity, duration, and location of the event. Even short-term droughts can be devastating, especially in conjunction with extreme temperatures.

Hydrologic drought events result in a reduction of stream flows, reduction of lake/reservoir storage, and a lowering of groundwater levels. These events have adverse impacts on public water supplies for human consumption, rural water supplies for livestock consumption and agricultural operations, water quality, natural soil water or irrigation water for agriculture, soil moisture, conditions conducive to wildfire events, and water for navigation and recreation. The WVEMD Emergency Operations Plan (EOP) uses a combination of five indices to determine the magnitude of a drought (State of West Virginia, 2016). Descriptions of the indices from the EOP are as follows:

a. Palmer Drought Severity Index

The PDSI attempts to measure the duration and intensity of the long- term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months.

b. Palmer Z Index

The Palmer Z index is a variation of the PDSI that measures short-term drought on a monthly scale.

c. Crop Moisture Index (CMI)

This index uses a meteorological approach to monitor week-to-week crop conditions by evaluating short-term moisture conditions across major crop-producing regions. It is based on the mean temperature and total precipitation for each week within a climate division, as well as the CMI value

from the previous week. The CMI responds rapidly to changing conditions, and it is weighted by location and time so that maps can be used to compare moisture conditions at different locations.

d. Standardized Precipitation Index (SPI)

This is a probability index that considers the probability of recording a given amount of precipitation. The probabilities are standardized so that an index of zero indicates the median precipitation amount where half of the historical precipitation amounts are below the median, and half are above the median. The index is negative for drought, and positive for wet conditions. The SPI is computed by the National Centers for Environmental Information (NCEI) for several time scales, ranging from one (1) month to 24 months, to capture both short-term and long-term drought.

e. National Fire Danger Rating System

A broad scale system that incorporates science, technology, and local experience to analyze the various factors of fuels, weather, topography, and risk, in combination, to assess the daily fire potential of an area including the potential for a fire to ignite, spread and require suppression action. Fire danger is usually expressed in numeric or adjective terms.

Precipitation, ground water, stream flow, reservoir levels, PDSI, CMI, SPI, Fire Weather Forecast, and the Fire Danger drought criteria are assessed by the WVEMD each month, the WVEMD then assigns one of four stages of concern as shown in Table 3.

Table 3.3.1-3: WVEMD EOP Levels of Concern for Drought

Level of Concern	Indices		
	PDSI	CMI	SPI
Normal (Stage I)	Normal levels	Normal levels	Normal levels
Alert (Stage II)	-2.00 to -2.99 Moderate Drought	-1.0 to -1.9 Abnormally Dry	-1.00 to -1.49 Moderately Dry
Conservation (Stage III)	-3.00 to -3.99 Severe Drought	-2.0 to -2.9 Excessively Dry	-1.50 to -1.99 Severely Dry
Emergency (Stage IV)	-4.00 and below Extreme Drought	3.0 or less Severely Dry	-2.00 and less Extremely Dry

I. Alerts are rescinded and drought status returns to normal when the PDSI is above -1, indicating normal or near normal levels.

II. Stage II is reached when the PDSI reads -2.00 to -2.99 and stream, reservoir, and ground water levels are below normal over a several month period and/or the WVEMD Director determines Stage II activities are required. The governor is requested to make a Drought Alert Declaration.

III. Stage III is reached when the PDSI reads -3.00 to -3.99, stream, reservoir, and ground water levels continue to decline, forecasts predict an extended period of below normal precipitation, and/or the WVEMD Director determines Stage III activities are required. A return to Stage II is allowed when precipitation increase, streams, reservoirs, and ground water levels stop declining, the PDSI reaches to -2.99 or higher, and/or the WVEMD Director determines Stage II activities are sufficient and Stage III is no longer required. and to

IV. Stage IV is reached when the PDSI reads -4.00 and/or the WVEMD Director determines Stage IV activities are required. The governor is requested to make a Drought Emergency Declaration when water supplies will be inadequate to meet projected demand and more extreme measures must be undertaken. This declaration allows state agencies to implement emergency programs and actions according to West Virginia Code and to review the allocation of water supplies in communities that are not adequately responding to their water shortage.

Environmental impacts of drought include:

- Hydrologic effects – lower water levels in reservoirs, lakes, and ponds; reduced streamflow; loss of wetlands; estuarine impacts; groundwater depletion and land subsidence; effects on water quality such as increases in salt concentration and water temperature.
- Damage to animal species – lack of feed and drinking water; disease; loss of biodiversity; migration or concentration; and reduction and degradation of fish and wildlife habitat.
- Damage to plant communities – loss of biodiversity; loss of trees from urban landscapes and wooded conservation areas.
- Increased number and severity of fires.
- Reduced soil quality.
- Air quality effects – dust and pollutants.
- Loss of quality in landscape.
- Loss of water for navigation and recreation.
- Increase in nitrate levels which can have health impacts on pregnant women and children.

Vulnerability Assessment

The entire County is exposed and vulnerable to drought. While drought events typically do not impact buildings, infrastructure that provides water may be impacted. This can include loss or severe reduction of water supply, loss of water pressure, or poor water quality. Even though droughts do not directly affect state buildings, there are secondary impacts related to drought that state buildings would be more susceptible to wildfires and tree mortality. Droughts can put more stress on trees, making them more susceptible to pest infestations and other diseases and dying trees. This leads to increased risk of tree limbs falling and damaging buildings and infrastructure and creating more fuel for wildfires.

In relation to wildfire, drought conditions can create more prolonged fires fueled by excessively dry

vegetation, along with reduced water supply for firefighting (NOAA - NIDIS n.d.). Risk to life and property is greatest in areas where forested areas adjoin urbanized areas known as the wildland urban interface (WUI). Therefore, all state buildings and critical facilities in and adjacent to the WUI zone and located in high wildfire risk areas are considered vulnerable to wildfire. Section XXXX (Wildfire) describes the County's vulnerability to the wildfire hazard.

Some of the most significant losses resulting from drought events are typically found in the agricultural sector. Jefferson County is home to agricultural activity, and the local economy could be severely impaired by prolonged drought. The 1999 drought was estimated to have caused more than $200 million in damage to agriculture across the state, and yields were down as low as 50 or 60 percent (USDA, 2012 a & b; Borger, 1999). State agencies and the WVU Extension Service are valuable resources in reducing drought vulnerability through education and other services to area farmers.

People

The entire population of Jefferson County is either directly or indirectly impacted and vulnerable to drought events. For those that rely on surface water (e.g., reservoirs and lakes) for potable water, a decline in surface water flows can be detrimental to the water supply.

Between 1997 and March 2023, droughts in Jefferson County did not directly or indirectly harm anyone physically. Still, severe droughts can have dire consequences on the wellbeing of Jefferson County's residents. For example, Jefferson County's water for utilities is sourced from primarily sourced from groundwater supplies. According to the U.S. Drought Monitor, groundwater levels begin to deplete during D2 level droughts. Therefore, a prolonged drought could interfere with the utility company's ability to provide water to its residents.

Structures

While drought events typically do not impact buildings, infrastructure that provides water may be impacted. This can include loss or severe reduction of water supply, loss of water pressure, or poor water quality. Even though droughts do not directly affect state buildings, there are secondary impacts related to drought that state buildings would be more susceptible to wildfires and tree mortality. Both wildfires and tree mortality can damage or destroy state assets, and droughts can increase that risk

Soil volume and firmness are highly susceptible to the amount of water soil holds. During periods of little to no rain, the soil will likely lose moisture and diminish in size. When soil volume varies greatly, infrastructure and buildings are prone to instability, which could damage structures, particularly if the foundation is not in good condition.

Systems

In the 2018 WV Statewide Mitigation Plan, Jefferson County is identified as the locality with the "highest amount of agricultural land per square mile (0.44)" in the state. Additionally, according to the USDA, Jefferson County accounts for 4% of West Virginia's state agriculture sales and is subsequently prone to experience interruptions the economy as the harvesting and production of crops declines as a result of droughts. In 2017, Jefferson County's Market Value of Crops Sold soared over $28.5 million. In addition to crops, farms in the county also participate in producing livestock and poultry products, which was reported to have a total Market Value of Livestock Sold of $10.884 million.

Long-term water shortages can have a high impact on agribusinesses, hydropower-dependent utilities, and other industries reliant on water for production services; all critical infrastructure in Jefferson County are vulnerable to the effects of a drought. From 2012 to 2017, the number of farms increased by 21% in Jefferson County. In contrast, the average size of a farm decreased by 19%, while the total acreage of farmland decreased by 1%. Also in the same timeframe, total market value of sold products and total farm-related income decreased by 19% and 30% respectively. Similarly, the average farm market value of sold products decreased by 33% and average farm-related income by 36%.

Drought can cause municipalities to enforce water rationing and distribution. It also increases the region's vulnerability to other hazards such as severe weather, extreme heat, and public health emergencies. The special needs population of any county must also be considered during drought conditions.

As with many hazards, determining specific risk and vulnerability areas for drought is difficult. Drought is an "overall" hydrologic condition; that is, if one small area was without precipitation but a nearby area was not, it would be difficult to classify the entire area as "in a drought" due to the eventual seepage of said precipitation to the overall groundwater supply. Consequently, drought is said to affect the entire region evenly.

Table 3.3.1-4: Jefferson County Agriculture Market Values (USDA, 2017 a & b)

	Market Value of Crops Sold	Market Value of Livestock Sold	Total
Jefferson County	$28,654,000	$10,844,000	$39,498,000

While the economic effects of a drought damaging crops are noticeable immediately, droughts also pose long-term threats to a farm's agricultural capacity. As described by the NCEI drought database narrative, recurring drought events throughout 1998 and 1999 stripped moisture from 81% of West Virginia's topsoil. In the long-run, severe drought conditions could contribute to the already rapidly declining number of farms, as limited harvesting capacity reduces profits.

Natural, Historic 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.

As most living beings are highly dependent on water, prolonged periods without it can have extremely detrimental effects on the health and condition of natural resources. Below, a table from the U.S. Drought Monitor describes the accumulating effects low to severe drought categories. From the lower end, a D0 drought can stunt crop growth and cause wilting, while also depleting surface water levels. On the higher end, a D3 drought can cause extensive crop loss and prompt extended well digging.

Figure 3.31-3: Drought Severity (U.S. Drought Monitor, 2023)

Category	Examples of historically observed impacts
D0	Crop growth is stunted; planting is delayed
	Fire danger is elevated; spring fire season starts early
	Lawns brown early; gardens begin to wilt
	Surface water levels decline
D1	Honey production declines
	Irrigation use increases; hay and grain yields are lower than normal
	Trees and landscaping are stressed; fish are stressed
	Voluntary water conservation is requested; reservoir and lake levels are below normal capacity
	Wildfires and ground fires increase
D2	Fish kills occur; wildlife move to farms for food
	Golf courses conserve water
	Producers begin feeding cattle; hay prices are high
	Specialty crops are impacted in both yield and fruit size
	Trees are brittle and susceptible to insects
	Warnings are issued on outdoor burns; air quality is poor
	Water quality is poor; groundwater is declining; irrigation ponds are dry; outdoor water restrictions are implemented
D3	Crop loss is widespread; Christmas tree farms are stressed; dairy farmers are struggling financially
	Extremely reduced flow to ceased flow of water is observed; river temperatures are warm; wells are running dry; people are digging more and deeper wells
	Water recreation and hunting are modified; wildlife disease outbreak is observed
	Well drillers and bulk water haulers see increased business

Community Activities

During D2 droughts and above, it is probable that the air and water quality of the region will considerably worsen. As a result, outdoor activities are at risk of cancellation. Businesses in Harpers Ferry, a town and hub for numerous outdoor and water recreation activities in Jefferson County, also face risk of temporarily pausing operations.

On-Line Resources:

(Historical Conditions)

https://www.drought.gov/states/west-virginia/county/jefferson

https://www.rma.usda.gov/-/media/RMA/Maps/Total-Crop-Indemnity-Maps/Crop-Year-2022/050823table.ashx?la=en

https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/West_Virginia/cp54037.pdf

https://emd.wv.gov/MitigationRecovery/Documents/Jefferson%20County.pdf

https://www.rma.usda.gov/Information-Tools/Crop-Indemnity-Maps

0573-Front_Cover.pub (jeffersoncountywv.org)

Microsoft Word - SWC Summary - Safe Water Conservation_2020.docx (sourcewatercollaborative.org)

Cover (wv.gov)

3.3.2 Earthquake

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock, usually within the upper 10-20 miles of the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, or the collapse of underground caverns. They can also result from human activity like mine blasts and nuclear experiments. Future earthquakes are most likely to occur in the same general regions that have had earthquakes previously. Earthquakes can cause damage to buildings and other rigid superstructures, depending on factors like magnitude, distance of local areas to the epicenter, and local geologic conditions. It remains incredibly difficult to predict when and where an earthquake will occur in the northeast U.S. and West Virginia.

Earthquakes move or shake the earth in three different directions depending on the plate movements: convergent, divergent, and transform generating primary and secondary waves. There are three common ways to measure an earthquake:

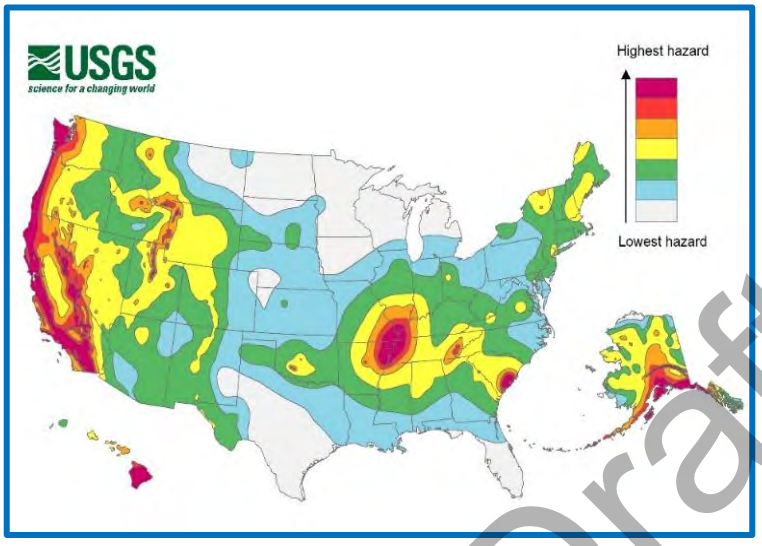
- **Richter Scale**: The Richter scale measures the scale and severity of an earthquake; the magnitude of an earthquake can range between 0 and 10. The effects of an earthquake can extend far beyond the site of its occurrence.
- **Modified Mercalli Scale**: The modified Mercalli scale measures earthquakes based on their intensity on the surface. This scale uses Roman numerals I through XII to denote detection and damage levels associated with an earthquake.
- **Peak Ground Acceleration (PGA)**: PGA is "the maximum ground acceleration that occurred during earthquake shaking at a location. PGA is equal to the amplitude of the largest absolute acceleration recorded on an accelerogram at a site during a particular earthquake" (Douglas, 2003).

Location and Extent

The U.S. has areas that are prone to earthquakes; the coasts of California, Oregon and Washington are more vulnerable to seismic activity due to the presence of the Ballenas, Brothers, and the San Andreas Faults on the west coast. Also of note is the New Madrid Seismic Zone located in Arkansas, Missouri, and Tennessee. On the east coast, there is the Eastern Tennessee Seismic Zone that stretches from Alabama to Virginia.

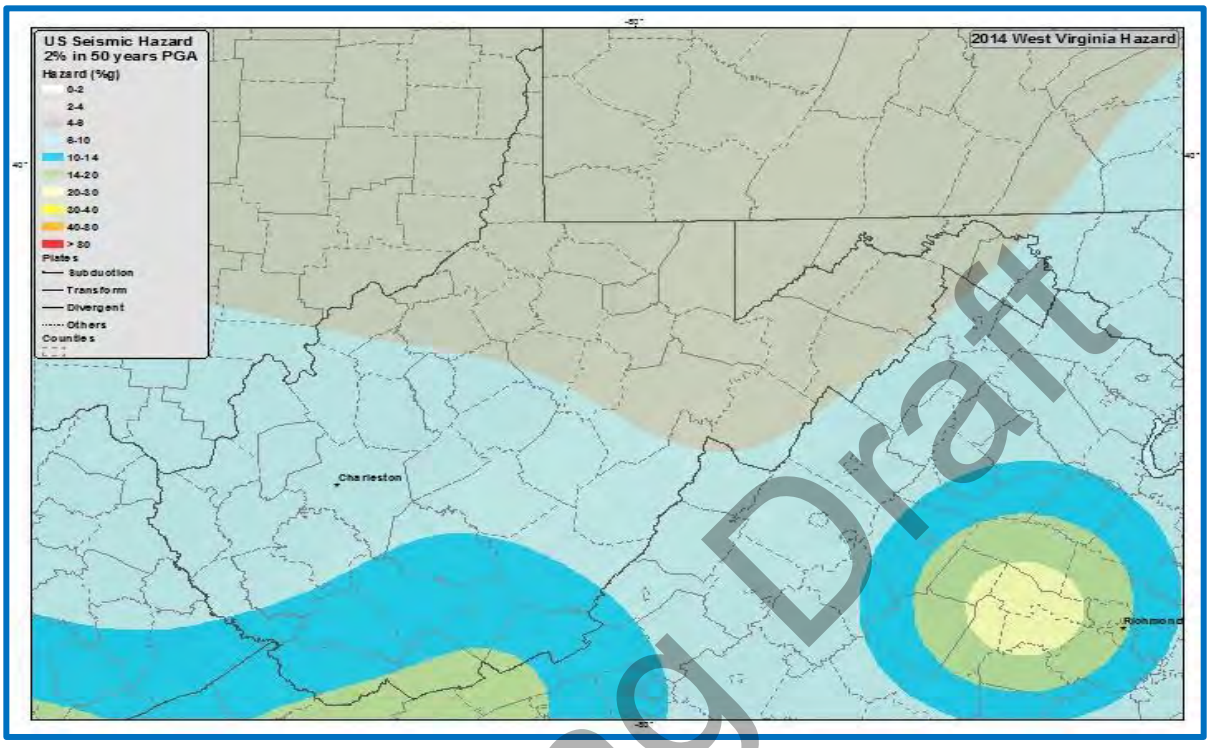
The nearest area of seismic activity is the southeast and south-central United States region, which covers a large area of relatively diffuse, low- rate seismicity. Principle areas of activity include the New Madrid Seismic Zone of the central Mississippi Valley and the Southern Appalachian Seismic Zone, extending from Virginia to Alabama; Figure 3.3.2-1. This map shows the majority of the State of West Virginia as low risk; this includes Jefferson County. The southernmost part of the state has only a slightly higher risk of earthquake hazards.

Figure 3.3.2-1 Simplified 2018 USGS Hazard Map, 2% Chance of Exceedance in 50 Years Scaled in Peak Ground Acceleration (PGA) (USGS, 2018)



When events occur, they impact relatively small areas. According to a region-specific seismic hazard map, as seen in Figure 3.3.2-2, Jefferson County faces the possibility of marginally more severe earthquake with a 2 percent chance of exceeding a Peak Ground Acceleration (PGA) of 8-10 %g in 50 years (USGS, 2018).

Figure 3.3.2-2 WV 2014 USGS Hazard Map, 2 percent Chance of Exceedance in 50 Years (most recent figure available) (USGS, 2018)

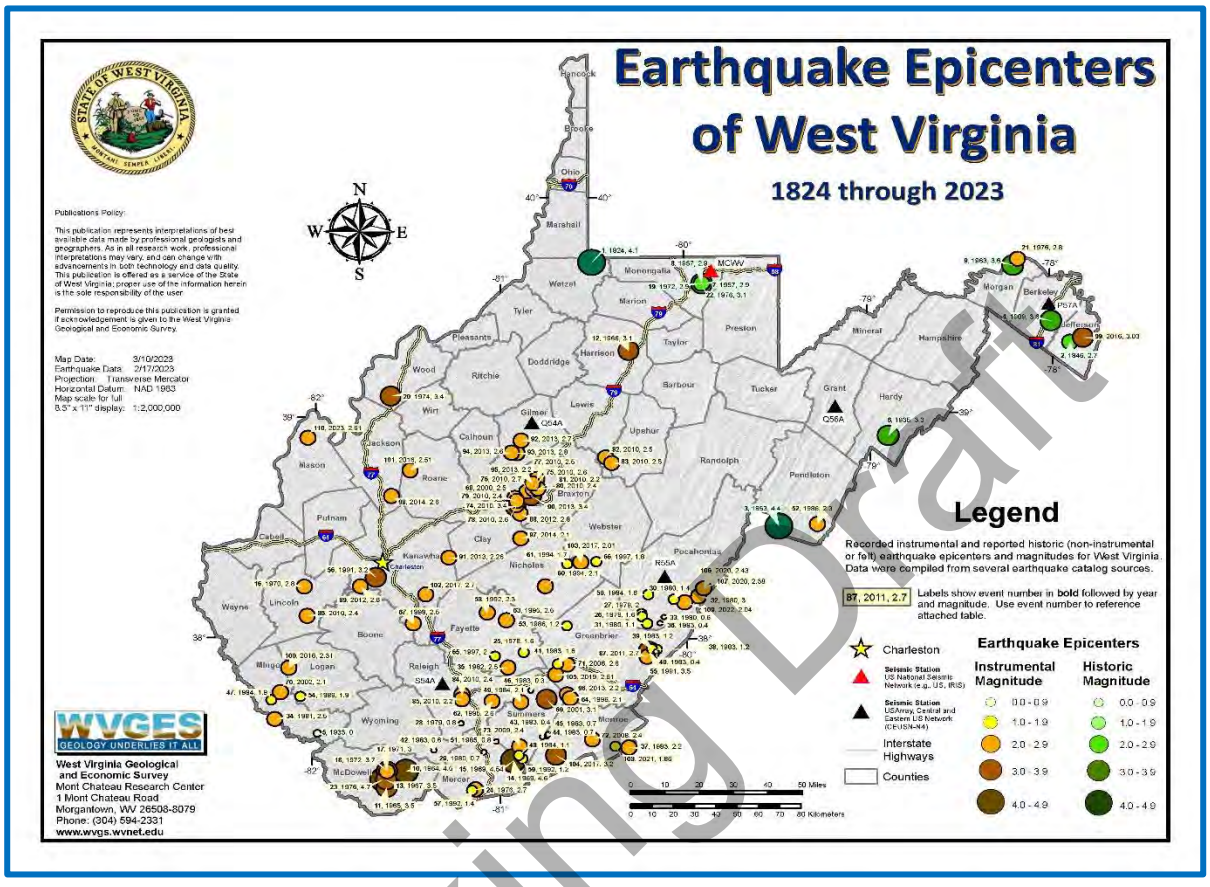


Past Occurrence

According to the U.S. Geological Society, based on historical trends, the frequency of an earthquake occurrence inversely relates to its magnitude. There are an estimated 1.3 million earthquakes every year with a magnitude between 2.0 and 2.9 while there is, on average, one magnitude 8.0 or higher earthquake annually.

In 2016, Jefferson County experienced an earthquake of 3.0 magnitude, but according to the State of West Virginia 2023 Hazard Mitigation Plan, the intensity measured a V, which is higher than the expected intensity for a 3.0 magnitude earthquake. The table to the right lists the epicenters of earthquakes within an 80-mile radius of Jefferson County. Since 2000, there have been five epicenters although the community has felt others originating from further away. The location of these earthquakes can be seen in Figure 3.3.2-3, as well as other historical earthquake locations throughout West Virginia.

Figure 3.3.2-3: West Virginia Geological and Economic Survey Earthquake Epicenters (WVGES, 2023)



The USGS has an earthquake hazards program in which they ask, '[did you feel it](?)' and anyone can record their answers. The USGS then takes that data and creates a map for every year. Since 2000, the maps show that there have been seven earthquakes that people have felt in 2003, 2010, 2011, 2012, 2014, 2016, and 2017. As data shows, there have been more earthquakes felt in the last six years than since 2000, which indicates that they are becoming a more common occurrence.

August 23, 2011

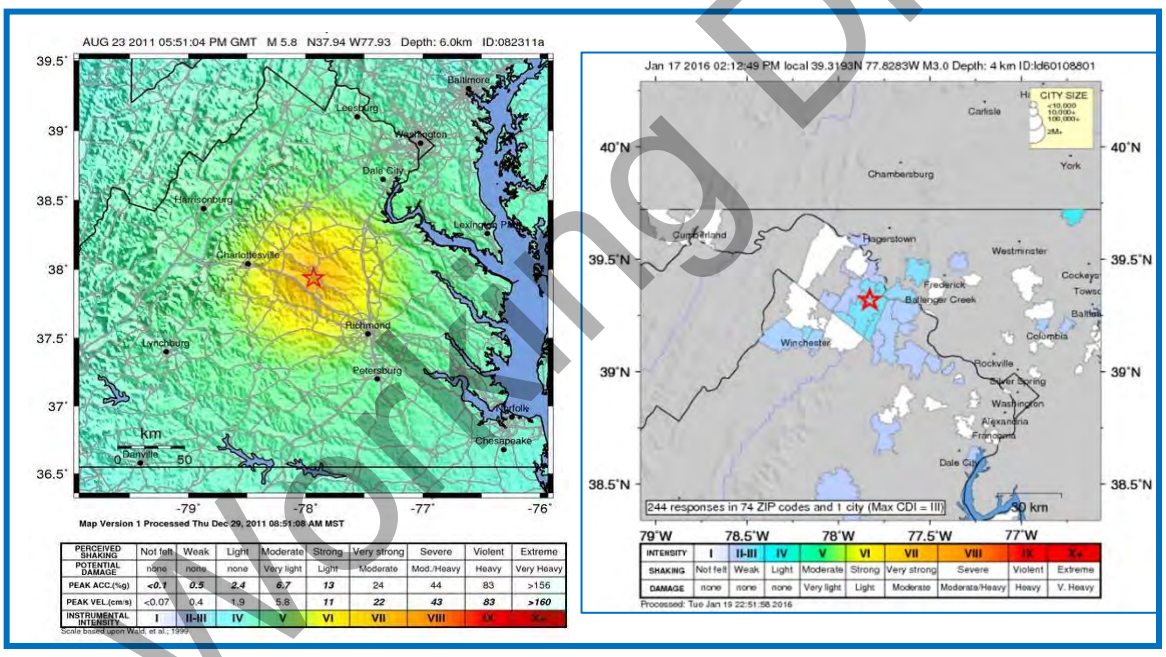
The most high-profile earthquake event to occur near the Potomac Highlands of West Virginia occurred in August 2011. A magnitude (Richter Scale) 5.7 earthquake centered in Louisa, Virginia (a little over 100 miles from Jefferson County) shook structures throughout West Virginia, Pennsylvania, Virginia, Maryland, and New York. Several aftershocks, ranging up to 4.5 in magnitude, occurred after the main tremor. Damage to historic structures like the National Cathedral and the Washington Monument were noted in Washington D.C. Evacuations occurred in D.C. as well as New York City because the general population was not accustomed to experiencing an earthquake of that magnitude. However, the intensity of the earthquake was quite low outside of central Virginia, as seen in Figure 3.3.2-4. No deaths and only minor injuries were reported, and minor damage to buildings was widespread. In Martinsburg, several

government buildings were evacuated, and multiple citizens reported feeling their homes shaking violently enough to rattle picture frames off the walls. In Charleston, the Kanawha County Courthouse, the West Virginia State Capitol campus, and several other downtown buildings were evacuated. In Philippi, part of a chimney collapsed at the Barbour County courthouse. No damages were reported in Jefferson County.

January 17, 2016

More recently, in January 2016, an earthquake shook the West Virginia – Virginia state border. The earthquake happened at 2:12 p.m., and its epicenter was about two miles south-southeast of Bolivar, which is next to Harpers Ferry. The magnitude was 3.0 according to the Richter Scale and the intensity was minimal, but the earthquake was clearly felt up to 28 miles away in Martinsburg (USGS, 2016). There were no reports of damage or injuries. That day, 51 people in Charles Town reported feeling it, and 38 in the Bolivar and Harpers Ferry areas reported experiencing it. According to USGS records of earthquakes from 1900-Present, the 2016 earthquake is the most recent in the area of this scale (USGS, 2016).

Figure 3.3.2-4: USGS ShakeMaps for August 2011 and January 2016 Earthquakes (USGS, 2011 & 2016)

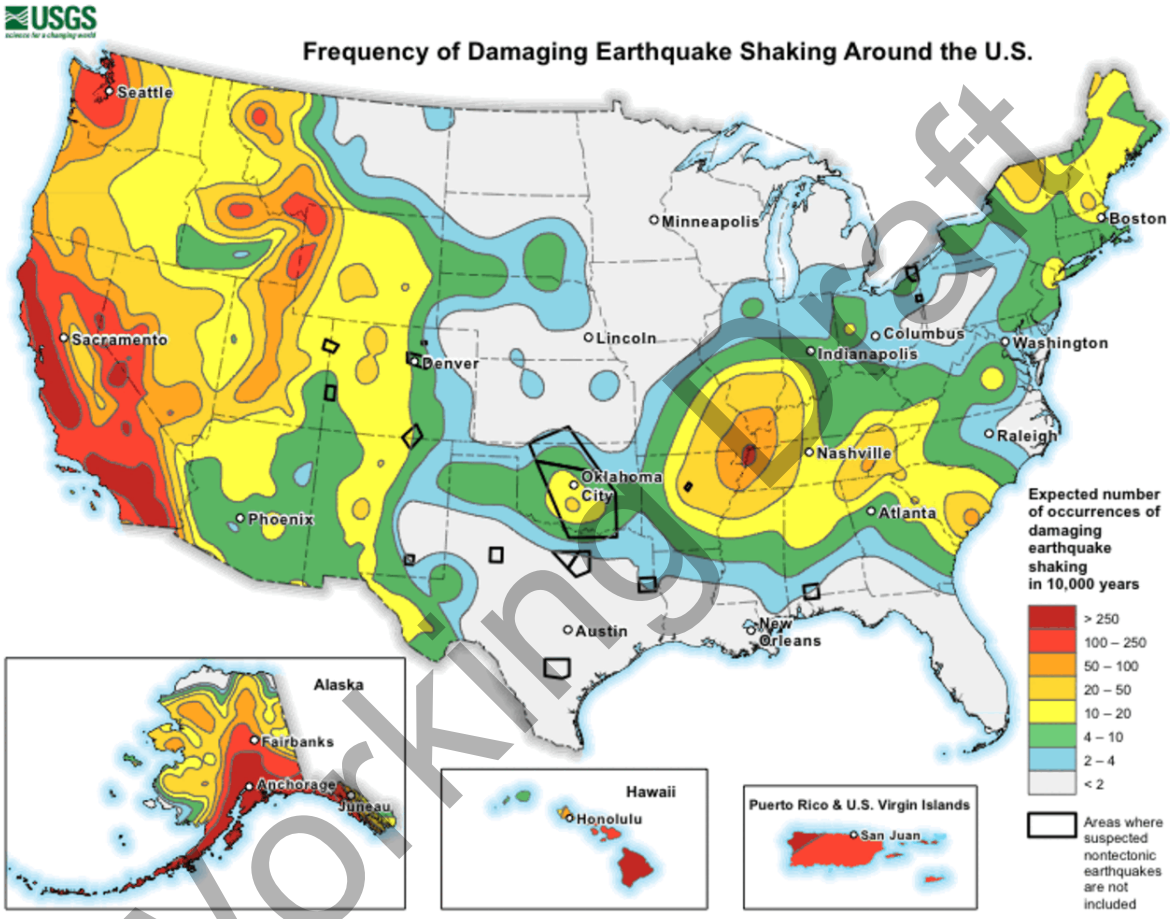


Future Occurrence

As aforementioned, Jefferson County has a 2 percent chance of exceeding a Peak Ground Acceleration (PGA) of 8-10 %g in 50 years according to Figure 3.3.2-2. The probability of an earthquake occurring in Jefferson County each year is very low, and the probability of a destructive earthquake is highly improbable. Historical records indicate that the future likelihood of an earthquake is *unlikely* as defined by the Risk Factor Methodology probability criteria (see Table 4.4.1-1).

Figure 3.3.2-5 depicts how many times earthquakes can cause damaging earthquakes (MMI VI or greater) in 10,000 years. The State of West Virginia 2023 Hazard Mitigation Plan states earthquakes of any magnitude can happen at any time in West Virginia. The figure shows that the northern portion of the state can expect between 2 and 4 damaging earthquakes in 10,000 years.

Figure 3.3.2-5: Frequency of Damaging Earthquake Shaking Around the United States, (USGS, 2023)



As of 2021, six seismic monitoring stations exist across West Virginia. These stations collect data about any future earthquake events and may help West Virginians further understand their earthquake risk.

Range of Magnitude

The map in Figure 3.3.2-1 is measured using Peak Ground Acceleration (PGA). This is defined as the maximum acceleration experienced by an area during the motion of an earthquake. This unit of measure is often used because building codes tend to regulate how much horizontal force a building should be able to endure during an earthquake, and force is directly proportional to acceleration. This is measured in %g, referring to the quotient of the PGA divided by the acceleration due to gravity (known as g, which is a

constant of 9.80665 m/sec^2) expressed as a percentage. A reference point for this unit of measure is 10%g, which the USGS believes approximates the maximum threshold of damage for pre-1965 or non-earthquake resistant buildings and roughly equates to VI to VII on the Modified Mercalli Intensity Scale, which is defined below (USGS, 2016).

The impact of an earthquake event is often measured in terms of earthquake intensity, which is measured using the Modified Mercalli Intensity (MMI) Scale, shown in Table 3.3.2-1. This scale has a measure of severity from I to XII, and relates to another commonly used scale, the Richter Scale (USGS, 2016).

Table 3.3.2-1 Modified Mercalli Intensity Scale with Associated Impacts.

Scale	Intensity	Description	Corresponding Richter Scale Magnitude
I	Instrumental	Usually detected only on seismographs.	<4.2
II	Feeble	Felt only by a few persons at rest, especially on upper floors of buildings.	
III	Slight	Felt quite noticeably indoors, especially on upper floors. Most people do not recognize it as an earthquake (i.e. a truck rumbling).	
IV	Moderate	Can be felt by people walking; dishes, windows, and doors are disturbed.	
V	Slightly Strong	Sleepers are awoken; unstable objects are overturned.	<4.8
VI	Strong	Trees sway; suspended objects swing; objects fall off shelves; damage is slight.	<5.4
VII	Very Strong	Damage is negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, and considerable in poorly built or badly designed structures; some chimneys are broken.	<6.1
VIII	Destructive	Damage is slight in specially designed structures; considerable in ordinary, substantial buildings. Moving cars become uncontrollable; masonry fractures, poorly constructed buildings damaged.	<6.9
IX	Ruinous	Some houses collapse, ground cracks, pipes break open; damage is considerable in specially designed structures; buildings are shifted off foundations.	
X	Disastrous	Some well-built wooden structures are destroyed; most masonry and frame structures are destroyed along with foundations. Ground cracks profusely; liquefaction and landslides widespread.	<7.3

Table 3.3.2-1 Modified Mercalli Intensity Scale with Associated Impacts.			
Scale	**Intensity**	**Description**	**Corresponding Richter Scale Magnitude**
XI	**Very Disastrous**	Most buildings and bridges collapse, roads, railways, pipes, and cables destroyed.	<8.1
XII	**Catastrophic**	Total destruction; trees fall; lines of sight and level are distorted; ground rises and falls in waves; objects are thrown upward into the air.	>8.1

Source: USGS - The Modified Mercalli Intensity Scale

Earthquake magnitudes are often measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake. Table 3.3.2-2 summarizes Richter Scale magnitudes as they relate to the spatial extent of impacted areas. The Richter Scale does not give any indication of the impact or damage of an earthquake, although it can be inferred that higher magnitude events cause more damage. Instead, the Modified Mercalli Intensity Scale is used to measure earthquake intensity (USGS, 2016).

Table 3.3.2-2 Richter Scale Magnitudes and Associated Earthquake Size Effects.	
Richter Magnitudes	**Earthquake Effects**
Less than 3.5	Generally, not felt but recorded.
3.5-5.4	Often felt, but rarely causes damage.
Under 6.0	At most, slight damage to well-designed buildings; can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive up to about 100 kilometers from epicenter.
7.0-7.9	Major earthquake; can cause serious damage over large areas.
8.0 or greater	Great earthquake; can cause serious damage in areas several hundred kilometers across.

Source: USGS Richter Scale

The worst earthquake recorded in West Virginia according to records maintained by The West Virginia Geological and Economic Survey was a magnitude 4.6 (or VI MMI) earthquake centered in Mercer County, WV, a county along the southern border of the state. Therefore, a worst-case scenario for this hazard would likely be if an earthquake of similar magnitude occurred in the Eastern Panhandle region or near the border of adjacent counties, which may cause mild damage in populated areas. Structural damage would not be expected in this scenario for most buildings, but blighted structures or those in a state of disrepair might experience further structural damage (West Virginia Geological and Economic Survey, 2016).

Environmental impacts of earthquakes can be numerous, widespread, and devastating, particularly if

indirect impacts like economic impacts are considered. Earthquakes are known for causing induced tsunamis, flooding, landslides, and avalanches; poor water quality; damage to vegetation; and breakage in sewage or toxic material containments. However, because of their geographic location, these impacts are extremely unlikely to occur in Jefferson County (USGS, 2016).

Vulnerability Assessment

The somewhat random historical occurrences of earthquakes would indicate that all structures throughout Region 9's counties to be equally at risk from earthquakes. The severity of those earthquakes, though, is expected to be very low. In a mild earthquake of the magnitude typically experienced in West Virginia, no structural damage is anticipated. In other cases, damages are expected to be limited, and examples of anticipated damages are broken dishes and windows and toppled file cabinets.

However, for earthquakes, the available history covers a period of less than 300 years, which is a relatively short period of time for an examination of earthquakes. Large earthquakes may only affect a location every several centuries or millennia. Environmental impacts of earthquakes can be numerous, widespread, and devastating, particularly if indirect impacts are considered. Some secondary hazards caused by earthquakes may include fire, hazardous material release, landslides, flash flooding, avalanches, tsunamis, and dam failure. These secondary events could also result in disruptions to natural ecosystems, poor water quality, damage to vegetation, and the release of toxic materials and sewage. Impacts to infrastructure could include train derailments, pipe failures, and utility interruptions. A very large earthquake affecting the counties might cause structural damage in dilapidated structures or structures that do not meet current building codes. Thus, the impact of an earthquake might range from negligible to catastrophic. Based on historical data for the counties, damage is likely to be minimal.

FEMA's National Risk Index indicates that Jefferson County's risk index is very low compared to other counties to the United States, in fact 45% of U.S. counties have a lower risk index than Jefferson County. The risk index rating for neighboring jurisdictions is relatively low for Berkeley County (West Virginia) and Loudoun County (Virginia), while Clarke County (Virginia) is very low.

The hazard type Risk Index score measures the relative risk of a community for a specific hazard type by comparing its hazard type Risk Index value with other communities at the same level. These scores are calculated using data for only a single hazard type and reflect a community's Expected Annual Loss (EAL) value, community risk factors, and the adjustment factor used to calculate the risk value. The composite Hazard Type Risk Index score for earthquake in Jefferson County is detailed in Table 3.3.2-5.

Table 3.3.2-5 Jefferson County Earthquake Hazard Type Risk Index Score

Hazard Type	Expected Annual Loss Value	Social Vulnerability	Community Resilience	Community Risk Factor	Risk Value	Score
Earthquake	$121,715	Very Low	Relatively Moderate	1.04	$135,772	47.8

Source: National Risk Index – Jefferson County, West Virginia

Jefferson County as an expected annual loss value of $121,715 from an earthquake impact, is rated "very low" for social vulnerability, and is "relatively moderate" in terms of community resilience.

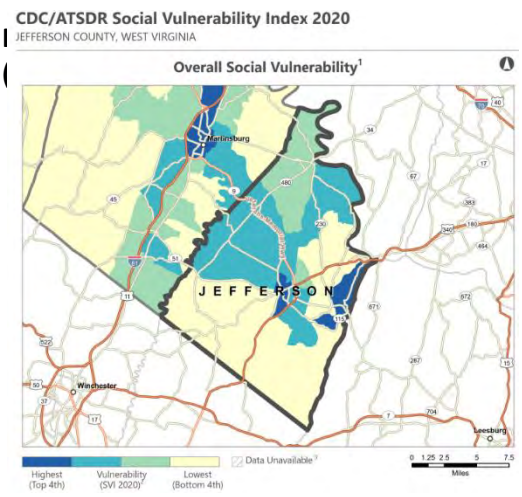
People

Earthquakes can affect people and structures alike, although older structures may be more susceptible to cracks and damage. "With most earthquakes, trauma caused by the collapse of buildings is the cause of most deaths and injuries. However, a surprisingly large number of patients require acute care for non-surgical problems such as acute myocardial infraction, exacerbation of chronic diseases such as diabetes or hypertension, anxiety and other mental health problems, respiratory disease from exposure to dust and asbestos fibers from rubble, and near drowning because of flooding from broken dams. As with most natural disasters, the risk of secondary epidemics is minimal, and only mas vaccination campaigns based on results of epidemiological surveillance are appropriate following earthquakes" (Noji, 1999).

The HAZUS-MH program from the Federal Emergency Management Agency analyzes the effects of a potential earthquake striking Jefferson County. The scenario depicts a 5.0 earthquake (the lowest possible magnitude to use in the program) located at the epicenter of the latest 2016 earthquake, just northeast of Ranson. According to the Hazus results, estimates for the county are as follows:

- 118 injuries that require medical attention, but not hospitalization,
- 28 injuries that require hospitalization, but are not life-threatening,
- 5 injuries that require hospitalization that can become life-threatening if not promptly treated, and
- 7 deaths.

In terms of social vulnerability, the National Risk Index (NRI) determines social group susceptibility to the adverse impacts of natural hazards when compared to the rest of the U.S. This is measured using the Social Vulnerability Index (SVI) published by the Centers for Disease Control and Prevention (CDC). The SVI considers well-established indicators of social vulnerability, including socioeconomic status, household characteristics, racial & ethnic minority status, and housing type & transportation.



According to the NRI, people, including underserved communities and socially vulnerable populations, in Jefferson County have a very low susceptibility to the adverse impacts of natural hazards in comparison to the rest of the U.S. Related to neighboring jurisdictions, Loudoun County (Virginia) social vulnerability is very low as well, while Berkley County is relatively low. The likelihood of an

earthquake causing major damage or injuries in Jefferson County is low, however, the area in and around Charles Town and south of Harpers Ferry, which contains socially vulnerable populations, Figure 3.3.2.6 should be considered for preparedness and response activities.

Structures

Considering that there is no history of damage in the region due to earthquakes, damages are estimated to be limited to the more dilapidated structures and structures with unreinforced masonry. Therefore, structures identified as potentially at risk of damage due to an earthquake are older structures. In consideration of new structures, modern building codes and the low expected magnitude of earthquakes in the county, limited property damage is anticipated.

The Hazus analysis data in Tables 3.3.2-6 and 3.3.2-7 have not been recently updated, however due to the low probability of an earthquake event and damages resulting from the magnitude of an earthquake likely to be experienced by Jefferson County. Based on past earthquake hazard occurrences specific to Jefferson County, the previous Hazus analysis is sufficient for planning purposes. Keep in mind that the Hazus analysis used a probabilistic earthquake scenario, which was not a past occurrence.

Building damages by occupancy type and the building-related economic loss estimates results from FEMA's Hazus program for the earthquake scenario, a 5.0 earthquake with the epicenter just northeast of Ranson, are described in the following tables. Note, historical occurrences for Jefferson County indicates that two (2) earthquakes were felt by people in the area, however, no damages or deaths were reported.

Table 3.3.2-6 Jefferson County Expected Building Damage By Occupancy (Hazus)

	None		Slight		Moderate		Extensive		Complete	
	Count	%	Count	%	Count	%	Count	%	Count	%
Agriculture	25	0.30	22	0.41	25	0.62	10	0.71	3	0.79
Commercial	207	2.43	162	3.04	222	5.46	108	7.34	32	8.43
Education	9	0.10	6	0.12	9	0.22	4	0.28	1	0.32
Government	11	0.12	8	0.15	12	0.30	6	0.43	2	0.50
Industrial	68	0.80	51	0.95	79	1.95	42	2.84	13	3.27
Other Residential	1,655	19.46	1,173	21.92	1,269	31.29	602	41.00	138	35.93
Religion	31	0.37	20	0.37	19	0.47	9	0.58	2	0.61
Single Family	6,503	76.43	3,908	73.05	2,424	59.72	688	46.81	192	50.15
TOTAL	**8,509**		**5,350**		**4,060**		**1,469**		**383**	

Source: 2018 Jefferson County Hazard Mitigation Plan

Table 3.3.2-7 Jefferson County Hazus Building-Related Economic Loss Estimates (Millions Of Dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses	Wage	0.00	3.53	13.25	0.68	1.27	**18.74**
	Capital Related	0.00	1.49	11.89	0.40	0.21	**14.00**
	Rental	6.43	4.67	5.16	0.25	0.58	**17.10**

	Relocation	23.77	4.14	8.40	1.30	3.65	**41.26**
	Subtotal	30.20	13.83	38.71	2.64	5.71	**91.09**
Capital Stock Losses	Structural	36.88	7.08	9.14	3.16	3.72	**59.98**
	Non-Structural	126.40	26.92	27.66	10.10	9.61	**200.70**
	Content	46.66	6.78	14.58	6.86	5.42	**80.30**
	Inventory	0.00	0.00	0.36	1.57	0.13	**2.06**
	Subtotal	209.94	40.79	51.74	21.70	18.88	**343.04**
TOTAL		**240.14**	**54.61**	**90.45**	**24.33**	**24.59**	**434.13**

Source: 2018 Jefferson County Hazard Mitigation Plan

In addition to overall building losses, essential facilities may suffer some damage based on the probabilistic earthquake scenario, not past occurrences.

Systems

An earthquake may precipitate a major technologic disaster by damaging or destroying nuclear power stations, hospitals with dangerous biologic products, hydrocarbon storage areas, and hazardous chemical plants. Hazus generated the following results for utility systems in Jefferson County.

- **Transportation and Utility Lifeline Damage**: two bridges and one light rail facility will have at least moderate damage; economic loss estimate is $4.8 million.
- **Utility System Facility Damage**: one potable water, eleven wastewater, and three communications facilities will have at least moderate damage; economic loss estimate is $203.10 million.
- **Utility System Pipeline Damage**: there will be 211 potable water, 106 wastewater, and 36 natural gas pipeline leaks, and 53 potable water, 26 wastewater, and nine natural gas pipeline breaks.

Historic Resources & Community Activities

Historic buildings are especially vulnerable considering the structures were not designed and constructed to absorb the swaying ground motions caused by earthquakes. Therefore, major structural damage, or outright collapse, can result. However, given the extremely low risk factor and associated impacts for Jefferson County, the likelihood of damages resulting from an earthquake are very low. This is also true for impacts from an earthquake to community events. While a slight disruption to events may occur as a result of an earthquake in the region, long term disruptions or event cancelations are not anticipated from this hazard, based on past occurrences.

3.3.3 Extreme Temperatures

Extreme temperature includes both hot and cold temperatures. Extreme cold temperatures drop well below what is considered normal for an area during the winter months and often accompany winter storm events. Combined with increases in wind speed, such temperatures in West Virginia can be life threatening to those exposed for extended periods of time. Extreme temperatures can be described as temperatures that are 10°F or more above or below the average temperature for a region during summer and winter months.

The National Oceanic and Atmospheric Administration (NOAA) can generate reports of monthly "normals" at its different stations. The data chosen for the region is from the Eastern WV Regional Airport (the closest to Jefferson County in West Virginia).

Heat

Temperatures vary widely over the course of a year, but each season has average temperature ranges associated with them. Summer and winter have, generally, the highest and lowest range of temperatures, respectively. When the temperature is consistently greater than the normal in summer, meteorologists refer to it as a heat wave, which means, "temperatures of ten or more degrees above the average high temperature persist across the geographic region for several days or weeks" (Haddow, Bullock, & Coppola, 2014, p.51). These conditions can be a contributor to drought conditions when combined with a lack of rainfall. Excessive heat has a history of being deadly. In the United States, "more than 1,500 die from exposure to excessive heat" (Haddow, Bullock, & Coppola, 2014, p.52). These conditions can also have serious impacts on crops, causing below average harvests. Repeated years of extreme temperatures can easily cause significant economic impacts on agricultural industries. The National Centers for Environmental Information (NCEI) tracks two types of extreme heat temperatures.

- **Heat:** A period of heat resulting from the combination of high temperatures (above normal) and relative humidity. A heat event occurs whenever heat index values meet or exceed locally/regionally established advisory thresholds, or a directly related fatality occurs due to the heat event.

- **Excessive Heat:** Excessive heat results from a combination of high temperatures (well above normal) and high humidity. An excessive heat event occurs when heat index values meet or exceed locally/regionally established excessive heat warning thresholds, on a widespread or localized basis (National Weather Service Instruction 10-1605, 2007).

Cold

While there is no widely accepted definition of extremely cold temperatures, periods of colder than average conditions can cause an array of negative consequences depending on their duration (Haddow,

Bullock, & Coppola, 2014, p.51). Extremely cold temperatures are immediately dangerous to both humans and livestock by causing frostbite and hypothermia, which can lead to permanent injury and death. The chart on the next page shows how quickly frostbite can occur at different temperatures and wind speeds. In unprotected structures cold temperatures can freeze water pipes causing them to burst upon thawing, leading to significant damage. Cold snaps during typically warmer weather during the growing season can damage and destroy some crops, depending on their sensitivity to temperature. 71 Jefferson County Hazard Mitigation Plan 2.0 Risk Assessment NCEI tracks two types of extreme cold temperatures.

- **Cold/Wind Chill:** Period of low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined advisory (typical value is -18° F or colder) conditions, on a widespread or localized basis. There can be situations where advisory criteria are not met, but the combination of seasonably cold temperatures and low wind chill values (roughly 15° F below normal) may result in a fatality.

- **Extreme Cold/Wind Chill:** A period of extremely low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined warning criteria (typical value around -35° F or colder), on a widespread or localized basis. Normally these conditions should cause significant human and/or economic impact. The polar vortex is a large area of low pressure and cold air surrounding both of the Earth's poles. It ALWAYS exists near the poles, but weakens in summer and strengthens in winter. The term "vortex" refers to the counter-clockwise flow of air that helps keep the colder air near the Poles. Many times during winter in the northern hemisphere, the polar vortex will expand, sending cold air southward with the jet stream. This occurs fairly regularly during wintertime and is often associated with large outbreaks of Arctic air in the United States.

In addition to the extreme cold temperature events listed above, NCEI tracks "Frost/Freeze" conditions.

- **Frost/Freeze:** The threshold for these conditions can be met when the temperature falls below 36°F but impact is further exacerbated the more the temperature drops. When the temperature hits below 32°F, it is more likely that a larger portion of the environment will be affected. When the temperature falls below 28°F, the event can be classified as a "hard freeze" because of its severity. Jefferson County typically experiences its first range of Freeze events of the year sometime between October and mid-November. Because temperatures commonly drop below the thresholds for Frost/Freeze in the winter, weather warnings are only issued for these events from May 1 to October 20.

Location and Extent

All of Jefferson County is subject to extreme temperatures in the summer and winter seasons. Urban environments are more susceptible to extreme heat as they tend to retain the heat well into the night, leaving little opportunity for dwellings to cool. Demographics also are a consideration, as large

populations of elderly or poor represent those most vulnerable to temperature extremes.

Table XXX shows monthly mean maximum and minimum temperatures between 1981 and 2010 and the average number of days where temperatures exceed 90°F or drop below 32°F. Elevation, topography, and surrounding development may account for much of the difference between these two locations. The Eastern Panhandle reaches its highest maximum mean daily temperature in July. Eastern WV Regional Airport climbs to a mean daily maximum of 85.8 °F in July. The region reaches its lowest temperatures in January, with Eastern WV Regional Airport ~~(Martinsburg Regional Airport)~~ dropping to a mean daily minimum of 22.3°F (NCEI NOAA, 2021).

Table 3.3.3-1: Summary of Monthly Extreme Temperatures (°F), 1981-2010, Martinsburg Eastern WV Regional Airport (NCEI NOAA, 2021)

	Mean		Mean Number of Days	
Month	Daily Max	Daily Min	Max >= 90	Min <= 32
Jan	39.5	22.3	0.0	25.7
Feb	43.2	24.4	0.0	22.7
March	52.6	31.4	0.0	16.5
April	64.0	40.8	0.1	4.5
May	72.7	49.6	0.8	0.2
June	81.7	58.9	3.6	0.0
July	85.8	63.7	7.5	0.0
Aug	83.9	61.8	5.6	0.0
Sept	76.7	53.9	1.5	0.0
Oct	65.4	42.3	0.0	3.7
Nov	54.3	34.1	0.0	12.1
Dec	42.8	25.5	0.0	23.9
Summary	63.6	42.4	19.1	109.3

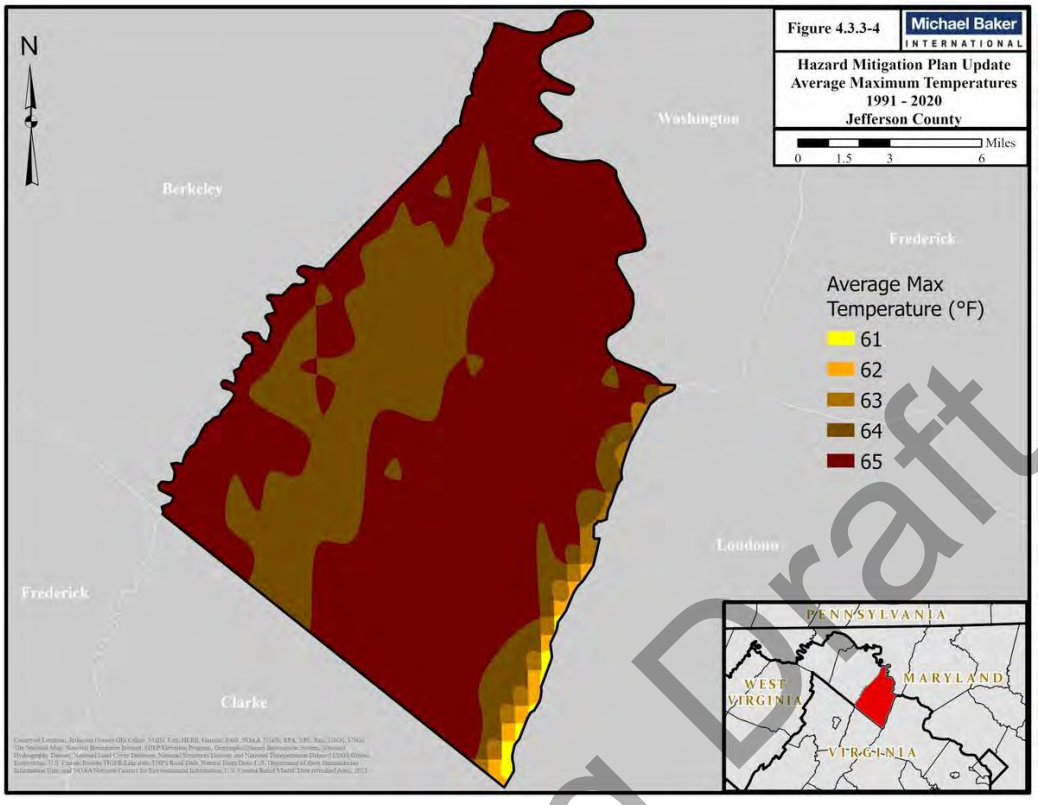
Table 2: Summary of Monthly Extreme Temperatures (°F), 1980-2023 Martinsburg Eastern WV Regional Airport (NCEI NOAA, 2021)		
Month	**Daily Max**	**Daily Min**
Jan	75 in 1997	-18 in 1994
Feb	83 in 2018	-5 in 1996
March	88 in 2018	-3 in 2014
April	93 in 2002	19 in 2013
May	96 in 1996	30 in 2005
June	102 in 2012	39 in 1993
July	107 in 1988	48 in 2010
Aug	103 in 1991	40 in 1986
Sept	100 in 1998	32 in 2020
Oct	92 in 2019	22 in 1992
Nov	81 in 1982	13 in 2014
Dec	78 in 2001	-12 in 1983

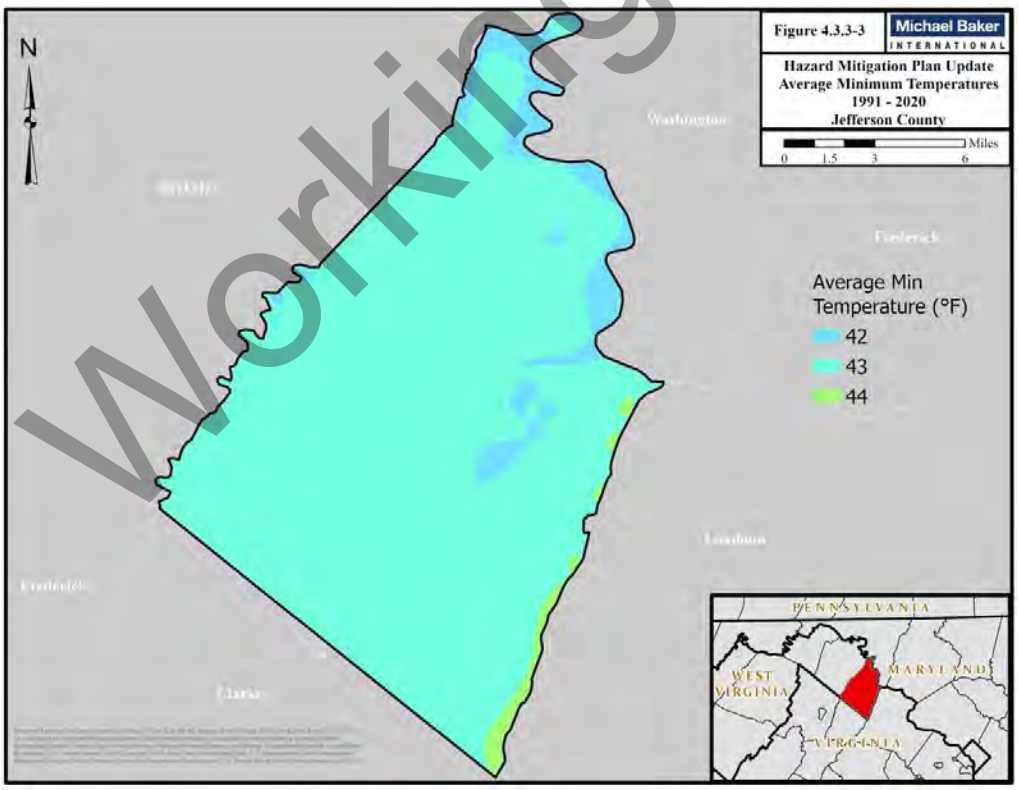
Given Martinsburg's proximity to Jefferson County, it is beneficial to use its data because the National Weather Service does not provide information for specific towns or cities in the county. From 1980 to 2023, Martinsburg experienced numerous abnormal weather events, as portrayed in Figure XXX. One of the most notable discrepancies between the monthly daily maximums and minimums happened just four years apart. In March 2018, the highest recorded value was 88 degrees while in 2014 the lowest recorded value was -3.

It is beneficial to use Eastern WV Regional Airport's data because the NWS does not provide data for cities or towns in Jefferson County.

Past Occurrence

The region has often encountered severe and dangerous temperatures in the past. A map of minimum temperatures in Jefferson County can be seen in Figure XXXX, and a map of maximum temperatures can be seen in Figure XXXX for the years 1981 to 2010. This data was the most current geospatial temperature data available for analysis (NOAA, 2021). Previous temperature extremes impacting Jefferson County can be as seen in Table XXXX. Historically, the Eastern WV Regional Airport experienced a WV record of 112°F on July 11, 1936. According to the NWS Heat Index in Figure 4.3.4-1, a temperature of that magnitude presents an extreme danger. On the other end of the spectrum, on January 21, 1994, Eastern WV Regional Airport reached -18°F (The Weather Channel, 2016). With wind chill, these cold temperatures could quickly cause frostbite on exposed skin.





Since 1997, the NCEI reports a total of 33 heat events, four excessive heat events, nine cold/wind chill events, five extreme cold/wind chill events, and 37 Frost/Freeze events. Heat events are more prevalent historically with a total of 37 events, while cold events since 1997 have only amounted to 47. All combined, there have been a total of 88 extreme temperature events that NCEI has recorded. The occurrences between 1997 and 2023 are outlined in Table 3 below, which includes event-specific injuries and crop damage. The NCEI has not reported any deaths or property damage as a result of extreme temperatures.

Table 3.3.3-3: Temperature Extremes Impacting Jefferson County (1997-2023) (NOAA NCEI, 2023)

Date	Event	Injuries	Crop Damage ($)	Date	Event	Injuries	Crop Damage ($)
4/10/1997	Frost/Freeze	0	1000000	10/29/2011	Frost/Freeze	0	0
8/16/1997	Heat	0	0	3/27/2012	Frost/Freeze	0	0
1/6/1998	Heat	0	0	7/7/2012	Heat	0	0
3/11/1998	Cold/Wind Chill	0	0	10/13/2012	Frost/Freeze	0	0
3/27/1998	Heat	0	0	5/14/2013	Frost/Freeze	0	0
7/21/1998	Heat	0	0	10/25/2013	Frost/Freeze	0	0
6/7/1999	Heat	3	0	10/18/2015	Frost/Freeze	0	0
7/4/1999	Heat	0	0	10/19/2015	Frost/Freeze	0	0
1/2/2000	Excessive Heat	0	0	4/3/2016	Frost/Freeze	0	0
1/21/2000	Extreme Cold/Wind Chill	0	0	4/5/2016	Frost/Freeze	0	0
1/22/2000	Extreme Cold/Wind Chill	0	0	4/5/2016	Frost/Freeze	0	0
1/27/2000	Extreme Cold/Wind Chill	0	0	4/9/2016	Frost/Freeze	0	0
3/8/2000	Heat	0	0	4/13/2016	Frost/Freeze	0	0
5/6/2000	Heat	0	0	4/14/2016	Frost/Freeze	0	0
6/10/2000	Heat	0	0	7/25/2016	Heat	0	0
6/25/2000	Heat	0	0	8/13/2016	Heat	0	0
12/22/2000	Extreme Cold/Wind Chill	0	0	10/26/2016	Frost/Freeze	0	0
4/19/2001	Extreme Cold/Wind Chill	0	0	5/9/2017	Frost/Freeze	0	0
6/12/2001	Heat	0	0	7/20/2017	Heat	0	0
6/27/2001	Heat	0	0	10/27/2017	Frost/Freeze	0	0
8/6/2001	Heat	0	0	1/5/2018	Cold/Wind Chill	0	0
5/20/2002	Frost/Freeze	0	0	4/21/2018	Frost/Freeze	0	0
7/2/2002	Heat	0	0	6/18/2018	Heat	0	0
7/28/2002	Heat	0	0	7/1/2018	Heat	0	0
8/1/2002	Heat	0	0	7/2/2018	Heat	0	0
8/12/2002	Heat	0	0	7/3/2018	Heat	0	0

Table 3.3.3-3: Temperature Extremes Impacting Jefferson County (1997-2023) (NOAA NCEI, 2023)							
Date	Event	Injuries	Crop Damage ($)	Date	Event	Injuries	Crop Damage ($)
8/22/2002	Heat	0	0	9/4/2018	Heat	0	0
12/7/2002	Cold/Wind Chill	0	0	10/19/2018	Frost/Freeze	0	0
1/10/2004	Cold/Wind Chill	0	0	1/21/2019	Cold/Wind Chill	0	0
1/15/2004	Cold/Wind Chill	0	0	1/30/2019	Cold/Wind Chill	0	0
1/31/2004	Cold/Wind Chill	0	0	7/19/2019	Excessive Heat	0	0
4/28/2004	Frost/Freeze	0	0	7/20/2019	Excessive Heat	0	0
10/27/2005	Frost/Freeze	0	0	7/21/2019	Excessive Heat	0	0
10/29/2005	Frost/Freeze	0	0	10/19/2019	Frost/Freeze	0	0
5/23/2006	Frost/Freeze	0	0	4/16/2020	Frost/Freeze	0	0
7/17/2006	Heat	0	0	4/18/2020	Frost/Freeze	0	0
8/1/2006	Heat	0	0	5/8/2020	Frost/Freeze	0	0
10/13/2006	Frost/Freeze	0	0	5/9/2020	Frost/Freeze	0	0
4/6/2007	Frost/Freeze	0	0	7/19/2020	Heat	0	0
4/7/2007	Frost/Freeze	0	0	7/20/2020	Heat	0	0
4/8/2007	Frost/Freeze	0	0	10/31/2020	Frost/Freeze	0	0
4/9/2007	Frost/Freeze	0	0	4/23/2021	Frost/Freeze	0	0
4/10/2007	Frost/Freeze	0	0	8/12/2021	Heat	0	0
10/29/2007	Frost/Freeze	0	0	12/23/2022	Cold/Wind Chill	0	0
7/22/2011	Excessive Heat	0	0				

Future Occurrence

Jefferson County is unlikely to face hazardous extreme temperatures in a given year, though temperatures are of some concern during winter and summer months. Jefferson County is more likely to encounter extreme cold weather than excessive heat. As seen in Table XXXX the region is more likely to experience temperatures under 0°F than over 100°F in a given year. However, topography and vegetation can impact temperature differentials in the area. Therefore, the probability of an extreme temperature event in the region is considered *possible* as defined by the Risk Factor Methodology probability criteria.

Members of the Hazard Mitigation Committee rated temperature hazards a medium level of concern, but as seen in Table XXXXX, Jefferson County should be aware of a general trend of warming. According to the Fourth National Climate Assessment, which utilized the Intergovernmental Panel on Climate Change's Representative Concentration Pathways (RCP) 4.5 and 8.5 scenarios, the annual average temperature across the United States is projected to increase by 2.5°F (RCP 4.5) or 2.9°F (RCP 8.5) between 2021 and 2050, relative to 1976-2005. The RCP 4.5 scenario assumes moderate measures are taken to reduce

emissions, while the 8.5 scenario assumes a lower effort and thus more severe impacts. For the Northeast region, the change in annual average temperature is 3.98°F (RCP 4.5) or 5.09°F (RCP 8.5) by 2036-2065 and 5.27°F (RCP 4.5) or 9.11°F (RCP 8.5) by 2071-2100. These changes translate to approximately 20 to 30 more days above 90°F and 20 to 30 fewer days below freezing in the northeastern parts of the United States by mid-century (RCP 8.5) (Vose et al. 2017).

Range of Magnitude

Temperature advisories, watches, and warnings are issued by the National Weather Service (NWS) relating the above impacts to the range of temperatures typically experienced in West Virginia. Table 4 summarizes thresholds for heat advisories given across the region.

Table 3.3.3-4: Thresholds for Heat Advisories (NWS, 2021)

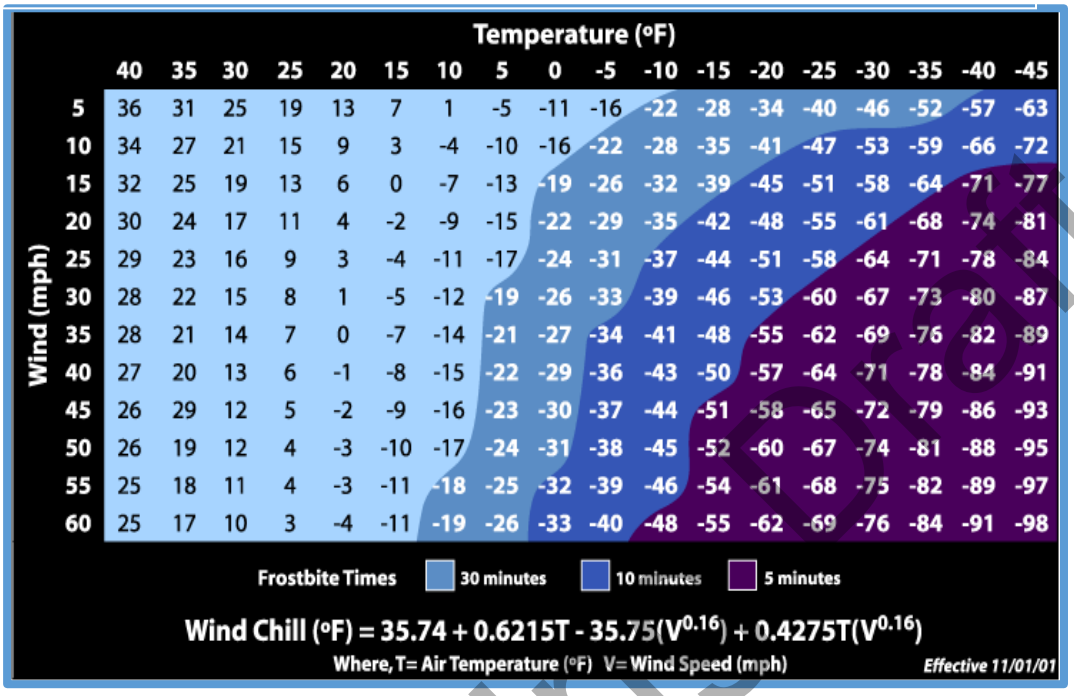
Advisory Level	Description
Heat Advisories	Criteria for a Heat Advisory is a heat index of 100-104°F. The heat index must remain at or above criteria for a minimum of 2 hours. Heat advisories are issued by county when any location within that county is expected to reach criteria
Excessive Heat Warnings	Criteria for an Excessive Heat Warning is a heat index of 105°F or greater that will last for 2 hours or more. Excessive Heat Warnings are issued by county when any location within that county is expected to reach criteria
Excessive Heat Watches	Issued when Heat Warning criteria is possible (50-79 percent) 1 to 2 days in advance

In terms of human health concerns, extremely high temperatures cause heat stress which can be divided into four categories. Each category is defined by apparent temperature which is associated with a heat index value that captures the combined effects of dry air temperature and relative humidity on humans and animals. Major human risks for these temperatures include heat cramps, heat syncope, heat exhaustion, heatstroke, and death. Note that while the temperatures in Figure XXXXX serves as a guide for various danger categories, the impacts of high temperatures will vary from person to person based on individual age, health, and other factors. The elderly, the very young, and those with low or no income are most vulnerable to health-related impacts of extreme temperatures (Seltenrich, 2015).

Cold temperatures can be extremely dangerous to humans and animals exposed to the elements. Without heat and shelter, cold temperatures can cause hypothermia, frost bite, and death. Wind chill temperatures are often used in place of raw temperature values because wind can have in drawing heat from the body under cold temperatures (NOAA NWS, 2021). These values represent what temperatures actually feel like to humans and animals under cold, windy conditions. Similarly, to high temperatures, the effect of cold temperatures will vary by individual.

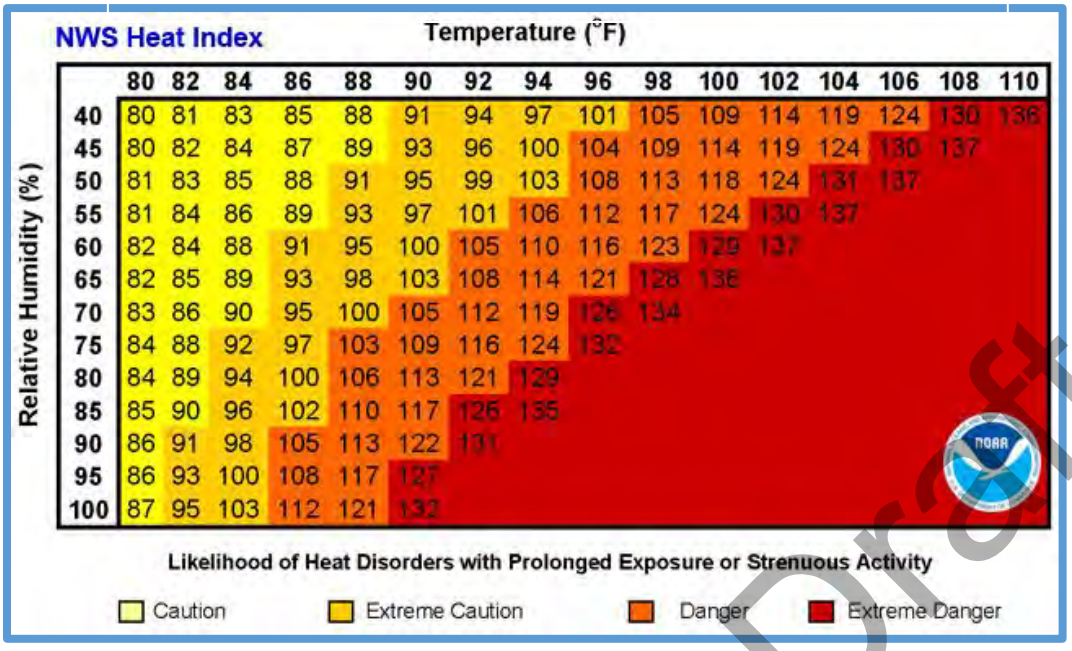
Figure XXXX and Figure XXXX shows the effects of wind speed on extreme cold events and humidity on extreme heat events. These compounding factors can increase the risk experienced by vulnerable populations and the public.

Figure 3.3.3-3: Danger Posed by Low Temperatures and Wind (NOAA NWS, 2021)



Cold weather has several effects, most dramatically on the general population mortality rate. The average mortality on a winter day is about 15 percent higher than on a summer day. Cold weather is directly responsible for deaths through hypothermia, influenza, and pneumonia. It is also an indirect factor in several ways such as death and injury from falls, accidents, carbon monoxide poisoning, and house fires all of which are partially attributable to cold. Exposure to heat can also cause health problems indirectly, such as through increased workload on the heart. This can be especially dangerous to individuals with pre-existing medical conditions, typically the elderly (Seltenrich, 2015).

Figure 3.3.3-4: Danger Posed by Heat and Humidity (NOAA NWS,



The following impacts can be observed following extreme temperature events:

- ***Health Impacts:*** The health impacts of extreme cold are greater in terms of mortality in humans, but often after more prolonged exposure vs. a cold snap. Extreme heat waves, however, can prove more deadly over a shorter duration. At greatest risk of death in heat waves are the urban-dwelling elderly without access to an air-conditioned environment for at least part of the day.
- ***Transportation:*** Cold weather can impact automotive engines, possibly stranding motorists, and stress metal bridge structures. Highway and railroad tracks can become distorted in high heat. Disruptions to the transportation network and accidents due to extreme temperatures represent an additional risk.
- ***Agriculture:*** Absolute temperature and duration of extreme cold can have devastating effects on trees and winter crops. Livestock is especially vulnerable to heat and crop yields can be impacted by heat waves that occur during key development stages.
- ***Energy***: Energy consumption rises significantly during extreme cold weather, and any fuel shortages or utility failures that prevent the heating of a dwelling place residents in extreme danger. Extreme heat also can result in utility interruptions, and sagging transmission lines due to the heat can lead to shorting out.

The range of these impacts, especially health effects, can be mitigated through improved forecasts, warnings, community preparedness, and appropriate community-based response. A worst-case event for Jefferson County would include extreme cold temperatures, with injuries resulting from direct exposure (as a result of an interruption of energy supplies), and from being cut off from medical care due to associated snow or ice impacting travel. Medical afflictions could be a result of direct influence on the

coronary circulation system and the respiratory system, and influenza and other infectious diseases would be secondary impacts. Extreme heat could also be disastrous, particularly if mixed with effect of a drought (Seltenrich, 2015).

Vulnerability Assessment

The potential for extreme heat and cold always exists in and around the summer and winter months. Meteorologists and weather forecasters can normally predict the temperature with excellent accuracy. Adhering to extreme temperature warnings can significantly reduce the risk of temperature related deaths. Those hardest hit by both heat and cold waves are adults 75 years of age or older, many who are already physically vulnerable. Excessive heat exposure also affects people with certain pre-existing medical conditions, including cardiovascular disease, respiratory illnesses, and obesity. As of July 2022, 17.3% of Jefferson County's population was over the age of 65, while 33% of the population was classified as obese in 2021. Additionally, Jefferson County's ageing population grew by 58.7% between 2010 and 2021, becoming the fastest-growing age group in the area. Efforts to mitigate the impacts should focus on those groups most vulnerable. These groups will more likely be located in XXXXX, where the population is aging; however, affects will be noticed in senior communities and neighborhoods in Jefferson County. Officials should also focus on mobile home parks, where populations also tend to be aging. Jefferson County is vulnerable to extreme temperatures, but vulnerabilities are extremely individualized among the general population and will continue to be extremely difficult to address from a county-wide or even local emergency response standpoint.

People

Historically, only one person in Jefferson County has suffered physical injuries from extreme temperatures and there have been no deaths. However, as extreme temperature events increase in frequency, the likelihood they will impact the population also increases.

Extreme temperature events can pose a threat to the entire county's population. Still, certain populations are considerably more vulnerable to experiencing health issues due to underlying health conditions or age. People living without adequate access to air conditioning and heating are also particularly vulnerable.

From excessive heat to extreme cold, extreme temperatures have the capacity to cause a wide range of health problems varying in severity. In the United States, extreme heat is one of the biggest culprits in of weather-related deaths, while also causing heat strokes, heat exhaustion, rhabdomyolysis, heat syncope, heat cramps, and heat rashes. Prolonged exposure to extreme cold can cause hypothermia or frostbite, which can lead to permanent health damages, amputation, or death in worst-case scenarios.

Structures

Typically, heat or excessive heat events do not significantly damage structures, besides potentially "overheating of heating, ventilation, and air conditioning (HVAC) systems." On the other hand, extreme

cold can freeze pipes or cause them to burst. Poor condition or aging facilities are especially susceptible to extreme temperature events and may not be able to tolerate them.

Systems

Extreme heat events can sometimes cause short periods of utility failures, commonly referred to as "brown-outs," created by increased usage from air conditioners, appliances, and similar equipment. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature events, can interrupt power as well.

Between 2012 and 2022, West Virginia was included in nine extreme temperature-related agricultural disaster declarations.

Natural, Historic and Cultural Resources

Extreme heat events, especially when accompanied by drought conditions, can lead to environmental consequences. Increasing temperatures can lead to exacerbated risk of wildfire; drought and its effects on the health of watersheds; and increased stress, migration, and death in plants and animals. Freezing and warming weather patterns create changes in natural processes. An excess amount of snowfall followed by early warming periods may affect natural processes such as flow of water resources.

Community Activities

Outdoor activities are likely the most at risk to cancellation during extreme heat events, as mitigating risk to the community primarily revolves around taking shelter in adequately heated or cooled spaces, depending on the type of extreme temperature occurring.

Monthly Highs

https://www.weather.gov/wrh/climate?wfo=lwx

Monthly Lows

https://www.weather.gov/wrh/climate?wfo=lwx

3.3.4 Flooding

Flooding has impacted Jefferson County in the past and will continue to threaten the County in the future, particularly as storms are expected to become more severe due to the changing climate. Flooding is normally the result of a larger event such as a thunderstorm, rapid snowmelt, and/or ice jam. Flooding can be as frequent as the occurrence of a spring rain or summer thunderstorm. The amount of precipitation produced by storm events determines the type of flooding. Flash floods, which typically occur more frequently than general floods, occur along small streams and creeks of the type that are widely present throughout the Eastern Panhandle.

Flooding is one of the most frequent natural hazards faced by communities across the country as well as one of the costliest. West Virginia is no stranger to flooding; in fact, it is the number one natural hazard in the state. The topography of the region is mountainous with many valleys and gorges with rivers and streams, making the region prone to flooding activity. There are several types of floods, each with their own characteristics and related dangers.

- Riverine Floods typically develop over a period of days and occur when a river gradually rises and overspills its banks. These floods can be attributed to large amounts of rain or snowmelt both in the region impacted and upstream. Due to their nature of gradually building up, these types of floods will typically have a warning period of a few days.
- Flash Floods are the most common severe weather emergency in the United States according to the National Flood Insurance Program (NFIP) (2016). The NFIP also states that a flash flood is, “a rapid flooding of low-lying areas in less than six hours, which is caused by intense rainfall from a thunderstorm or several thunderstorms” (2016).

According to NOAA, some of the possible causes for flooding include the following:

- Excessive Rainfall: This is the most common cause of flooding. Water accumulates quicker than the soil can absorb resulting in flooding.
- Snowmelt: It occurs when the major source of water involved is caused by melting snow. Unlike rainfall that can reach the soil almost immediately, the snowpack can store the water for an extended amount of time until temperatures rise above freezing and the snow melts.
- Ice or Debris Jams: Common during the winter and spring along rivers, streams, and creeks. As ice or debris moves downstream, it may get caught on any type of obstruction to the water flow. When this occurs, water can be held back, causing upstream flooding. When the jam finally breaks, flash flooding can occur downstream.
- Dam Breaks: Dams can overtop, have excessive seepage, or have structural failure. Dam failure has been identified as a new threat and is included as a new chapter in this plan.

Location and Extent

Flood sources within Jefferson County include rivers and streams. For inland areas like the Eastern Panhandle, excess water from snowmelt or rainfall accumulates and overflows onto stream banks and adjacent floodplains. Jefferson County is located at the confluence of the Potomac and Shenandoah rivers and is separated by three (3) major drainage divides; Potomac River, Shenandoah River, and Opequon Creek. Communities located along the banks of the Potomac and Shenandoah Rivers are in particularly low-lying areas. Examples include the towns of Bolivar, Harpers Ferry, and Shepherdstown.

A network of 22 major streams feed into the Potomac River, Shenandoah River, and Opequon Creek. Most streams in the County flow northwest-southeast orientation toward Opequon Creek or Shenandoah River. Large tributaries in the region include Turkey Run, Evitts Run, and Flowing Springs Run. All waters flow into the lower Potomac River and the Chesapeake Bay.

From a municipal perspective:

- In Bolivar and Harpers Ferry, the 1-percent-annual chance flood hazard area reaches the outer edges of the towns along the Shenandoah and Potomac Rivers. It mainly covers the rail lines that pass through the town and a few streets along the rivers. See Figure 3.3.4-6 and Figure 3.3.4-8.

- In Charles Town, the main areas that flood include the areas around Evitts Run and its tributaries to the south and Cattail Run and extend to reach a few streets in the surrounding area. See Figure 3.3.4-7.

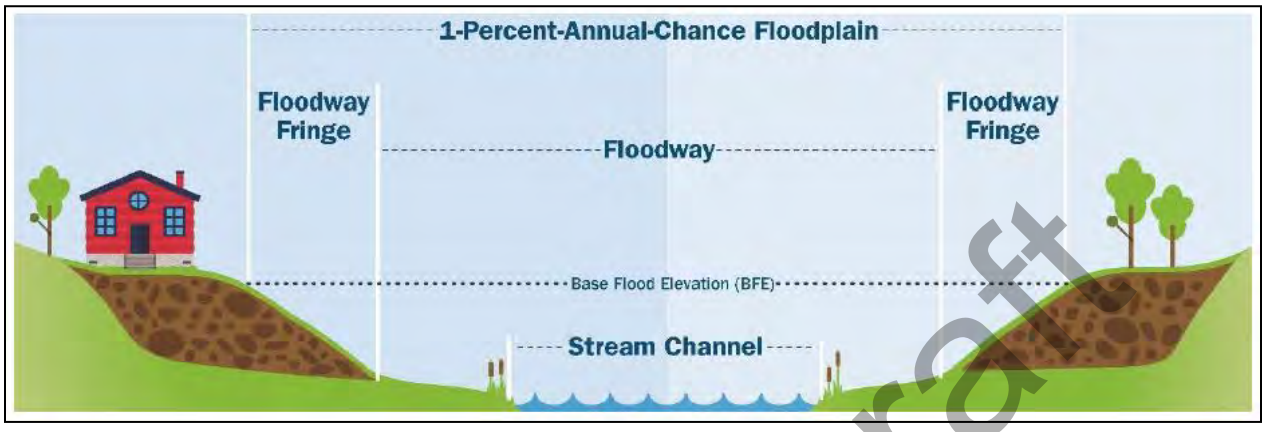
- Evitts Run similarly affects Ranson in that it can overflow and reach some surrounding streets; Flowing Springs Run could also affect rails and streets that are close to the stream. See Figure 3.3.4-8 .

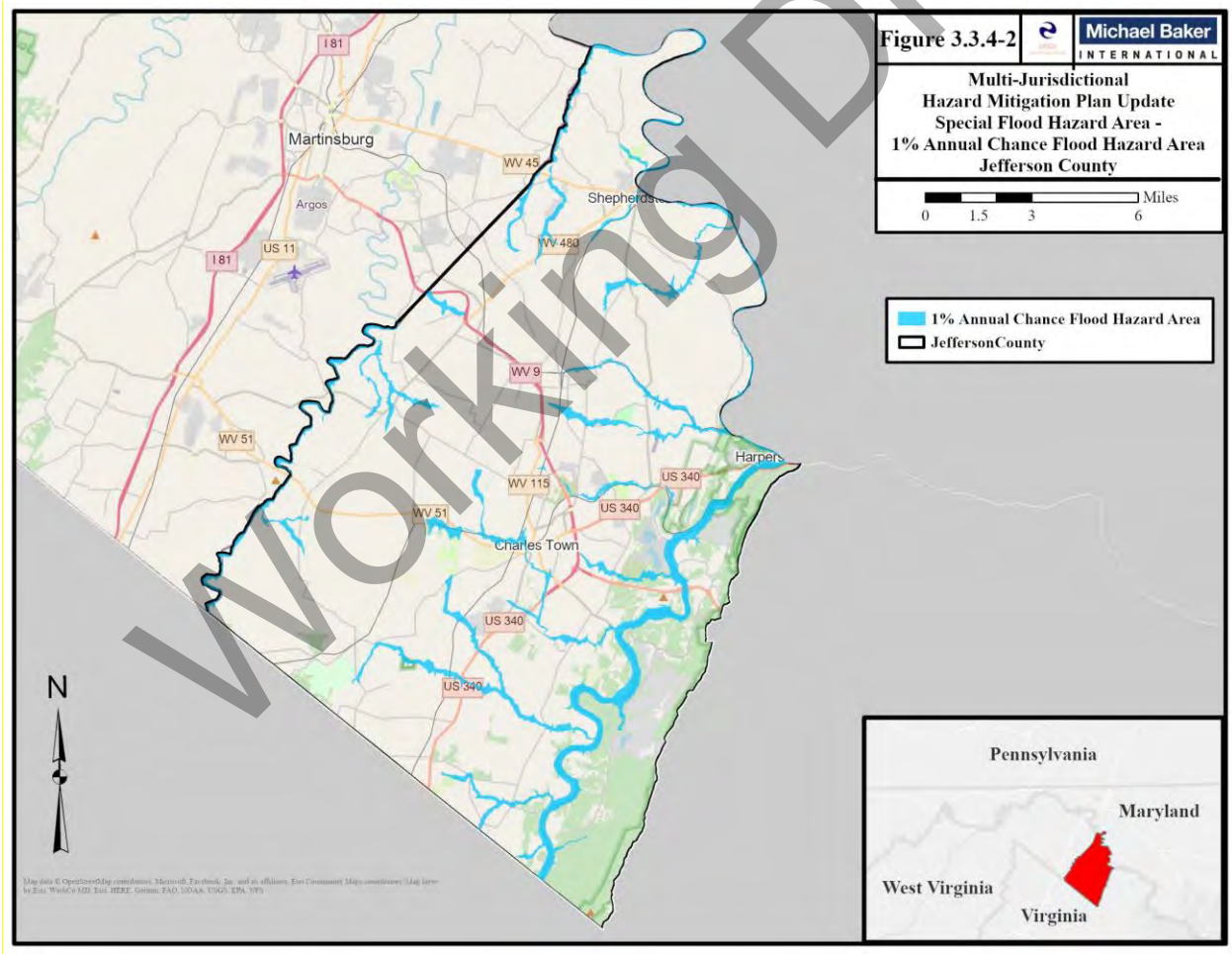
- Shepherdstown is along the Potomac River but does not experience significant flooding along the river itself but along Town Run that cuts through the jurisdiction and can significantly flood the downtown area. See Figure 3.3.4-9 .

Floodplains are lowlands, adjacent to rivers, streams, and creeks that are subject to recurring floods. The size of the floodplain is described by the recurrence interval of a given flood. However, in assessing the potential spatial extent of flooding it is important to know the difference between the 1-percent-annual chance floodplain and the 0.2-percent-annual chance floodplain. The 1-percent-annual chance flood event, also known as the base flood, represents a flood event having a 1-percent chance of being equaled or exceeded in any given year or 100-year flood. The National Flood Insurance Program (NFIP), for which Flood Insurance Rate Maps (FIRM) are published, identifies the risk associated with the 1-percent-annual chance flood. This 1-percent-annual chance flood event is used to delineate the Special Flood Hazard Area (SFHA) and to identify Base Flood Elevations (BFE). Figures 3.3.4-1 and 3.3.4-2 illustrates these terms. The SFHA serves as the primary regulatory boundary used by FEMA, and the State of West Virginia, when

determining risk associated with flooding.

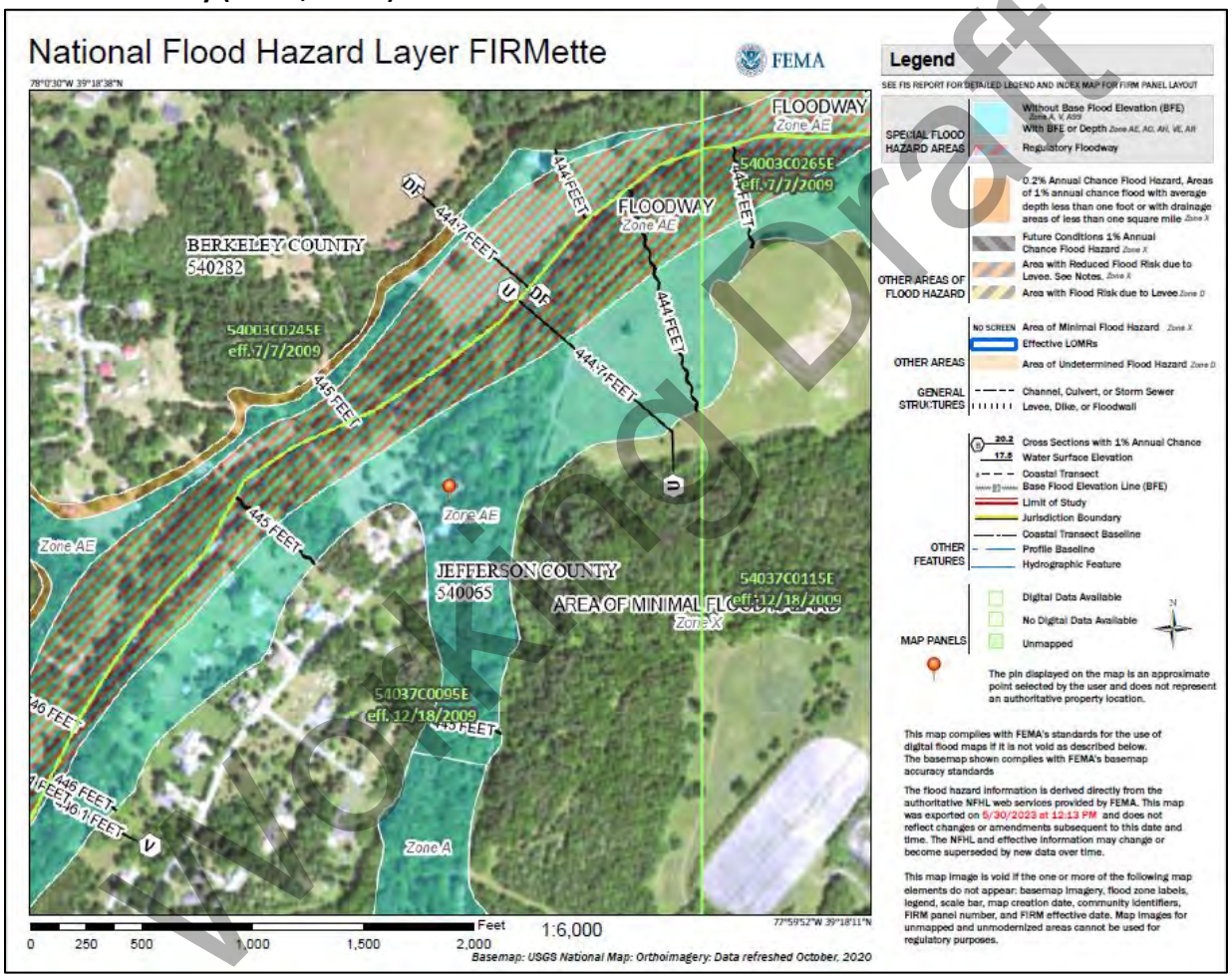
Figure 3.3.4-1: Diagram Identifying Special Flood Hazard Area and 100-Year Floodplain





The current countywide FIRM and Flood Insurance Study (FIS) report was published for Jefferson County on December 18, 2009 (FEMA, 2023c). The best available flood hazard data, which was used to update this flood hazard profile, included current effective FIRM data and incorporated Letters of Map Revision (LOMRs). Figure 3.3.4-3 displays an example of a FIRM, found along Opequon Creek. The FIRM and FIS for Jefferson County can be obtained from the FEMA Map Service Center (http://www.msc.fema.gov) and can be used to identify the expected spatial extent and elevation of flooding from a 1-percent and 0.2-percent-annual chance event.

Figure 3.3.4-3: FIRM Panel 54037C0095E Showing Flood Hazard Areas along Opequon Creek in Jefferson County (FEMA, 2023c)



According to Figure 3.3.4-2, Jefferson County faces flooding countywide. Jefferson County is most threatened by flooding resulting from Opequon Creek and its tributaries on the western boundary, while the Shenandoah River and its tributaries impacts the eastern to southeastern portion of the County. Jefferson County also faces some risk of flooding from the Potomac River. In these figures, Zone A represents areas with a 1 percent annual chance of flooding and a 26 percent chance of flooding over the

life of a 30-year mortgage. Zone AE represents the base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones. Zone X represents an area of moderate flood hazard (FEMA, 2023c).

In terms of future conditions, climate changes are expected to increase both the quantity and severity of storms. As a result, the locations and geographic extent of flooding are expected to increase. In addition to the 1-percent-annual chance floodplain, the 0.2-percent-annual chance flood represents a flood event having a 0.2-percent chance of being equaled one exceeded in any given year, sometimes referred to as the 500-year flood. This area is considered a moderate risk area, however, may become a high hazard risk area in the future.

As reported in a Washington Post article, American Underwater, extreme floods expose the flaws in FEMA's risk maps. Excerpt from the article provided below:

Half a century ago, Congress directed FEMA to model for one-in-100-year floods, which is still what prompts property owners with federally backed mortgages to purchase flood insurance. But now, even more extreme precipitation events are growing increasingly common, as a warming climate allows storms to carry more moisture, producing greater rain or snow in a short period of time.

"Climate has changed so much that the maps aren't going to keep up for some time," said W. Craig Fugate, FEMA administrator under President Barack Obama. "They are not designed for extreme rainfall events."

FEMA Flood Zones

In developing zone maps, FEMA focuses primarily on identifying the 1-percent annual chance floodplain (also known as the 100-year floodplain, Special Flood Hazard Area, or SFHA). As a result, FEMA maps the areas with a 1% annual chance of flooding. The SFHA designation is important because it is the basis for floodplain management regulations for communities across the country and because it decides whether a home is required to have flood insurance or not.

FEMA's high-risk flood zones – those that make up the SFHA – are those that begin with the letters "A" or "V." Note, Jefferson County does not have "V" zones as these are only found in coastal areas. Homeowners located in A or V zones are required to purchase flood insurance if they have a mortgage from a federally backed or federally regulated lender. FEMA's low and moderate-risk flood zones – those outside the SFHA – are those that begin with the letters "X," "B," or "C." Flood insurance is not required within these zones. These zones could still have flood risk as historically more than 20% of NFIP claims are made by policyholders in an X, B, or C zone.

Source: Understand The Differences Between FEMA Flood Zones

Past Occurrence

Jefferson County has a long history of flooding events. Some small, localized flooding events occur annually with minimal property damage. However, occasionally larger floods can occur, seriously impacting communities and destroying property. Flood and flash flood events are listed in Table 3.3.4-1. These are the oldest floods for which data is available from the National Centers for Environmental Information (NCEI). Property damages are estimates reported to the NCEI by trained storm spotters and displayed in the Storm Events database. Please note a zero-dollar entry may indicate minimal property damage, or that damage costs were not reported.

Table 3.3.4-1 Flood and Flash Flood Events Impacting Jefferson County, 1996-April 2023 (NCEI NOAA, 2023b)

County	Starting Location	Date	Type	Property Damage ($)
Jefferson	Not Provided (NP)	1/19/1996	Flood	20,000,000
Jefferson	All	1/19/1996	Flash Flood	0
Jefferson	Countywide	9/6/1996	Flash Flood	100,000
Jefferson	North Portion	9/10/1997	Flash Flood	4,000
Jefferson	Countywide	11/7/1997	Flash Flood	0
Jefferson	Countywide	1/8/1998	Flash Flood	5,000
Jefferson	Countywide	2/4/1998	Flash Flood	0
Jefferson	Countywide	3/20/1998	Flash Flood	2,500
Jefferson	Countywide	6/15/2000	Flash Flood	0
Jefferson	NP	1/2/2003	Flood	0
Jefferson	NP	2/22/2003	Flood	0
Jefferson	NP	3/7/2003	Flood	0
Jefferson	NP	3/21/2003	Flood	0
Jefferson	NP	5/11/2003	Flood	0
Jefferson	NP	5/16/2003	Flood	0
Jefferson	Countywide	6/13/2003	Flash Flood	0
Jefferson	NP	9/19/2003	Flood	100,000
Jefferson	NP	11/19/2003	Flood	0
Jefferson	NP	2/6/2004	Flood	0
Jefferson	NP	4/13/2004	Flood	0
Jefferson	Charles Town	9/28/2004	Flash Flood	0
Jefferson	Countywide	11/29/2005	Flash Flood	150,000
Jefferson	Millville	6/27/2006	Flash Flood	25,000
Jefferson	Shepherdstown	3/2/2007	Flood	15,000
Jefferson	Shepherdstown	4/16/2007	Flood	0
Jefferson	Charles Town	3/13/2010	Flood	0
Jefferson	Shepherdstown	3/13/2010	Flood	0

Table 3.3.4-1 Flood and Flash Flood Events Impacting Jefferson County, 1996-April 2023 (NCEI NOAA, 2023b)				
County	**Starting Location**	**Date**	**Type**	**Property Damage ($)**
Jefferson	Mountain Mission	4/16/2011	Flood	0
Jefferson	Bolivar	4/16/2011	Flood	0
Jefferson	Leetown	5/16/2014	Flood	0
Jefferson	Leetown	5/16/2014	Flood	0
Jefferson	Leetown	6/1/2015	Flash Flood	0
Jefferson	Millville	2/4/2016	Flood	0
Jefferson	Mountain Mission	5/6/2017	Flood	0
Jefferson	Bloomery	5/26/2017	Flood	0
2023 Plan Update				
Jefferson	Shepherdstown	4/17/2018	Flood	0
Jefferson	Engle	5/16/2018	Flood	0
Jefferson	Engle	5/16/2018	Flood	0
Jefferson	Shepherdstown	5/18/2018	Flood	0
Jefferson	Meyerstown	5/18/2018	Flood	0
Jefferson	Engle	6/2/2018	Flood	0
Jefferson	Uvilla	6/2/2018	Flood	0
Jefferson	Meyerstown	6/3/2018	Flood	0
Jefferson	Shepherdstown	6/3/2018	Flood	0
Jefferson	Harpers Ferry	6/4/2018	Flood	0
Jefferson	Millville	6/23/2018	Flood	0
Jefferson	Shepherdstown	9/9/2018	Flood	0
Jefferson	Aldridge	9/10/2018	Flood	0
Jefferson	Uvilla	9/10/2018	Flood	0
Jefferson	Meyerstown	9/18/2018	Flood	0
Jefferson	Shepherdstown	9/26/2018	Flood	0
Jefferson	Meyerstown	9/28/2018	Flood	0
Jefferson	Shepherdstown	9/28/2018	Flood	0
Jefferson	Harpers Ferry	9/29/2018	Flood	0
Jefferson	Millville	12/16/2018	Flood	0
Jefferson	Bolivar	12/16/2018	Flood	0
Jefferson	Millville	12/22/2018	Flood	0
Jefferson	Uvilla	5/5/2019	Flood	0
Jefferson	Leetown	5/5/2019	Flood	0
Jefferson	Aldridge	5/5/2019	Flood	0
Jefferson	Mt Pleasant	5/5/2019	Flood	0
Jefferson	Leetown	5/5/2019	Flood	0

Table 3.3.4-1 Flood and Flash Flood Events Impacting Jefferson County, 1996-April 2023 (NCEI NOAA, 2023b)				
County	**Starting Location**	**Date**	**Type**	**Property Damage ($)**
Jefferson	Charles Town	7/8/2019	Flood	0
Jefferson	Charles Town	7/8/2019	Flood	0
Jefferson	Kearneysville	7/8/2019	Flood	0
Jefferson	Shepherdstown	5/1/2020	Flood	0
Jefferson	Leetown	12/25/2020	Flood	0
Jefferson	Bloomery	12/25/2020	Flood	0
Jefferson	Shepherdstown	3/1/2021	Flood	0
Jefferson	Bolivar	6/11/2021	Flood	0
Jefferson	Engle	6/11/2021	Flood	0
Jefferson	Mt Pleasant	6/11/2021	Flood	0
Jefferson	Bolivar	9/1/2021	Flood	0
Jefferson	Vanclevesville	5/7/2022	Flood	0

Source: National Centers for Environmental Information, June 2023.

Since 1996, which is the earliest year of record for flood events from NCEI, Jefferson County has experienced 13 flash floods and 61 floods; 2.7 events per year. The Spatial Hazard Events and Losses Database (SHELDUS) records flooding events before 1996; Table 3.3.4-2 includes these events.

Table 3.3.4-2 Flood Events Impacting Jefferson County Before 1996 (SHELDUS)		
Hazard	**Year**	**Month**
Flooding	1967	March
Flooding	1968	May
Flooding	1978	January
Flooding	1978	December
Flooding	1979	September
Flooding	1980	May
Flooding	1980	August
Flooding	1981	June
Flooding	1985	November
Flooding	1987	April
Flooding	1994	March
Flooding	1994	August

According to FEMA, there has been one disaster declaration for flooding in Jefferson County for events at the beginning of June of 2008. On June 19, 2008, President Bush declared that a major disaster exists in the State of West Virginia. This declaration made Individual Assistance requested by the Governor available to affected individuals and households in Barbour, Doddridge, Gilmer, Harrison, Jackson, Jefferson, Marion, Taylor, and Tyler Counties.

However, the NCEI storm event database does not present any records for flooding during this period. This declaration is for thunderstorm wind in Jefferson County.

The most severe flooding event Jefferson County encountered was the January 1996 flood event caused by heavy rain and snowmelt. The January 19, 1996 flooding resulted from an unprecedented combination of unseasonably warm air, rainfall totals between 3 to 5 inches, and an existing dense snowpack between 12 to 18 inches that melted within a 12-hour period. This influx of rain and snowmelt produced

catastrophic flooding across the region, damaging homes, businesses, and causing several towns to evacuate. Property damage in Jefferson County was estimated at roughly $20,000,000 (NCEI, 2023). The National Park Service at historic Harpers Ferry (WVZ053) estimated damage to the park (and new construction within) at $3 million, comparable to the 1985 damage figures.

Another particularly intense year for flooding in the region was 2018. West Virginia Governor Jim Justice declared a State of Emergency in eight counties for flooding from heavy rain, including Jefferson County in June 2018. According to the NCEI event narrative, stream gauges on the Shenandoah River near Millville, the Potomac River at Shepherdstown, and the Potomac River at Harpers Ferry indicated each waterway exceeded the flood stages during this flood event (NCEI, 2023). On June 4, 2018 numerous locations in Jefferson County flooded according to National Weather Service (NWS) (NWS, 2023). This flood event was the third event in 2018 for Shepherdstown. Numerous roadways were closed, and several sections of road were damaged or washed out.

Figure 3.3.4-4: The Potomac River flows under the railroad bridge in Harpers Ferry.
(Journal photo by Victoria Dewey)
Source: Flood waters rising; Jefferson County declares state of emergency

Repetitive Loss Properties

In addition to past flood events, the NFIP identifies properties that experience frequent flooding and can be used to determine areas of higher risk. These properties are identified through the NFIP when they receive more than one payment for flood damages. The NFIP defines a **Repetitive Loss (RL)** property as "any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling ten-year period, since 1978." The data provided in Table 3.3.4-3 and throughout the plan represents the NFIP's definition of RL.

The FEMA NFIP defines a **repetitive loss property** as:

- Properties are those for which two or more losses of at least $1,000 each have been paid under the National Flood Insurance Program (NFIP) within any 10-year period since 1978."

The FEMA NFIP defines **severe repetitive loss properties** as:

- A property that has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or,
- A property for which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

The 2023 Hazard Mitigation Assistance Program and Policy Guide (page 304) defines repetitive loss and severe repetitive loss properties differently, and these definitions are as follows:

A **repetitive loss property** is a structure covered by a contract for flood insurance made available under the NFIP that:

a) Has incurred flood-related damage on 2 occasions, in which the cost of the repair, on the average, equaled or exceeded 25 percent of the market value of the structure at the time of each such flood event and
b) At the time of the second incidence of flood-related damage, the contract for flood insurance contains increased cost of compliance coverage.

A **severe repetitive loss property** is a structure that:

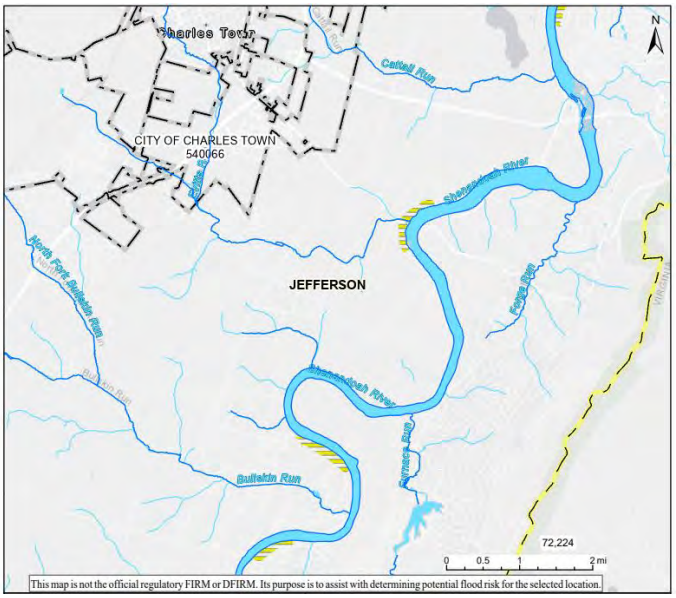
a) Is covered under a contract for flood insurance made available under the NFIP
b) Has incurred flood related damage –
    i. For which 4 or more separate claims payments (includes building and contents) have been made under flood insurance coverage with the amount of each such claim exceeding $5,000, and with the cumulative amount of such claims payments exceeding $20,000 or
    ii. For which at least 2 separate claims payments (includes only building) have been made under such coverage, with the cumulative amount of such claims exceeding the market value of the insured structure.

Although Jefferson County has completed many flood mitigation projects in the past and continues participating in the community rating system, there still have been some repetitive and severe repetitive loss properties in the county. Using data provided by FEMA in 2023, table 3.3.4-3 displays repetitive loss properties by jurisdiction and type in Jefferson County. There is a total of ?? repetitive loss properties, and ?? severe repetitive loss properties in the county. Of the ?? repetitive loss structures in the county, most are single family homes.

Table 3.3.4-3 Summary of the number and type of Repetitive Loss Properties by Municipality (FEMA, 2023)				
Jurisdiction	Type			Sum of Repetitive Loss Properties
	2-4 Family	Other Non-Residential	Single Family	
Jefferson County				
Bolivar				
Charles Town				
Harpers Ferry				
Ranson				
Shepherdstown				
Jefferson County Total				

Table 3.3.4-4 Summary of the number and type of Severe Repetitive Loss Properties by Municipality (FEMA, 2023)				
Jurisdiction	Type			Sum of Severe Repetitive Loss Properties
	2-4 Family	Other Non-Residential	Single Family	
Jefferson County				
Bolivar				
Charles Town				
Harpers Ferry				
Ranson				
Shepherdstown				
Jefferson County Total				

Repetitive loss areas are a portion (or portions) of a community that includes buildings on FEMA's list of repetitive losses and also any nearby properties that are subject to the same or similar flooding conditions. WV Flood Tool provides Repetitive Loss Areas, which are areas identified for flood risk assessment as part of HMGP project. Note, these areas are preliminary and not supposed to be definitive source for identification of repetitive loss areas. As depicted in below, four repetitive loss areas have been identified in the unincorporated areas of the County along the Shenandoah River. An additional area along Rockymarsh Run, which runs along the border of Berkeley and Jefferson County.



NFIP and CRS

Floods are the most common and costly natural catastrophe in the United States. In terms of economic disruption, property damage, and loss of life, floods are "nature's number-one disaster" (CRS, 2021). For that reason, flood insurance is a critical way for citizens to protect their property against flood loss. Home and business owners can purchase flood insurance through private insurers or through the National Flood Insurance Program (NFIP).

Congress established the NFIP in 1968 to help control the growing cost of federal disaster relief (CRS, 2021). The NFIP, administrated through FEMA, offers federally backed flood insurance at discounted rates when communities adopt and enforce effective floodplain management ordinances to reduce future flood losses based on flood maps. NFIP is based on voluntary participation of communities but is required for communities to receive federal disaster relief funding.

Each jurisdiction participating in the NFIP has a designated NFIP coordinator, sometimes referred to as the floodplain manager. This individual maintains the jurisdiction's floodplain ordinance and ensures that development is compliant with that ordinance. Each local floodplain manager serves as the point of contact with FEMA regarding floodplain mapping. Table 3.3.4-5 lists the Jefferson County municipalities participating in the NFIP.

The minimum floodplain management requirements to be a community in good standing in the NFIP include:

- Review and permit all development in the Special Flood Hazard Area (SFHA);
- Elevate new and substantially improved residential structures above the Base Flood Elevation;
- Elevate or dry floodproof new and substantially improved non-residential structures;

- Limit development in floodways;
- Locate or construct all public utilities and facilities to minimize or eliminate flood damage; and
- Anchor foundation or structure to resist floatation, collapse, or lateral movement.

Table 3.3.4-5 Jefferson County NFIP Policies and Claim Information

Community	Policies in Force	Total Coverage	Prior Claims	Total Amount of Paid Claims	A-Zone
Jefferson County					
Bolivar					
Charles Town					
Harpers Ferry					
Ranson					
Shepherdstown					
Total					

New information was added during the 2023 plan update which includes the FEMA Region 3 NFIP Questionnaire, see Appendix ??. The questionnaire was reviewed by Jefferson County staff and includes the following topics:

- Floodplain Identification & Mapping,
- Floodplain Management,
- Flood Insurance, and
- Next Steps.

Next steps identified following the completion of the questionnaire have been integrated into the new mitigation strategies developed during this plan update.

The Community Rating System (CRS) is an additional, voluntary program run by the NFIP to encourage additional community activities that exceed minimum NFIP requirements, with the goal of reducing flood risk. By participating in the CRS, a community can receive discounted flood insurance premiums. Jefferson County is one of the five counties in West Virginia that participate in the CRS.

Jefferson County entered into CRS in October of 2006. In October of 2016, Jefferson County had a class 8 designation, which meant that flood insurance policyholders were eligible for a 10% discount on their rates. As of this plan update, Jefferson County is a class 7 CRS community which means that residents enjoy a 15% discount on their NFIP flood insurance.

Future Occurrence

The NFIP recognizes the 1 percent-annual-chance flood as the standard for identifying properties subject to federal flood insurance purchase requirements. The FIRMs published in 2009 can be used to identify areas subject to the 1 percent- and 0.2 percent-annual-chance flooding. Other storm frequencies such as the 2 percent- or 50-year flood and 10 percent-annual-chance flood are not shown on maps; however, water surface elevations associated with these events are included in the flood source profiles contained in the Flood Insurance Study Report. In this plan, the term "Special Flood Hazard Area" is used rather than floodplain to clarify that the area under consideration is identified on the FIRM as having at least a 1-percent chance of flooding in any given year. Historically, the area with a 1-percent chance of flooding in any given year has been called the "100-year floodplain" or the "base flood" and the area with a 0.2-percent chance of flooding in any given year has been called the "500-year floodplain." As these terms can be misleading by suggesting that there will be a flood only every 100 or 500 years respectively, are no longer used.

In Jefferson County, flooding occurs commonly and can take place during any season of the year. However, the possibility of flooding is greatly reduced during the winter months. Although most severe floods are attributable to rainfall alone, the spring floods can be compounded by snowmelt and moving ice. The major floods in the late summer and fall are often associated with tropical storms moving up the Atlantic coastline. Every two to three years, serious flooding occurs along one or more of the area's major rivers or streams and it is not unusual for such events to happen several years in succession. Floods are described in terms of their extent (including the horizontal area affected and the vertical depth of floodwaters) and related probability of occurrence. Historical records are used to determine the probability of occurrence (percent chance) for a flood of specific extent to occur. Annualized events for Jefferson County reported by the National Centers for Environmental Information using both flood and flash flood events, are 2.7 events per year.

Range of Magnitude

Floods are considered hazards when people and property are affected. Injuries and deaths can occur when people are swept away by flood currents or bacteria and disease are spread by moving or stagnant floodwaters. Most property damage results from inundation by sediment-filled water. A large amount of rainfall over a short time span can result in flash flood conditions. Small amounts of rain can result in floods in locations where the soil is frozen or saturated from a previous wet period or if the rain is concentrated in an area of impermeable surfaces such as large parking lots, paved roadways, or other impervious developed areas.

Several factors determine the severity of floods, including rainfall intensity and duration, topography, ground cover and rate of snowmelt. Water runoff is greater in areas with steep slopes and little or no vegetative ground cover. The topography of the county varies from steep mountains east of the Shenandoah River to more gently rolling terrain west of the river. Elevations in the county range from approximately 275 feet at Harpers Ferry to approximately 1,700 feet in the mountains east of the

Shenandoah River (FIS, 2009). Therefore, the significant amounts of sloping and mountainous terrain can contribute to more severe floods as runoff reaches receiving water bodies more rapidly over steep terrain. Also, urbanization typically results in the replacement of vegetative ground cover with asphalt and concrete, increasing the volume of surface runoff and stormwater, particularly in areas with poorly planned stormwater drainage systems. According to the Jefferson County Stormwater Management Ordinance, in addition to quantity control criteria for newly developed impervious surface and/or changes to land cover, quality criteria requirements for site plans of 5,000 square feet or more of impervious surface and for major residential or commercial subdivisions are applicable.

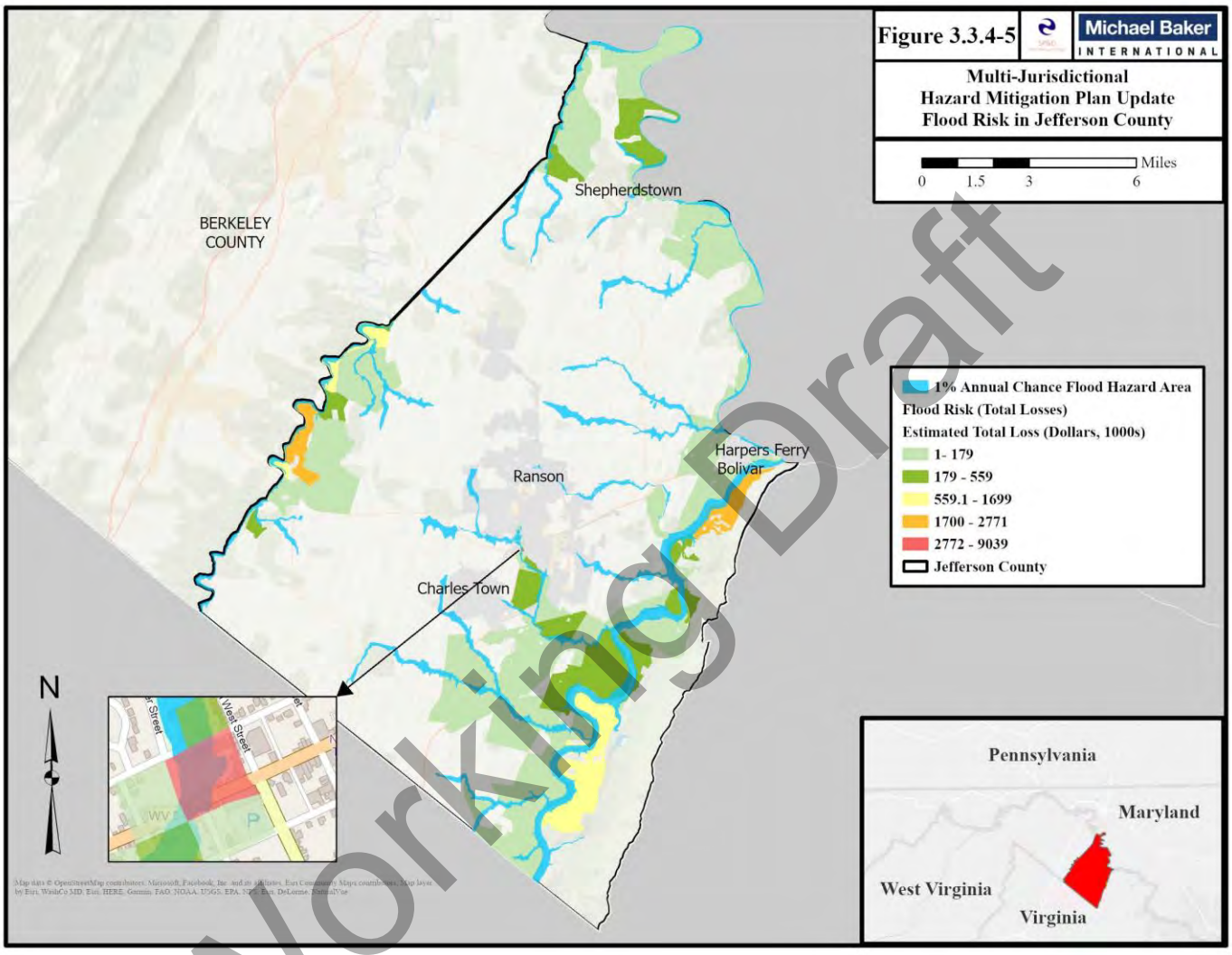
In much of the northeastern United States, including Jefferson County, there are seasonal differences in how floods are caused. In the winter and early spring (February to April), major flooding has occurred as a result of heavy rainfall on dense snowpack throughout contributing watersheds, although the snowpack is generally moderate during most winters. Summer floods have occurred from intense rainfall on previously saturated soils. Summer thunderstorms deposit large quantities of rainfall over a short period of time that can result in flash flood events.

Flood effects can be volume or force related. Major floods along larger streams having wide floodplains tend to result in large-scale inundations. This causes widespread damage through soaking and silt deposits in homes, businesses, and industrial plants. In hilly regions where runoff paths are steep, flash floods may be prevalent. Flash floods are short in duration and usually occur in a somewhat localized area. In these floods, the velocity rather than the volume of water causes flood damage. Torrents of water can rush down minor hillside gullies at 30-50 miles per hour, carrying trees, debris, and rocks. These floods are often unpredictable and, particularly if they occur at night, can cause major panic and loss of life. Frozen surfaces can more than double normal runoff velocities, particularly in small drainage areas. This causes flash floods which can be compounded by ice and debris jams in channels and culverts. Also, obstructions within the floodplain such as bridges and undersized culverts can also increase flooding.

Although floods can cause damage to property and loss of life, floods are naturally occurring events that benefit riparian systems which have not been disrupted by human actions. Such benefits include groundwater recharge and the introduction of nutrient rich sediment improving soil fertility. However, the destruction of riparian buffers, changes to land use and land cover throughout a watershed, and the introduction of chemical or biological contaminants which often accompany human presence cause environmental harm when floods occur. Hazardous material facilities are potential sources of contamination during flood events. Other negative environmental impacts of flooding include water-borne diseases, heavy siltation, damage, or loss of crops, and drowning of both humans and animals.

According to Figure 3.3.4-5, one census block within Charles Town shows the highest risk in terms of total losses. Evitts Run's 1-percent-annual chance floodplain encompasses this area between West Liberty and West Washington streets. The next highest flood risk is near Harpers Ferry at the confluence of the Potomac River and Shenandoah River and continues on the east side of the Shenandoah River until the Blue Ridge Community. Another high-risk area is located on the western boarder of Jefferson and

Berkeley county. This high-risk area is in the vicinity of Wide Horizon Boulevard to Hidden Hollow Road and impacted by Opequon Creek. Flood mitigation measures in these high-risk areas along with other areas with projected loss should be considered.

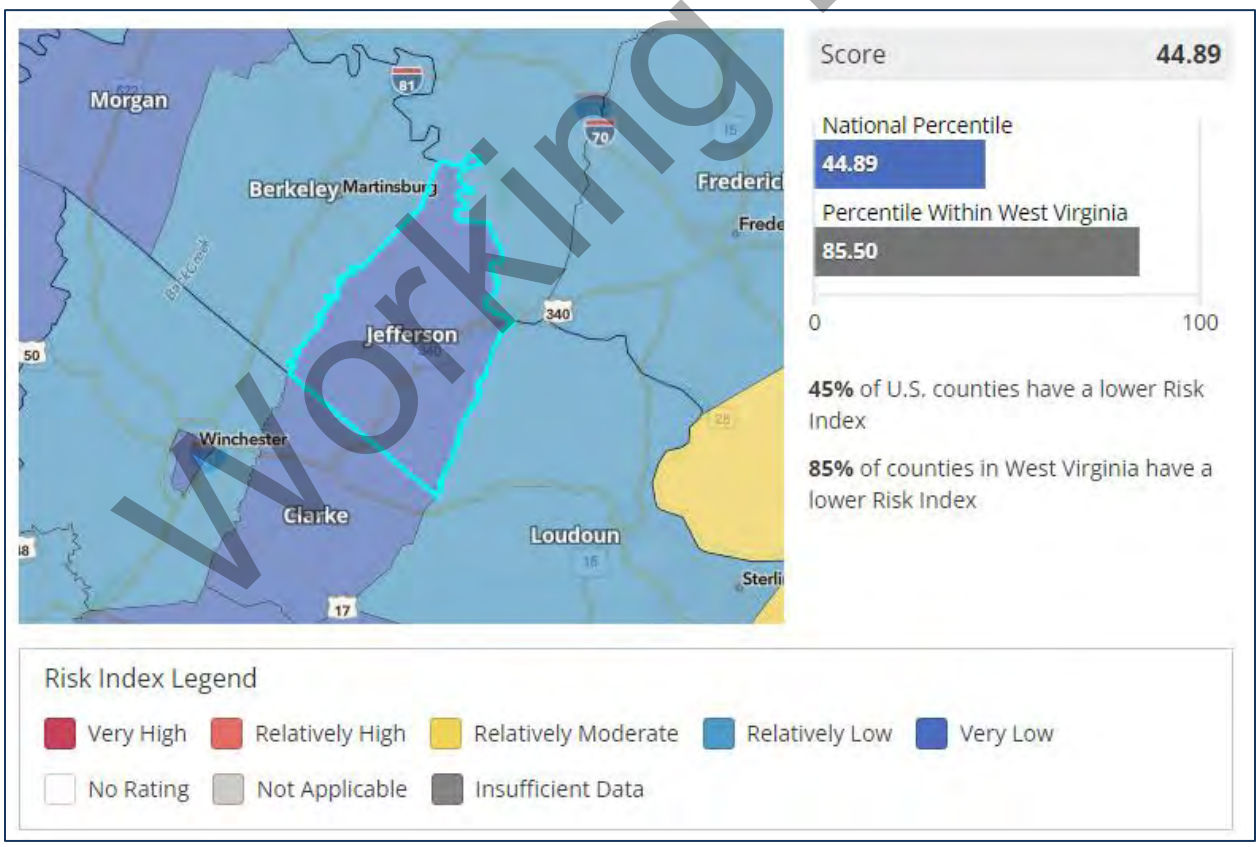


Vulnerability Assessment

Flooding can lead to property loss as well as to loss of life. Flooding damages structures, including homes and businesses, vehicles, and infrastructure, including roadways. People who are surrounded by flood waters may at some point require evacuation, placing their lives and the lives of rescuers in danger. Flooding can disrupt the operation of businesses and schools. Recovery from flood damage can be time consuming and costly.

According to FEMA, vulnerability is a description of which assets, including structures, systems, populations, and other assets as defined by the community, within locations identified to be hazard prone, are at risk from the effects of the identified hazard(s). As part of this plan update, the analysis of vulnerability to community assets was expanded. In addition, impacts from climate change, social vulnerability, and changes in land use have been included. Information has been integrated from FEMA's recently updated National Risk Index, which according to FEMA has changed the way risk is assessed.

Using data and analysis from FEMA's National Risk Index, Jefferson County's risk index is very low compared to other counties to the United States, in fact 45% of U.S. counties have a lower risk index than Jefferson County. The risk index rating for neighboring jurisdictions is relatively low for Berkeley County (West Virginia) and Loudoun County (Virginia), while Clarke County (Virginia) is very low.



The hazard type Risk Index score measures the relative risk of a community for a specific hazard type by comparing its hazard type Risk Index value with other communities at the same level. These scores are calculated using data for only a single hazard type and reflect a community's Expected Annual Loss (EAL) value, community risk factors, and the adjustment factor used to calculate the risk value. The composite Hazard Type Risk Index score for flood in Jefferson County is detailed in Table 3.3.4-6.

Table 3.3.4-6 Jefferson County Flood Hazard Type Risk Index Score

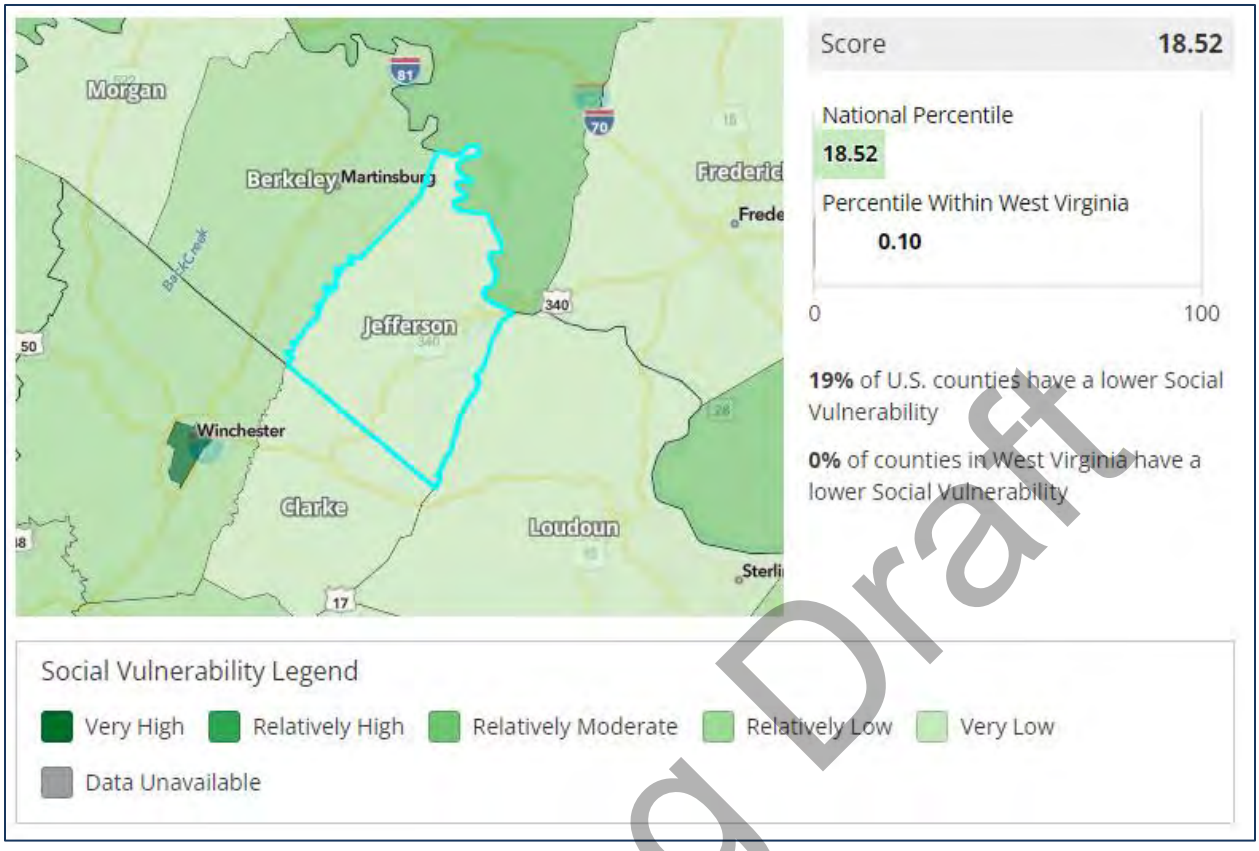
Hazard Type	Expected Annual Loss Value	Social Vulnerability	Community Resilience	CRF	Risk Value	Score
Flood	$378,074	Very Low	Relatively Moderate	1.04	$379,699	45.8

Jefferson County as an EAL value of $378,024 from flood impacts, is rated "very low" for social vulnerability, and is "relatively moderate" in terms of community resilience.

People

This section specifically focuses on how people are impacted by the flood hazard, including underserved communities and socially vulnerable populations. During a flood, people and first responders run the risk of sustaining injuries related to saving people and property as well as the possibility of drowning. In rare circumstances, floodwater can carry bacteria that can be harmful. One of the primary health-related flood concerns is power outages caused by flooding which impacts people who are reliant on power to run life-sustaining medical equipment; this is an example of a medically and socially vulnerable population.

Social Vulnerability for the Nation Risk Index (NRI) is measured using the Social Vulnerability Index (SVI) published by the Centers for Disease Control and Prevention (CDC). The SVI considers well-established indicators of social vulnerability, including socioeconomic status, household characteristics, racial & ethnic minority status, and housing type & transportation. According to the NRI, people, including underserved communities and socially vulnerable populations, in Jefferson County have a very low susceptibility to the adverse impacts of natural hazards when compared to the rest of the U.S. In comparison to neighboring jurisdictions, Loudoun County (Virginia) social vulnerability is very low as well, while Berkley County is relatively low.



In addition, National Centers for Environmental Information (NCEI) provides death and injuries for flood and flash flood events in Jefferson County. The NCEI database reported no deaths or injuries due to flood and flash flood events in the County or its municipalities. However, according to NCEI reports for flood, drivers had to be rescued from their vehicles stalled in high water on Bloomery Road, which runs parallel to the Shenandoah River near the community Bloomery and Avon Bend Road, which also is parallel to the Shenandoah River, during the February 2003 flood event. A water rescue was required along the Berkeley/Jefferson County line when a man was stranded in a van on a water-covered bridge on Sulphur Springs Road. The Centers for Disease Control and Prevention report that over half of all flood-related drownings occur when a vehicle is driven into hazardous flood water (NWS, 2023). These drownings typically occur when people underestimate the force of flood waters.

Structures

The best way for communities to strengthen floodplain management is by reviewing current codes and ordinances and by strongly enforcing their floodplain codes on new developments to avoid worsening future flooding. Significant residential growth in the outlying rural townships can increase opportunities for flash flooding if floodplain development and stormwater management are not properly regulated. Numerous times since the January 1996 floods, localized rainstorms that went undetected by the National Weather Service created surface flooding, which forced evacuations in several floodplain communities.

Structures including facilities, lifelines and critical infrastructure were reviewed for vulnerability. In 2017, a Flood Risk Report (FRR) for the Conococheague – Opequon Watershed was developed. Unincorporated areas of Jefferson County, the Towns of Harpers Ferry and Shepherdstown, and the City of Ranson were included in this assessment. According to the FRR, The Conococheague-Opequon Watershed covers an area of 5,936 square miles and includes portions of Berkeley, Jefferson, and Morgan Counties in West Virginia. A community overview for Harpers Ferry, Shepherdstown, Ranson, and unincorporated areas of Jefferson County are provided in Table 3.3.4-7, below.

Table 3.3.4-7 Flood Risk Report (FRR) for the Conococheague - Opequon Watershed Community Overview (FEMA FRR, 2017)

Community	Total Community Population	Percent of Population in TIEF	Total Community Land Area (sq mi)	Percent of Land Area in Watershed
Harpers Ferry	286	33	0.5	68
Ranson	4,440	<1	8.0	28
Shepherdstown	1,734	30	0.4	100
Jefferson County (unincorporated)	53,498	18	0.0	100
Berkeley County (unincorporated)	177,843	18	288.1	100
Morgan County (unincorporated)	28,159	35	219.2	68

Source: FEMA Flood Risk Report: Conococheague-Opequon Watershed, 02070004; Report Number 01; 1/31/2017

The FRR flood risk analysis incorporated results from the Total Exposure in Floodplain (TEIF) loss estimation tool and provides FEMA Average Annualized Loss (AAL) Study results for comparison; Table 3.3.4-8. The results indicate that the Town of Shepherdstown has the greatest loss ratio with 36%. The higher loss ration percentage for the Town is probable since 30% of the population is located within TEIF. Loss ratios for the unincorporated areas of Jefferson County is greater than Berkley or Morgan County even though the unincorporated areas Morgan County has a higher percentage of population in the TEIF.

Flood risk assessment results reported in the Flood Risk Report (FRR) were developed using Total Exposure in Floodplain (TEIF), a loss estimation tool that was developed at FEMA Region III using ArcGIS and Microsoft Excel. TEIF provides an approximate value of total exposure -- total potential economic losses -- in the Special Flood Hazard Areas (SFHAs). The economic losses are estimates, derived from national level datasets -- 2010 Census and ACS data applying 2012 RS Means valuations -- and should be used for relative comparison of potential losses and risk. The National Flood Hazard Layer that was used to develop TEIF was extracted in May 2013. TEIF allows the user to develop a relative comparison of potential flood loss among all levels of the census geographies.

Source: FEMA Flood Risk Report: Conococheague-Opequon Watershed, 02070004; Report Number 01; 1/31/2017

Table 3.3.4-8 Conococheague-Opequon Watershed: Comparison of Estimated Potential Losses for Structures in the SFHA (FEMA FRR, 2017)				
Community	Total Estimated Value	Total Exposure in Floodplain (TEIF)		Average Annualized Loss (AAL)*
		Dollar Losses[1,2]	Loss Ratio[3]	Dollar Losses[1]
Harpers Ferry	$19,400,000	$4,980,000	26%	$170,000
Ranson	$0	$18,260,000	0%	$180,000
Shepherdstown	$46,880,000	$16,860,000	36%	$20,000
Jefferson County (unincorporated)	$1,012,440,000	$226,850,000	22%	$2,040,000
Berkeley County (unincorporated)	$2,713,190,000	$256,440,000	9%	$5,660,000
Morgan County (unincorporated)	$908,280,000	$111,040,000	12%	$2,040,000

Source: FEMA Flood Risk Report: Conococheague-Opequon Watershed, 02070004; Report Number 01; 1/31/2017

Source: TEIF and AAL results stored as the Flood Risk Assessment Dataset in the Flood Risk Database.

1 Losses shown are rounded to nearest $10,000.

2 Estimated Value = Asset Replacement Value of all buildings for the community within the extent of the countywide floodplains.

3 Loss ratio = Dollar Losses / Estimated Value. Loss Ratios reflect community TEIF values and are rounded to the nearest integer percent.

**The AAL indicates the estimated economic loss value to property in any single year. It is generated by calculating losses for the 0.2%, 1%, 2%, 5% and 10% annual chance flood events and creating an average of those values. However, in many communities, the AAL inaccurately reports economic losses, and therefore should be used only to compare potential losses between states and counties. TEIF aims to address these inaccuracies by providing a total potential economic loss value to property, for all communities with development within the special flood hazard area. The total economic loss value can be used to understand the degree of risk in each community relative to others.*

The 2022 West Virginia Statewide Risk Assessment estimates that approximately 734 buildings in Jefferson County are located within the 1% annual chance flood hazard area. The assessment estimates that the building dollar exposure to be approximately $118,388,409. The following tables summarize the HAZUS data.

Table 3.3.4-9 Building Dollar Exposure: Residential versus Non-Residential								
Community	Residential		Commercial Non-Residential		Other Non-Residential		Total Building Value	
	#	Value ($)	#	Value ($)	#	Value ($)	#	Value ($)
Unincorporated	505	$60,022K	14	$4,889K	7	$5,349K	526	$70,260K
Bolivar	3	$251K	0	$0K	1	$4,000K	4	$4,251K
Charles Town	23	$2,073K	4	$7,893K	0	$0K	27	$9,966K
Harpers Ferry	6	$722K	25	$6,243K	0	$0K	31	$6,965K
Ranson	3	$251K	0	$0K	1	$4,000K	4	$4,251K
Shepherdstown	23	$2,073K	4	$7,893K	0	$0K	27	$9,966K
Total	**654**	**$76,146K**	**67**	**$27,999K**	**13**	**$14,243K**	**734**	**$118,388K**

Source: Region 9 Tabular Community-Level Report Link: data.wvgis.wvu.edu - /pub/RA/State/CL/Community_Asset/

No essential facilities in Jefferson County were located within the 1-percent-annual or 0.2-pecent annual chance flood hazard areas. Essential facilities include police stations, fire stations, 911 center, schools, hospital, and nursing homes. Community assets for Jefferson County include government facilities (federal, state, local), emergency medical services (EMS), religious organizations, utilities, postsecondary educational facilities, or other buildings of significance that contribute to the built environment of community. A total of thirteen (13) community assets were located within the 1-percent-annual chance flood hazard area. Table 3.3.4-10 detail types of community assets at risk.

Table 3.3.4-10 Community Assets Flood Vulnerability for Jefferson County & Municipalities							
Community	Religious Org.	Govt. Bldg.	Utility	Education	EMS	Other	Total
Unincorporated	2	2	1	0	0	0	5
Bolivar	0	0	1	0	0	0	1
Charles Town	0	0	1	0	0	0	1
Harpers Ferry	0	1	0	0	0	0	1
Ranson	1	0	0	0	0	0	1
Shepherdstown	0	0	1	3	0	0	4
Jefferson County Total	**3**	**3**	**4**	**3**	**0**	**0**	**13**

Source: Region 9 Tabular Community-Level Report Link: data.wvgis.wvu.edu - /pub/RA/State/CL/Community_Asset/

Community assets most vulnerable to the 1-percent-annual-chance flood event are shown in Table 3.3.4-11. The flood depth grid and building damage estimates quantify the degree of risk at which facilities may be subject to the greatest flood damage.

Table 3.3.4-11 Community Assets Flood Vulnerability for Jefferson County & Municipalities					
Community	**Facility Name**	**Facility Type**	**Flood Tool Link**	**Flood Depth**	**Building Damage Percent**
Harpers Ferry	National Park Service Information Center	**Government**	FT	31.9	78%
Unincorporated Jefferson County	Millville Pentecostal Church	**Religious Institution**	FT	7.1	13%
Shepherdstown	Shepherd University White Hall	**Education**	FT	2.0	5%
Shepherdstown	Shepherd University McMurran and Reynolds Hall	**Education**	FT	2.0	5%

Source: Region 9 Tabular Community-Level Report Link: data.wvgis.wvu.edu - /pub/RA/State/CL/Community_Asset/

The WV GIS Technical Center has also performed in depth analysis of critical infrastructure, flood depth, building-level risk, and much more on the WV Flood Tool, located at: https://www.mapwv.gov/flood/map/. Hazus reports found in Appendix ?? provide links directly to different aspects of the flood tool.

Systems

Systems in this section refer to networks and capabilities. Floods often disrupt many systems including power, sewer, water, communications, and road access. Lacking these, it is difficult to continue critical services to the community. Damage to property, facilities, and infrastructure can range from minimal to total loss. The cost of recovery from floods can vary for everyone. Homeowners and businesses can claim insurance benefits if they have them but may not be able to continue working due to the flood-related damages within the community or of their own property.

According to the National Centers for Environmental Information narratives for flood and flash flood events impacted roadways and caused power outages. Below are examples of events that caused roadway closures and power outages.

- January 1996 - Across the entire region, numerous creeks and streams were out of their banks well into Friday morning, closing roads, damaging homes, and businesses, and causing mud and debris slides.
- September 1997 - A thin band of thunderstorms, laden with tropical moisture, dumped between 5 and 8 inches of rain in a small area of northern Jefferson County. Though no fatalities or injuries ((were reported, several local roads were closed.
- January 1998 - In Jefferson County, several secondary roads were closed due to high water, and many creeks were at or just above bankful. A portion of federal highway 340 was closed briefly just west of Harpers Ferry. Rainfall totals in the affected area ranged from 2 to 3 inches.

- February 1998 - Moderate rain, falling on top of 3 to 6 inches of snow, produced areas of flooding across the eastern panhandle late on the 4th and continuing through the afternoon of the 5th. In Jefferson County, 9 secondary roads closed.
- March 1998 - A combination of 22 primary and secondary roads were closed in Berkeley and Jefferson Cos, including state highways 51, 9, and 7 (all in Jefferson County).
- June 2000 - In Jefferson County, two trees were downed north of Charles Town where 2.85 inches of rain was recorded. Up to 4 feet of water covered roads in Ranson and several county roads were also flooded.
- June 2003 - In Jefferson County, water flowed over Leetown Road in Kearneysville.
- May 2003 - In Jefferson County, Route 230 was closed by high water. Roads were also flooded in the Ranson and Millville areas. In addition, flooding was reported along Route 340 near the confluence of the Shenandoah and Potomac rivers near Harpers Ferry.
- March 2007 - The South Branch of the Potomac River at Shepherdstown crested at 15 feet after midnight on March 2nd. A few nearby roads were flooded as a result of the heavy rain and river flooding.
- April 2007 - Heavy rain spread north across the region early April 15th, causing flooding by the afternoon and evening. Winds also increased in the wake of the low, downing trees and power lines across the eastern pan handle.

Utilities were assessed as part of the vulnerability analysis of systems. A total of four (4) utilities were located within the 1-percent-annual chance flood hazard area. The flood depth grid and building damage estimates quantify the degree of risk at which facilities may be subject to the greatest flood damage.

Table 3.3.4-12 Community Assets Flood Vulnerability for Jefferson County & Municipalities

Community	Facility Name	Facility Type	Flood Tool Link	Flood Depth	Building Damage Percent
Bolivar	Harpers Ferry Bolivar PSD Wastewater Treatment Plant	**Utilities**	FT	15.5	Not provided
Shepherdstown	Shepherd's Mill	**Utilities**	FT	12.3	55%
Shepherdstown	Shepherdstown Water Works Plant	**Utilities**	FT	2.9	16%
Charles Town	City of Charles Town Wastewater Treatment Plant	**Utilities**	FT	2.1	12%
Unincorporated Jefferson County	Harpers Ferry Water Works Treatment Facility	**Utilities**	FT	0.0	0%

Source: Region 9 Tabular Community-Level Report Link: data.wvgis.wvu.edu - /pub/RA/State/CL/Community_Asset/

Natural, Historic and Cultural Resources

The National Register of Historic Places was used to assess the vulnerability of natural, historic, and cultural resources. For more complete information about the historical designations, refer to the National Register WV Listings.

Jefferson County is ranked fourth in the State as having the most historical buildings in the high-risk floodplain. Most of these historical buildings are in the towns of Shepherdstown and Harpers Ferry. The unincorporated area of Jefferson County is ranked first among all unincorporated areas in the State of West Virginia with 26 historical buildings.

Table 3.3.4-13 Historical Community Assets Flood Vulnerability for Jefferson County & Municipalities

Community	NR Bldg. Sites	Bldg. in Historic District (older than 1930)	Total Historic Bldgs.	# NR Areas /Districts in 1% Floodplain
Unincorporated	3	23	26	21
Bolivar	0	3	3	3
Charles Town	0	14	14	2
Harpers Ferry	1	28	29	4
Ranson	0	0	0	1
Shepherdstown	1	50	51	2
Jefferson County Total	**5**	**118**	**123**	**23**

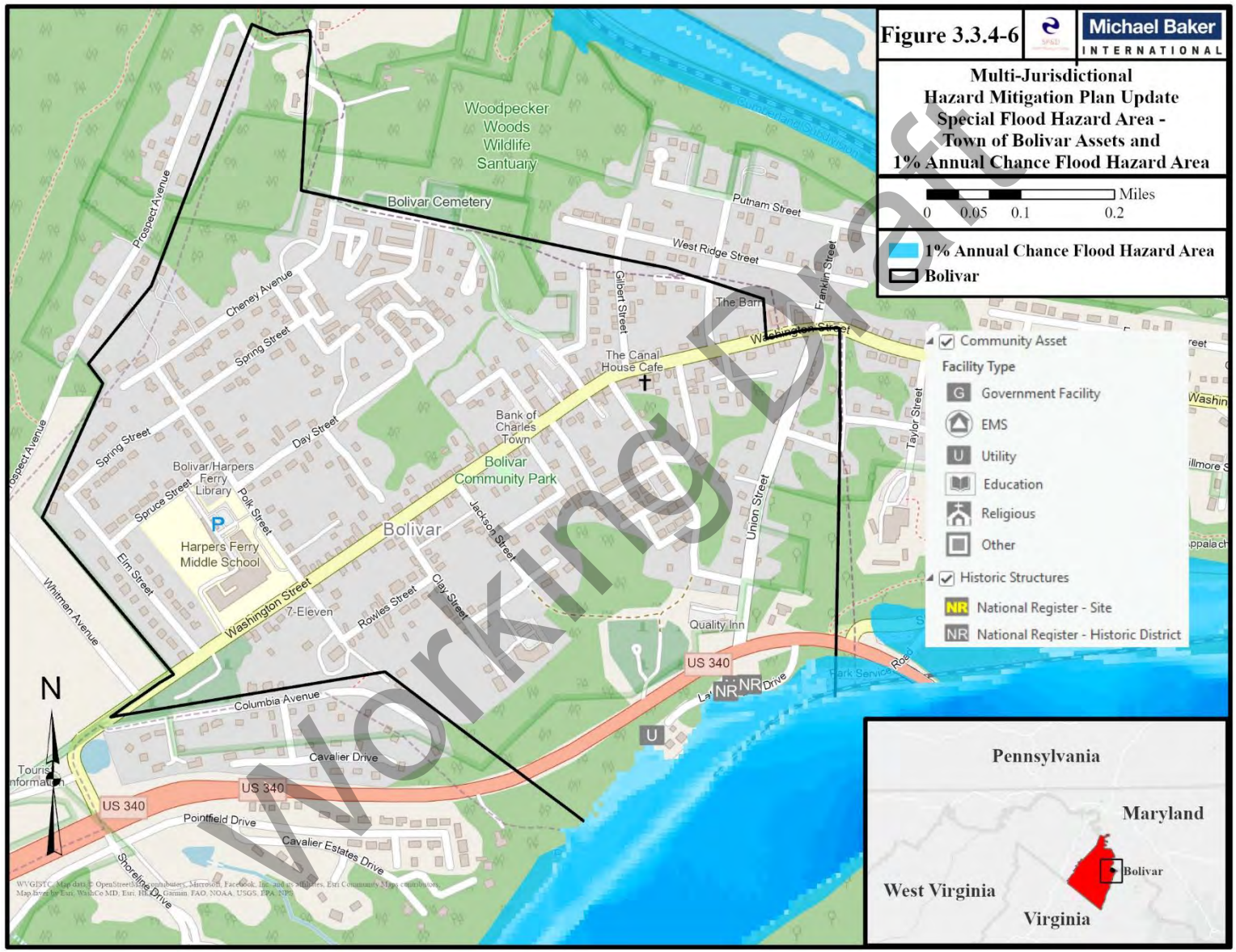
Source: Region 9 Tabular Community-Level Report Link: data.wvgis.wvu.edu - /pub/RA/State/CL/Community_Asset/

Community Activities

Activities that have value to the community could potentially be impacted by flood events. When these activities are delayed or cancelled due to flooding, the economy of the community is affected. Numerous activities are scheduled within Jefferson County and its municipalities. Below are community activities that occur throughout the year or annually.

- West Virginia's Mountain Heritage and Crafts Festival at Jefferson County Fairgrounds
- Jefferson County Fair – July and August at Jefferson County Fairgrounds
- Historical Walking Tours of Harpers Ferry, WV – Available All Year (Note four (4) of the National Register Areas within Harpers Ferry are located in the 1-percent-annual chance floodplain.)
- Hollywood Casino Horse Races – Reoccurring – Located in Charles Town
- September 22 - 24 - Mountain Heritage Arts & Craft Festival at Jefferson County Fairgrounds
- October 7 - Freedoms Run (Note: This event is held in part in Harpers Ferry.)

Impacts to community events would be dependent upon the event type and location.



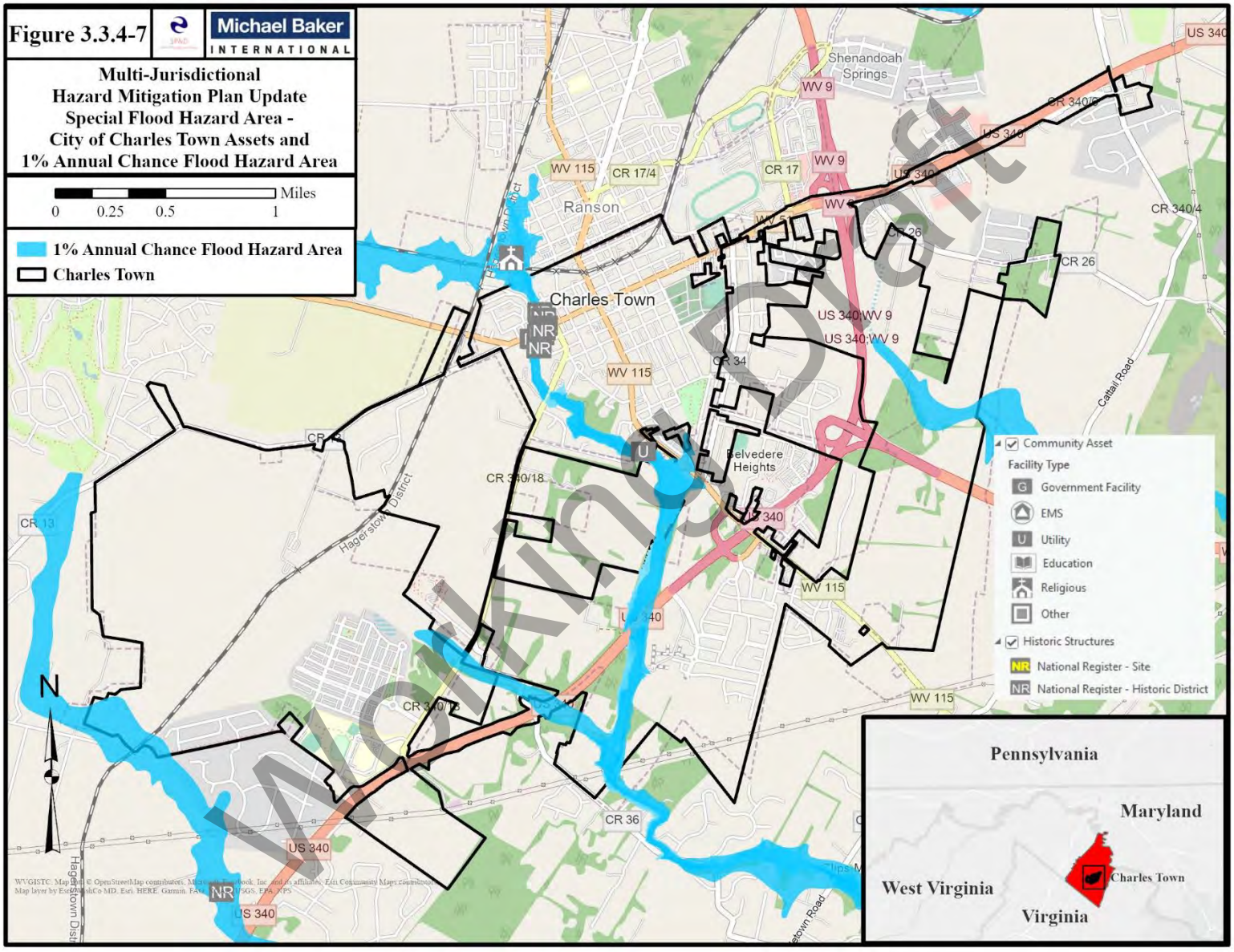
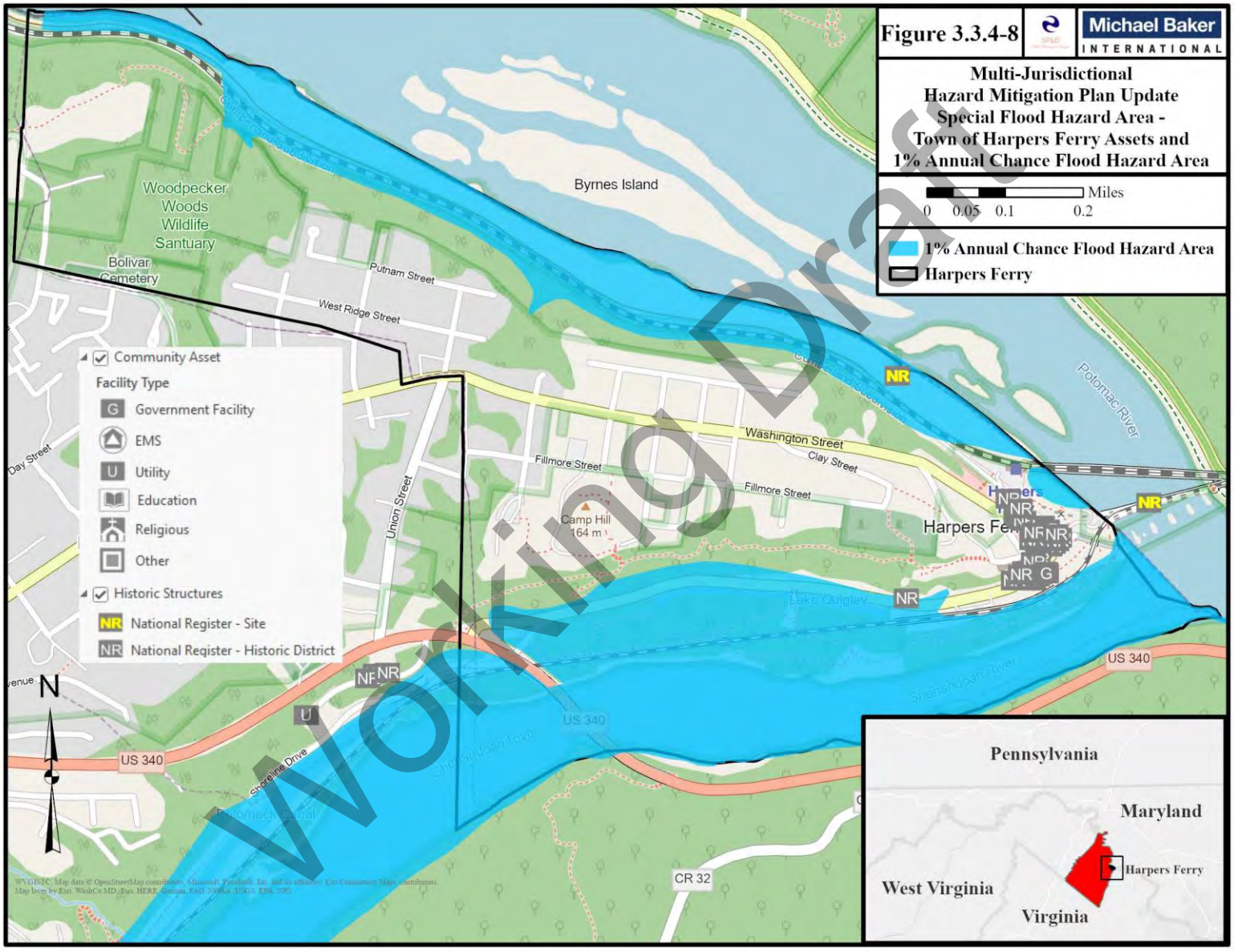
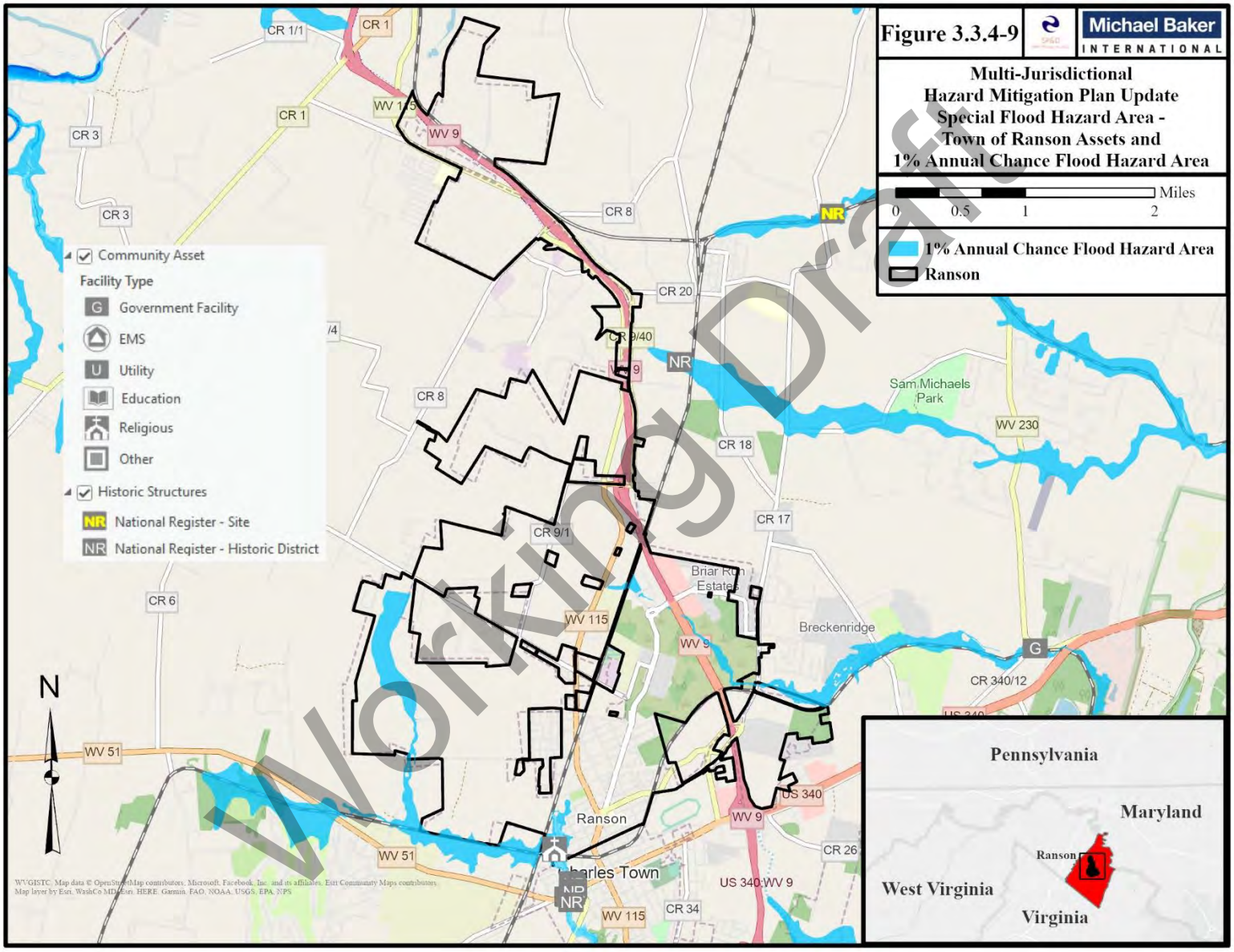
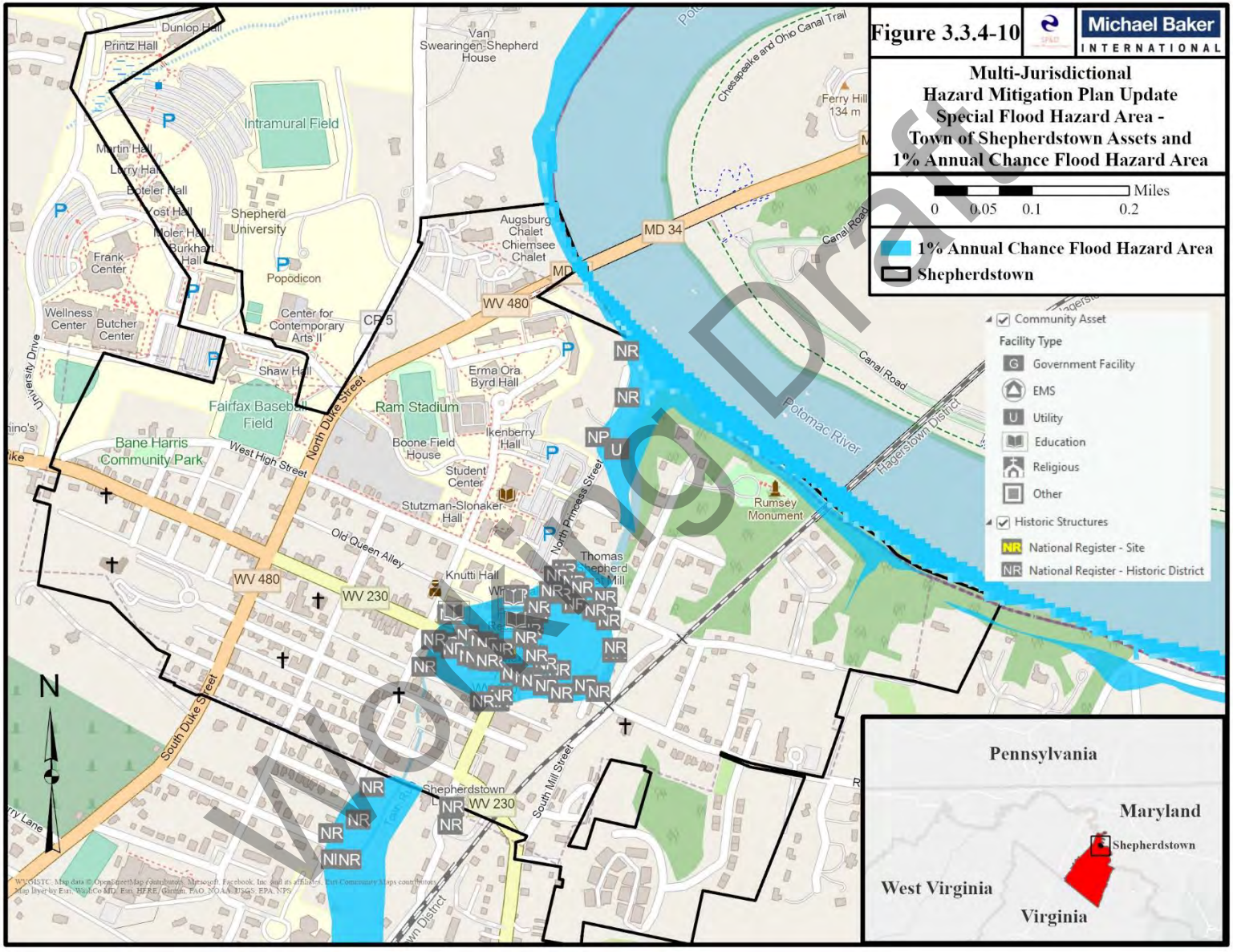


Figure 3.3.4-7
Michael Baker INTERNATIONAL
Multi-Jurisdictional
Hazard Mitigation Plan Update
Special Flood Hazard Area -
City of Charles Town Assets and
1% Annual Chance Flood Hazard Area
Miles
0 0.25 0.5 1
1% Annual Chance Flood Hazard Area
Charles Town
Shenandoah Springs
Ranson
Charles Town
Belvedere Heights
Hagerstown District
Cattail Road
WV 9
WV 115
CR 17/4
CR 17
CR 340/4
CR 26
CR 34
CR 340/18
CR 13
CR 36
US 340
US 340/WV 9
Community Asset
Facility Type
Government Facility
EMS
Utility
Education
Religious
Other
Historic Structures
National Register - Site
National Register - Historic District
N
Pennsylvania
Maryland
West Virginia
Virginia
Charles Town
Working Draft







3.3.5 Invasive Species

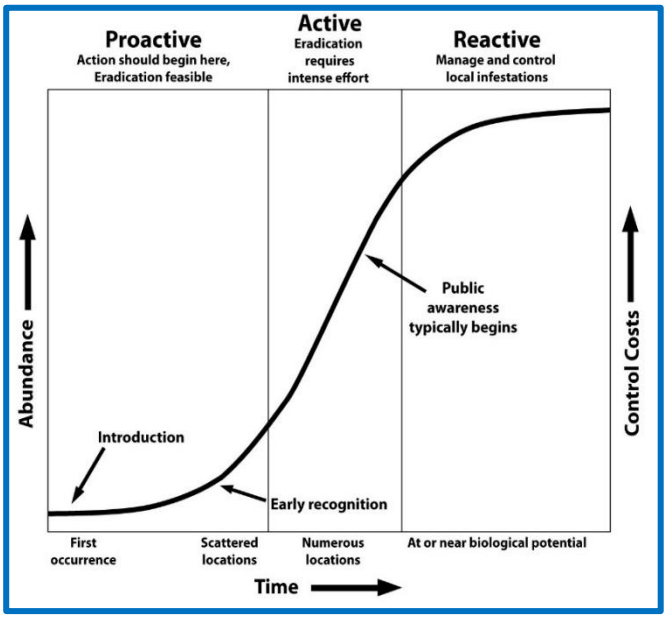
The spread of non-native plant, insect, and animal species, known as invasive species, has increased as international trade, travel and tourism have grown. Only a small percentage of these invasive species thrive and infest their new environment. Presidential Executive Order 13112 defines an invasive species as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." There are four main types of invasive species: aquatic species, plants, animals, and microbes (USDA, 2016). There are approximately 500 invasive plant species and over 50 invasive animals or insects in West Virginia (WVDNR, 2014), with 236 documented in Jefferson County, 229 plant species, and seven insect species (UGA, 2018).

Invasive species harm or kill native species, alter the ecosystem, introduce diseases, limit crop production, and harm humans and animals. Invasive species affect both aquatic and terrestrial habitats. The introduction of invasive species to a new environment may be either unintentional or deliberate. Vehicles, cargo, humans, and animals can all unintentionally transport these species, as "hitchhikers", into new environments. However, most invasive species "are deliberately introduced as pets, ornamental plants, crops, food, or for recreation, pest control or other purposes" (USDA, 2016).

Location and Extent

No area is immune to invasive species, and every area of the U.S. has an invasive species problem. Some regions have larger issues than others. Areas that are near large bodies of water are particularly vulnerable because of the number of transportation hubs those areas are known to have. Heavily wooded areas, fields, wetlands, streams, rivers, and bays are also identified as being invaded by invasive species because of the habitats and natural spread from pollution and water (U.S. Fish & Wildlife Service, 2018).

Figure 3.3.5-1: Phases of Invasive Species Infestation and Control



The effects of an infestation to this region could be quite damaging due to the thousands of acres of agriculture and forested land in the region. Infestations often spread regionally, as invasive species are often adept at gaining footholds and outcompeting native species in entire biomes. Typically, because of the make-up of the flora and fauna of an area, entire counties are impacted equally by the invasive species present there.

Range of Magnitude

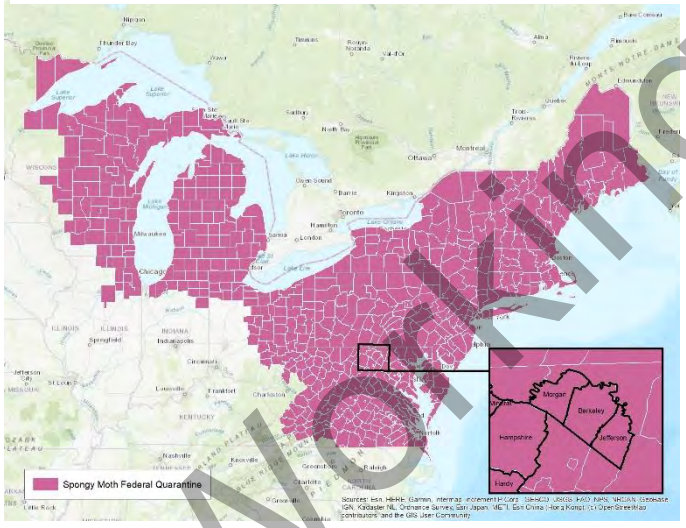
The magnitude of an infestation varies as widely as the species that can cause them. Invasive species can have severe impacts to

agriculture, wipe out tree species, and out compete native organisms. Infestations can be caused by plants, animals, insects, or pathogens, and there are over 1,000 invasive species in West Virginia. The complete scope of magnitude of these organisms is outside the scope of this document. However, as seen in Figure 3.3.5-1, infestations do not often occur overnight, and invasive populations grow along a logistic curve. The earlier along this curve control and eradication actions are taken against an infestation, the more effective they will be. Once populations reach their peak level, they are very difficult to eradicate, and communities are forced to rely on careful management and control of invasive populations (WV DNR, 2014). Education and public awareness become extremely important as invasive species spread.

Past Occurrence

Species that impact trees that have been of specific concern to Jefferson County in recent years include the emerald ash borer, the gypsy moth, hemlock woolly adelgid, and spotted lanternfly. The emerald ash borer eats the cambium (cellular plant tissue) of ash trees, killing the tree within 2 or 3 years of infestation. The emerald ash borer was first sighted in 2013 in Jefferson County, and ash trees are now extremely scarce in the Eastern Panhandle (WV DNR, 2014; USDA, 2016).

Figure 3.3.5-2: APHIS Spongy Moth Federal Quarantine Counties



Gypsy moths have been a widespread issue in West Virginia after they first arrived in the state in the early 1970s. According to The West Virginia Division of Forestry, the gypsy moth is considered the most serious insect pest ever to invade West Virginia (WV Division of Forestry, 2020). The moths eat the leaves of many hardwoods, which can kill trees and damage the health and appearance of forests. Exposure to the caterpillars of these moths can also cause minor health problems, such as irritation to the eyes or respiratory tract and rashes. Bans on the transport of certain trees and tree products, mobile homes, and outdoor household articles have been put in place in 44 West Virginia counties, including Jefferson County, to try to stop the spread of gypsy moths (WV DNR, 2014; USDA, 2016). Many counties are currently quarantined for Lymantria dispar by the USDA Animal and Plant Health Inspection Service (APHIS). Annually, new infestations are detected outside these counties and managed either by the STS program or eradicated by APHIS and state partners. Quarantined counties are shown in Figure 3.3.5-2 (USDA, 2023).

The hemlock woolly adelgid feeds off the sap of and is deadly to hemlock trees. It was reported in Jefferson County in 1997 and it has continued to spread across the state. The loss of hemlock trees contributes to dramatic changes in the composition of forests, habitat loss for birds, and the reduction of shade and increased sedimentation for cold water trout streams (WV DNR, 2014).

The spotted lanternfly has the potential to infest over 70 species of trees and vines. Its primarily known to infest the exotic and equally invasive tree-of-heaven (scientific name Ailanthus altissima) but has been detected on many of West Virginia's native tree hosts where it has the potential to cause severe economic and ecological damage. As of May 2021, a spotted lanternfly cluster was spotted in Jefferson County, just to the west of Kearneysville (West Virginia Department of Agriculture, July 2021).

Other infestations include a European fungus that causes white-nose syndrome and the death of bats, chestnut blight which eradicated chestnuts trees across their entire habitable entire range by 1940, and the brown marmorated stink bug which feeds on over 170 kinds of plants and crops (WV DNR, 2014). Feral cats are listed by the Global Invasive Species Database as one of the top 100 worst invasive species globally because of their impact on bird species and competition with other native species such as raccoons, foxes, and skunks. Over 270 invasive plants have been well documented in West Virginia, and more than a third of these are classified as posing moderate to high threats. These non-native species infest areas and out compete native plants and include Japanese knotweed, tree-of-heaven, and purple loosestrife (WV DNR, 2014).

Future Occurrence

It is impossible to predict what infestations may emerge as a hazard, as new species can be introduced to the area without warning and existing pathogens can evolve to become a greater threat. However invasive species that already exist in West Virginia and may be of some concern for Jefferson County in the future include beech scale, yellow poplar weevil, and the Matsucoccus scale/Caliciopsis canker complex. These all threaten specific tree species and could fundamentally change the composition of forests in the Eastern Panhandle. Beech scale is a disease that exposes beech bark to attack by fungi, killing the tree, and is spreading north from the east central portion of West Virginia. It is has already reached Hardy and Mineral County. Yellow poplar weevils attack and eat the leaves of yellow poplar trees and has already begun to infest neighboring Berkeley County. It may spread to Jefferson County in the coming years. Matsucoccus scale is a bug that attacks cankers caused by Caliciopsis pinea, which is thought to be a fungus. The combination of these two conditions can kill white pines, but it has not spread to the Eastern Panhandle and so far is limited only to West Virginia counties that are further south (USDA, 2016).

As seen in Pennsylvania over the past several years, where the spotted lanternfly population exceeds that of West Virginia, spotted lanternflies can spread rapidly when introduced to new areas, especially if major highways, railways, or rivers are in proximity of the introduction site. The key to controlling the spread of this invasive pest throughout West Virginia will be early detection and prompt eradication efforts. Within the Eastern Panhandle, there is a profitable orchard industry which could be affected by an increased spotted lanternfly population. The West Virginia Department of Agriculture is diligently working to prevent the continued spread of spotted lanternfly with joint efforts including the USDA APHIS and other professional agricultural agencies (West Virginia Department of Agriculture, 2021). The probability of future invasive species impacting the region can be considered possible according to the Risk Factor Methodology (see Table 4.4.1-1).

Vulnerability Assessment

The emerald ash borer and gypsy moth can be transported through firewood or other tree products. Spotted lanternflies can be spread long distances by people who move infested materials or items containing eggs. Farmers or individuals involved in timber sales may be more vulnerable to the impacts of infestation due to the potential for pests to damage crops or trees; farmers in Jefferson County have millions of dollars in crops that could be affected.

Based on historical documentation, and increased incidences of infestation throughout the State of West Virginia, it is estimated that Jefferson County will continue to experience infestation that may induce secondary hazards and health threats to the region's population, if infestations are not prevented, controlled, or eradicated efficiently.

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3.3.8 Public Health & Pandemic

In the 2023 Plan Update, the Public Health Crisis profile was changed to Public Health & Pandemic. Pandemic is defined as a disease affecting or attacking the population of an extensive region, including several countries, and/or continent(s). It is further described as an extensive epidemic. Generally, pandemic diseases cause sudden, pervasive illness in all age groups on a global scale. Infectious diseases are also highly virulent and can be spread person-to-person.

According to the Centers for Disease Control and Prevention (CDC), there are various levels that refer to the amount or extent of a disease occurrence.

- **Pandemic** refers to an epidemic that has spread over several countries or continents, usually affecting a large number of people.
- **Endemic** refers to the constant presence and/or usual prevalence of a disease or infectious agent in a population within a geographic area; it is the amount of a particular disease that is usually present in a community or baseline. Epidemics occur when an agent and susceptible hosts are present in adequate numbers, and the agent can be effectively conveyed from a source to the susceptible hosts. More specifically, an epidemic may result from:
    - a recent increase in amount or virulence of the agent,
    - the recent introduction of the agent into a setting where it has not been before,
    - an enhanced mode of transmission so that more susceptible persons are exposed,
    - a change in the susceptibility of the host response to the agent, and/or
    - factors that increase host exposure or involve introduction through new portals of entry.
- **Sporadic** refers to a disease that occurs infrequently and irregularly.
- **Hyperendemic** refers to persistent, high levels of disease occurrence.
- **Cluster** refers to an aggregation of cases grouped in place and time that are suspected to be greater than the number expected, even though the expected number may not be known.
- **Outbreak** carries the same definition of epidemic but is often used for a more limited geographic area.

Some diseases are so rare in a given population that a single case warrants an epidemiologic investigation (e.g., rabies, plague, polio), other diseases occur more commonly so that only deviations from the norm warrant investigation.

For this plan, diseases considered are limited to West Virginia Reportable Diseases according to the WV Code 16-3-1: 64 CSR 7.

The statistics for disease and epidemics are gathered on a county basis; municipalities are included in the overall risk analysis performed by the state. An epidemic can affect all parts of Jefferson County but is more probable to occur in densely populated areas, such as the City of Charles Town and Ranson, particularly large, multi-unit residential developments, and facilities at which a large workforce is employed.

Pandemic and infectious disease events cover a wide geographical area and can affect large populations, potentially including the entire population of the region. The exact size and extent of an infected population is dependent upon how easily the illness spreads, the mode of transmission and the amount of contact between infected and uninfected individuals. The transmission rates of pandemic illnesses are often higher in denser areas where there are large concentrations of people. The transmission rate of infectious disease will depend on the mode of transmission of a given illness. Pandemic events can also occur after other natural disasters, particularly floods, when there is the potential for bacteria to grow and contaminate water.

The region is primarily concerned with the possibility of a pandemic flu outbreak. Influenza, also known as “the flu,” is a contagious disease that is caused by the influenza virus and most commonly attacks the respiratory tract in humans. Influenza is considered to have pandemic potential if it is novel, meaning that people have no immunity to it, virulent, meaning that is causes deaths in normally healthy individuals, and easily transmittable from person-to-person.

Different strands of influenza mutate over time and replace older strands of the virus and thus have drastically different effects. The H1N1 virus, colloquially known as swine flu, is of particular concern. This virus was first detected in people in the United States in April 2009. On June 11, 2009, the World Health Organization signaled that a pandemic of 2009 H1N1 flu was underway (CDC, 2009). Avian influenza, also known as bird flu, infects birds. A recent strain, H5N1, has caused concern due to its ability to pass from wild birds to poultry then on to people. This virus has killed more than half of the people infected with it, although the avian flu is less likely to infect humans.

Prior to the beginning and during the 2023 Hazard Mitigation Plan Update process, a novel coronavirus spread into a worldwide pandemic. Named COVID-19, this type of coronavirus is a new virus that causes respiratory illness, is extremely contagious even prior to exhibiting symptoms or if the infected person is asymptomatic and can be fatal. Flu-like in nature, symptoms of the virus include fever, cough, shortness of breath, and diarrhea.

This virus became a great concern due to its high rates of transmission, and high incidence of mortality in addition to so little being known about it. Severe reactions that require immediate medical care include trouble breathing, persistent pain or pressure in the chest, new confusion, inability to wake or stay awake, and discolored skin, lips or nail beds (CDC, 2021a). In extreme COVID-19 cases that require hospitalization, patients require ventilators to support breathing and may pass away from COVID-19 or COVID-19 related reasons. Governor Jim Justice issued the first stay-at-home order on March 24, 2021 for all West Virginians. Schools were moved to virtual settings, non-essential businesses were closed, and all essential state services were continued operation (WVDHHR, 2020). The region adopted all state-level restrictions and guidelines to slow the spread of the virus. People were advised to practice social distancing; only leaving the house for essentials like grocery shopping, and to avoid gathering even in small groups. Even when going on walks, people should remain six feet apart to slow the spread of transmission. At least three new variants of the virus have been detected globally, each reaching the United States by January 2021, with the possibility of more occurring (CDC, 2021a). On March 5, 2021, Governor Justice announced that, after continued discussions with members of the West Virginia pandemic response leadership team regarding the decreasing number of COVID-19 cases and the increasing number of vaccinated West Virginians, he was lifting capacity restrictions on several types of West Virginia businesses, increasing the social gathering limit, and permitting more youth travel sports to take place.

Starting January 2021, vaccines were distributed in phases based off of vulnerable populations as well as those who are frequently exposed.

The West Virginia Department of Health and Human Resources (DHHR) reports as of July 5, 2023, there have a total of 8,156 deaths attributed to COVID-19. Currently, West Virginians ages 6 months and older are recommended to stay up to date with COVID-19 vaccination. The free online tool, Calculator, helps individuals figure out when they may be due for a COVID-19 shot, making it easier to stay up-to-date on COVID-19 vaccination.

Past Occurrence

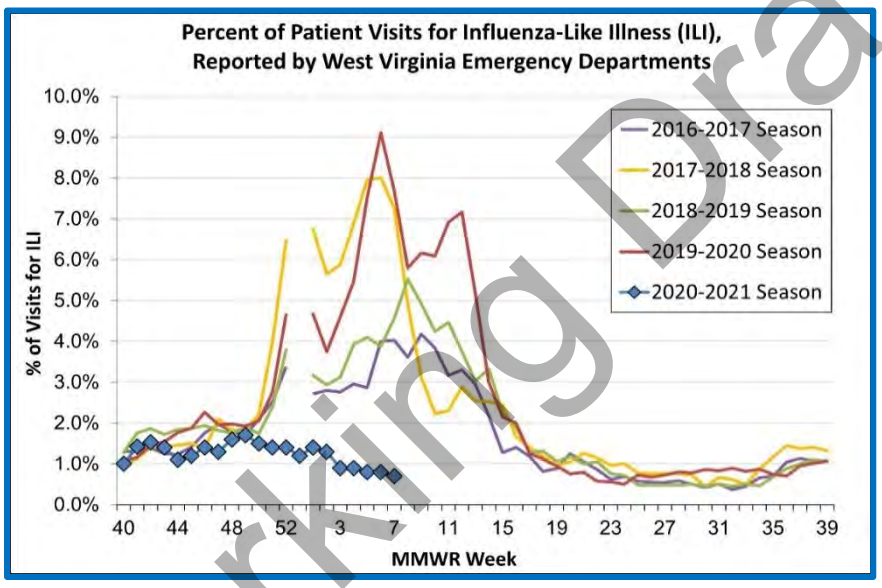
The United States Department of Health and Human Services estimates that influenza pandemics have occurred for at least 300 years at unpredictable intervals. There have been several pandemic influenza outbreaks over the past 100 years. A list of events and worldwide deaths are shown in Table 4.3.9-1 below.

Table 3.3.8-1 List of previous significant outbreaks of influenza over the past century (Global Security, 2009; WHO, 2009)

Date	Pandemic	Worldwide Deaths (approximate)
1918-1920	Spanish Flu / H1N1	50 million
1957-1958	Asian Flu / H2N2	1.5-2 million
1968-1969	Hong Kong Flu / H3N2	1 million
2009 - 2010	Swine Flu / A/H1N1	12,000
2020-Continuing	COVID-19	3.76 million +

The CDC marked the 2014-2015 flu season as severe, with approximately 590,000 hospitalizations. The 2017-2018 flu season was another severe season, with approximately 810,000 hospitalizations nationwide. Figure 3.3.9-1 below displays the percentage of emergency visits that were for influenza-like illness and that were reported during the current influenza season and the four preceding seasons (2015-2016, 2016-2017, 2017-2018, 2018-2019, and 2019-2020) in West Virginia. As demonstrated in that figure, influenza seasons vary in severity and duration. When peak influenza activity will occur and how severe it will be cannot be predicted. "MMWR Week" refers to the number assigned to each week of the year by the CDC, with January 1st falling either in Week 1 or Week 52/53. MMWR Week 40 is usually the first week of October. Flu cases were remarkably down in the 2020-2021 season, likely due to masking, social distancing, and stay-at-home mandates due to the COVID-19 pandemic.

Figure 3.3.8-1: Percentage of Emergency Visits for influenza-like symptoms, 2016-2021 (WVDHHR, 2021a)



The COVID-19 outbreak began in China in November 2019. According to a report published by the CDC on June 5, 2020, the first case of COVID-19 in the United States occurred on January 15, 2020 when a person traveled from Wuhan, China to Seattle and fell ill four days later. Small community spreading of the virus occurred during the second half of January and early February, prior to the more widespread outbreak of the virus in late February of 2020 (Jorden MA, Rudman SL, et al, 2020). The virus became more widespread in the US in late February 2020, and most counties in West Virginia were affected by March 2020. As of June 2021, there were more than 163,000 confirmed cases and more than 2,860 deaths in West Virginia, with 12,796 cases and 130 deaths reported in Berkeley County and 1,224 cases and 23 deaths in Morgan County (WVDHHR, 2021b). In January 2021, a vaccine became available, and is readily available at the time of this writing. In spring 2021, many states, including West Virginia began to lift masking and stay at home mandates. The federal COVID-19 PHE declaration ended on May 11, 2023. Most tools, like vaccines, treatments, and testing, remain available. CDC's ability to collect and share certain data has changed.

Epidemics

The regional epidemiologist provided information for the following table that includes reportable disease cases in Jefferson County from 2011 to 2021.

Table 3.3.8-2: Reportable Disease Cases in Jefferson County

Disease	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Amebiasis	0	1	0	0	0	0	–	–	–	–	–
Animal Bites/Exposures	0	1225	174	170	201	180	149	154	235	0	222
Botulism, Infant	0	0	0	0	0	1	0	0	1	0	0
Campylobacteriosis	<5	13	8	1	10	17	21	16	22	6	23
Carbepenem-resistant Enterobacteriaceae	0	0	0	0	0	5	2	0	1	0	2
Cholera	0	0	0	0	0	1	0	0	–	0	0
Cryptosporidiosis	0	0	1	0	0	0	0	7	6	0	3
E. coli shiga-toxin producing (STEC)	0	1	2	1	2	1	3	–	–	1	4
Ehrlichiosis/Anaplasmosis	0	0	2	1	2	1	2	0	0	0	0
Giardiasis	<5	5	4	2	3	1	1	0	7	0	5
Haemophilus influenzae, invasive	<5	3	2	1	2	1	1	0	2	0	1
Hepatitis A, Acute	0	1	0	0	0	4	0	1	1	0	1
Hepatitis B, Acute	<5	3	1	1	0	0	7	8	1	1	0
Hepatitis B, Chronic	0	3	13	13	5	9	16	1	8	1	8
Hepatitis C, Acute	<5	3	1	1	0	0	2	0	0	0	2
Hepatitis C, Chronic	0	51	57	113	132	86	117	187	139	19	110
Hepatitis E	0	0	1	0	0	0	–	–	–	–	–
Influenza-related death, underage 18	0	0	0	1	0	0	–	–	–	0	0
Legionellosis	0	1	3	0	0	1	2	1	2	1	0
Listeriosis	0	0	1	0	1	0	0	0	0	0	1
Lyme Disease	40	39	27	22	44	34	42	30	38	8	35
Pertussis	<5	0	1	1	0	0	0	2	0	0	0
Q Fever	0	0	0	1	0	0	0	0	–	0	0
Rabies, animal	<5	5	3	7	5	1	5	7	5	0	1
Rocky Mt. Spotted Fever	0	0	0	0	1	2	4	4	1	–	–
Salmonella	6	16	10	7	10	8	12	11	15	6	15
Shigella	<5	1	0	0	0	1	2	3	2	0	1
Streptococcus, Group A invasive	<5	0	0	0	0	0	–	–	0	0	–
Streptococcus,	0	0	1	0	1	4	–	–	8	2	–

Group B invasive											
Streptococcus pneumoniae, invasive	8	9	6	6	5	4	4	4	4	1	2
Tularemia	0	0	0	1	0	0	–	–	0	0	0
TOTAL	**73**	**283**	**321**	**352**	**426**	**363**	**392**	**436**	**498**	**46**	**436**
Source: WV Office of Epidemiology & Prevention Services Infectious Disease Surveillance Data - https://oeps.wv.gov/surveillance/pages/default.aspx											

Future Occurrence

Future occurrences of pandemics and infectious diseases are unclear. The precise timing of pandemic influenza is uncertain, but occurrences are most likely when the Influenza Type A virus makes a dramatic change, or antigenic shift, that results in a new or "novel" virus to which the population has no immunity. This emergence of a novel virus is the first step toward a pandemic. Future pandemics may also emerge from other diseases, especially invasive pathogens that West Virginian's do not have natural immunity to. While it is unlikely that pandemics and infectious diseases will affect the region, this hazard occurred recently. It is impossible to predict this type of hazard. The best form of county response is to expect that these events can occur at any time and to constantly evaluate resources and update emergency response plans.

Looking at the number of historical incidences of pandemic-potential diseases, the probability of future pandemic events can be considered *possible* according to the Risk Factor Methodology, Section 3.

Range of Magnitude

The magnitude of a pandemic or infectious disease threat in Jefferson County will range significantly depending on the aggressiveness of the virus in question and the ease of transmission. Pandemic influenza is easily transmitted from person-to-person, but advances in medical technologies have greatly reduced the number of deaths caused by influenza over time. The magnitude of a pandemic may be exacerbated by the fact than an influenza pandemic will cause outbreaks across the United States, limiting the ability to transfer assistance from one jurisdiction to another. Additionally, effective preventive and therapeutic measures, including vaccines and other medications, will likely be in short supply or will not be available.

In terms of lives lost, the impact various pandemic influenza outbreaks have had globally over the last century has declined. The severity of illness from the 2009 H1N1 influenza flu virus varied, with the gravest cases occurring mainly among those considered to be high risk. High risk populations are considered to be more vulnerable and include children, the elderly, pregnant women, and chronic disease patients with reduced immune system capacity. Most people infected with swine flu in 2009 recovered without needing medical treatment. Unlike a regular flu season, according to the Centers for Disease Control and Prevention (CDC) the majority of people who died, as many as 77 percent, were 18-64 years old with up to 11 percent of the deaths estimated in those 17 years old or younger (CDC, 2009).

The 1918 Spanish flu pandemic was the worst-case pandemic event in the 20th century for both West Virginia and worldwide. County data is unavailable, and mortality figures were probably under-reported. It is recorded that over 71,000 West Virginians died from the flu or its complications in this pandemic (Kercheval, 2020). Infection rates were much worse in denser cities, which should be a higher priority for response actions in future flu events.

In 2020 COVID-19, another worst-case pandemic began having worldwide impacts. As of June 2021, we are still facing impacts of the pandemic. Berkeley and Morgan County have faced varying impacts of the COVID-19 pandemic. It is believed that the virus originated in an open-air market in the Wuhan province of China in November 2019. Shortly afterwards, the virus began to spread to nearby countries including Japan and South Korea. By March 2020, the virus had reached almost every country worldwide, with the most cases in the United States. At first, concern was focused on people who might be infected due to recent travel. However, community infections soon began to crop up in many cities and towns. This led to a statewide shutdown of schools and businesses and the cancellation of large events for the remainder of 2020. Only life sustaining services were permitted to remain open, including medical facilities, pharmacies, and grocery stores. People were advised to remain home as much as possible in an attempt to slow the transmission of COVID-19. State health officials note that the virus has infected all age ranges at about the same rate, and that no age group can be considered more or less vulnerable to infection. However, people with underlying health conditions and the elderly population are more vulnerable to the virus having serious, or even deadly, symptoms. New variants of the virus reached the United States in January 2021. The CDC notes that these variants spread more easily and quickly than other variants, which may lead to a rapid increase in COVID cases (CDC, 2021a). It is currently unknown how new variants will interact with existing vaccines.

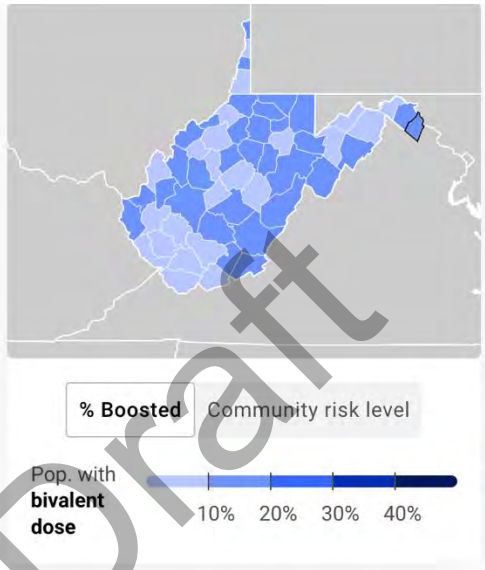
Vulnerability Assessment

Epidemics can develop with little or no warning and quickly erode the capacity of local medical care providers. A fast-developing epidemic can last several days and extend into several weeks. In some extreme cases, they can last for several months. An epidemic can occur at any time of the year, but the warm summer months, when bacteria and microorganism growth are at their highest, present the greatest risk.

Certain population groups are at higher risk of pandemic flu infection. This population group includes people 65 years and older, children younger than 5 years old, pregnant women, and people of any age with certain chronic medical conditions. Such conditions include but are not limited to diabetes, heart disease, asthma, and kidney disease (CDC, 2015). Schools, colleges, convalescent centers, and other institutions serving those younger than 5 years old and older than 65 years old, are locations conducive to faster transmission of pandemic influenza since population identified as being at high risk are concentrated at these facilities or because of a large number of people living in close quarters. In general, jurisdictions that are more densely population are more vulnerable to disease threats when the disease is directly spread from human to human, but every jurisdiction in the state has some vulnerability to pandemic and infectious disease threats.

Local health departments have taken steps to ensure a base level of preparedness for pandemics and other infectious diseases. National and state efforts to encourage vaccinations have also been relatively successful. According to COVIDActNow.org, in Jefferson County, West Virginia, 46,206 people (80.9%) have received at least one dose, 38,418 (67.2%) have received at least two doses or a single Johnson & Johnson dose, 18,319 (32.1%) have received a booster dose, and 9,994 **(17.5%)** have received an updated bivalent booster dose. Vaccinations help protect even non-vaccinated individuals due to herd immunity, meaning that a pathogen has a more difficult time spreading due to higher immunity rates.

Figure 3.3.8-2: West Virginia Updated Booster Dose Data, COVIDActNow.org,



People

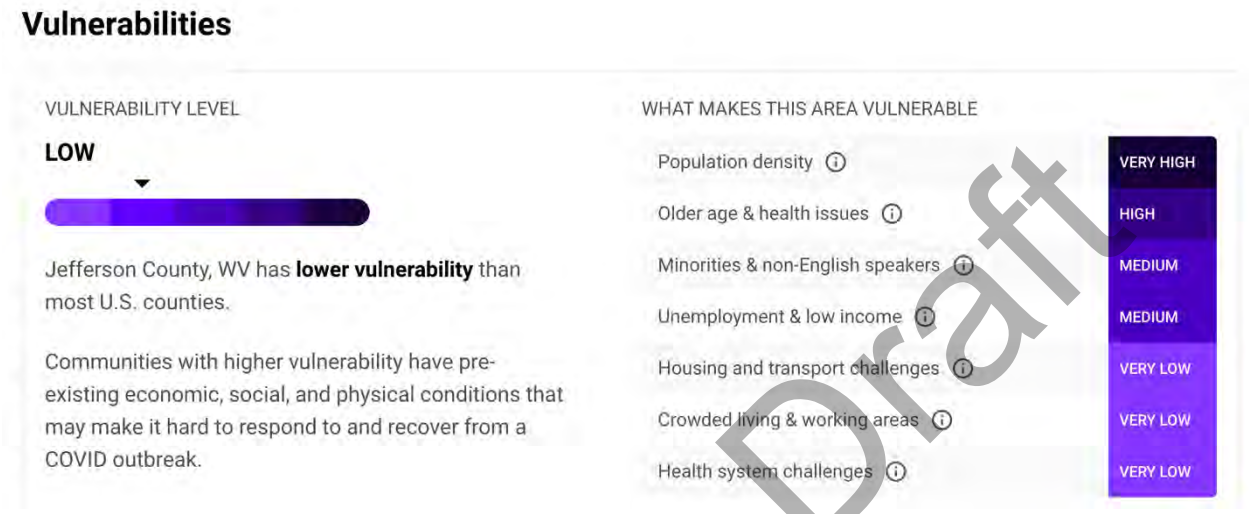
There are some occupation-specific risks that may make some employees more vulnerable. For example, those working in direct patient care situations are more likely to be exposed to a pandemic disease. Major concerns during an epidemic or outbreak include the ability of local health care providers to provide medical attention to everyone who becomes ill, and the ability to identify the source or what is causing the population to become ill. Cascading effects of epidemics can include the following.

- Illness or death
- Civil disturbance
- Distrust of government
- Poor water quality
- Temporary loss of income

In terms of social vulnerability, HHS emPower Map tool, users can select different geographies, as needed, to identify at-risk populations and download selected data results to inform their emergency preparedness, response, recovery, and mitigation public health activities. Users can also access near real-time natural hazard data layers to anticipate and address the needs of at-risk community members in emergencies. For more instructions and information, review the detailed job aids in the top right corner. Medicare data indicates that there are 12,235 beneficiaries within Jefferson County. Beneficiary means a person who is entitled to Medicare benefits and/or has been determined to be eligible for Medicaid. Medicare beneficiaries rely on electricity-dependent durable medical and assistive equipment (DME) and devices to live independently in their homes, and some of those individuals also have health care service dependencies.

Higher vulnerability areas are more likely to experience severe physical and economic suffering from COVID or other epidemics/pandemics, and to face a harder, longer recovery. According to COVIDActNow.org, Jefferson County has lower vulnerability than most counties in the U.S.

Figure 3.3.8-3: Jefferson County Vulnerability, COVIDActNow.org,



Structures, Systems, and Environmental Impacts

The West Virginia Electronic Disease Surveillance System (WVEDSS) utilizes the National Electronic Disease Surveillance System (NEDSS) framework to electronically manage and transmit communicable disease reports. The system serves healthcare providers, laboratories, hospitals, health departments and the Centers for Disease Control.

The environmental impacts of pandemics and infectious disease threats are still being determined. Many countries noted environmental benefits to everyone sheltering-in-place due to reduced commuting pollution and overall, an increase in air quality. Some areas have also identified "mask trash" from discarded face masks as a new form of litter that may have impacts on storm drains and otherwise still being determined. There will be significant economic and social costs beyond the possibility of disease-related deaths. Widespread illness may increase the likelihood of shortages of personnel to perform essential community services. In addition, high rates of illness and worker absenteeism occur within the business community, and these contribute to social and economic disruption. Social and economic disruptions could be temporary but may be amplified in today's closely interrelated and interdependent systems of trade and commerce. Social disruption may be greatest when rates of absenteeism impair essential services, such as power, transportation, and communications. Research of COVID-19 suggests that public transportation has greatly increased the transmission of this and other past viruses, bringing this vulnerability to light.

Jurisdictional losses in a pandemic or infectious disease outbreak stem from lost wages and productivity, not losses to buildings or land. Losses are difficult to estimate because the exact rates of absenteeism and

cost of treating a widespread disease will depend on the virus or bacterium in question, the availability of vaccination or treatment, and the severity of symptoms. The World Bank estimates that a severe flu pandemic could kill as many as 71 million people worldwide and cause a $3 trillion recession (CIDRAP, 2008).

The COVID-19 pandemic has also spurred conversations around creating safe public spaces and work environments regarding pandemic and infectious disease. The International Code Council (ICC) published an overview of code compliance that helps facilitate response to pandemic instances. For example, properly designed, installed, and maintained ventilation systems can help in mitigating the spread of pathogens (ICC, 2020). Many buildings have chosen to inspect and upgrade these systems during shelter in place orders. This is essential towards stopping the spread of pathogens in high density residential buildings and ensures workers will return to a safe environment when it is safe to work in offices again.

Losses based on historical epidemic occurrences are difficult to estimate. According to a study by Molinari (2007), seasonal influenza results in a substantial economic impact, estimated, in part, at $16.3 billion in lost earnings. By population, Jefferson County represents 0.17% of the United States. Since seasonal influenza primarily impacts the human population, using Jefferson County's composition of the U.S. as a multiplier (i.e., 0.0017) and applying it to the potential economic impact, lost earnings in Jefferson County could reach a staggering $27,710,000 each year. Though that number appears high, it equates to approximately $491 per year for each person in the county. Epidemics rarely affect structures. Epidemics may affect people and, at times, the operations of critical facilities, businesses, and other community assets.

Resources & Community Activities

According to the State of West Virginia 2023 Hazard Mitigation Plan-Section 5.9 Pandemic, potential statewide economic impacts include unemployment, price increases, and supply chain interruptions (Center on Budget and Policy Priorities, 2022). Significant economic disruption can occur due to death, loss of work time, food insecurity, and costs of treating or preventing the spread of the virus or disease.

Public events and community activities play a significant role in the transmission of viruses. Planned community events may be cancelled during a pandemic or outbreak in order to prevent the spread of viruses.

3.3.9 Thunderstorm and Hail

The wind gusts associated with thunderstorms pose a threat to life and/or property. Severe thunderstorms also have the potential of producing a tornado with little or no advanced tornado warning. Thunderstorms can also produce hail or heavy downpours that can lead to localized flooding. Thunderstorms are often characterized by frequent cloud-to-ground lightning as well.

Table 3.3.9-1: Types of Thunderstorms

Type	Description	Duration	Wd Speeds	Associated Hazards
Single Cell	Uncommon	20 - 30 minutes		• Non-damaging hail • Microbursts • Weak tornadoes
Multi Cell	Common, organized cluster of two or more single cells.	Each cell lasts approximately 20 minutes	Downbursts of up to 80 mph	• Heavy rainfall • Downbursts • Hail • Weak tornadoes
Mesoscale Convective System (MCS)	Well organized system of thunderstorms	Up to 12 hours or more	55 mph or more	• Torrential rainfalls • Derechos • Tornadoes
Squall Lines	May extend over 250 to 500 miles and 10 to 20 miles wide	Individual cells last from 30 to 60 minutes		• Significant rain after the storm • Derechos
Super Cells	Most dangerous storms, visible with Doppler radars	1 - 6 hours	Updrafts and downdrafts of more than 100 mph	• Tornadoes • Hail

Lightning is a rapid discharge of electrical energy in the atmosphere. When the charge difference between the ground and the cloud becomes too large, a conductive channel of air develops between the cloud and the ground, and a small amount of charge (step leader) starts moving toward the ground. When it nears the ground, an upward leader of opposite charge connects with the step leader. At the instant this connection is made; a powerful discharge occurs between the cloud and the ground. This discharge is seen as a bright visible flash of lightning.

Hail is a form of precipitation that occurs when updrafts in thunderstorms move raindrops up into incredibly cold areas of the atmosphere freezing them into balls of ice. Thunderstorms that have a very strong updraft repeatedly lift hailstones up into the top of the cloud where they encounter supercooled water drops. These water drops will freeze on contact with the hail, increasing its size. The hail falls when the updraft can no longer sustain the weight of the hailstones (NSSL NOAA, 2021).

When the hailstone is heavy enough, it will fall to the ground (NSSL, n.d.). In 1986, Jonathan Webb, a

member of the Tornado and Storm Research Organization (TORRO) in England, developed the TORRO Hailstorm Intensity Scale as a way to measure and categorize hailstorms (Voss Law Firm, n.d.).

Table 3.3.9-2: Torro Hailstorm Intensity Scale

Intensity		Typical Hail Diameter (mm)	Typical Hail Diameter (in)	Typical Damage	Example Size Description
H0	Hard Hail	5	Up to 0.33	No damage.	Pea
H1	Potentially Damaging	5 to 15	0.33-0.60	Slight general damage to plants, crops.	Mothball
H2	Significant	10 to 20	0.60-0.80	Significant damage to fruit, crops, vegetation.	Marble, Grape, Dime
H3	Severe	20 to 30	0.80-1.2	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored.	Walnut, Nickel to Quarter
H4	Severe	25 to 40	1.2-1.6	Widespread glass damage, vehicle bodywork damage.	Pigeon's egg > squash ball
H5	Destructive	30 to 50	1.6-2.0	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries.	Golf ball > Pullet's egg
H6	Destructive	40 to 60	2.0-2.4	Bodywork of grounded aircraft dented, brick walls pitted.	Hen's egg
H7	Destructive	50 to 75	2.4-3.0	Severe roof damage, risk of serious injuries.	Tennis ball > Cricket ball
H8	Destructive	60 to 90	3.0-3.5	(Severest recorded in the British Isles) Severe damage to aircraft bodywork.	Large orange > Soft ball
H9	Super Hailstorm	75 to 100	3.5-4.0	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open.	Grapefruit
H10	Super Hailstorm	>100	4.0+	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open.	Melon

Location and Extent

Thunderstorms are one of the most frequently occurring hazards throughout the County. NCEI records reflect the most severe of thunderstorms. Storms, however, are common throughout the spring and summer months (although a thunderstorm can occur in any season) that cause downed trees and power lines. Residents and businesses are likely to incur more damage because of these “smaller” storms as individual houses and vehicles are damaged by fallen limbs and businesses are forced to close due to a lack of electricity.

More than 100,000 thunderstorms occur in the U.S. each year, with lightning striking more than 30 million points on the ground during that same period. This causes an average of between 55-60 fatalities and 300 injuries each year. Lightning can occur with all thunderstorms, of which the entire region is susceptible. Lightning fatalities are also most common during the summer and during the afternoon and evening.

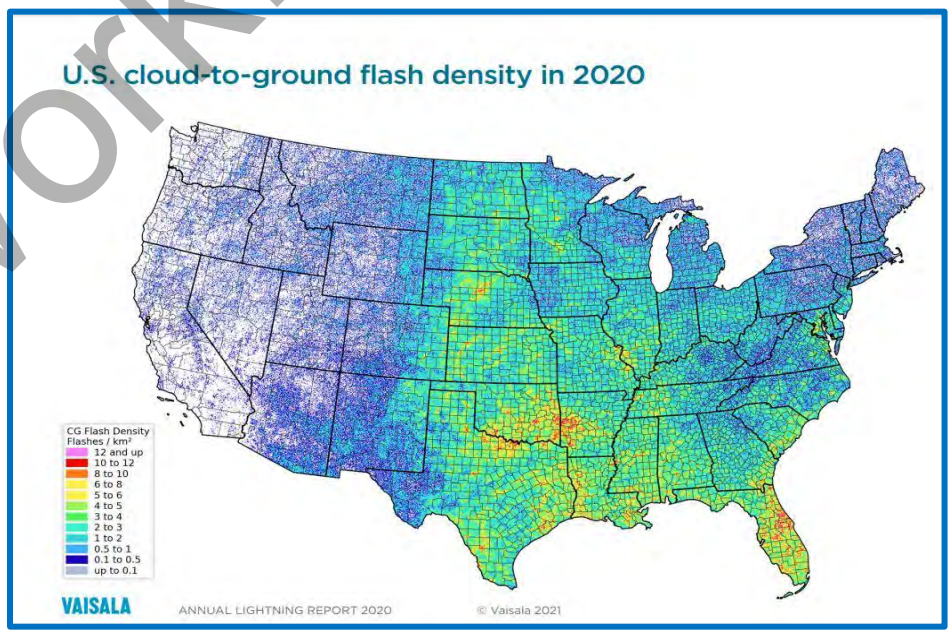
Hail is a relatively minor natural hazard in all parts of the region, but it occurs with some frequency. Even with these frequent occurrences, losses tend to be minor, especially to critical facilities and other infrastructure. Much like minor thunderstorms, hailstorms rarely slow down the daily lives of the residents in the region. If their vehicles or homes are damaged, they usually claim those damages on their insurance policies or repair the damage themselves.

When hail occurs, it can cause damage by battering crops, structures, automobiles, and transportation systems. When hailstorms are large, especially when combined with high winds, damage can be somewhat extensive. Hail is also much more common along mountain ranges because mountains force horizontal winds upwards thereby intensifying the updrafts within thunderstorms, where hail is formed, and making hail more likely. In mountainous areas, the falling hail has less time to melt before touching the ground (NSSL NOAA, 2021).

Past Occurrence

Even though lightning strike deaths and injuries are rare, they do happen. Between 1959 and 2017, 26 individuals have been killed by lightning in the State of West Virginia, an average of one person every other year (Vaisala, 2017). This puts West Virginia's risk in the bottom half of all states. Furthermore, West Virginia and the Eastern Panhandle have a moderate lightning flash density per year compared to other states. As seen in Figure 1, the density of lightning strikes the Eastern Panhandle experiences each year is 0.1 to 4 per square kilometer, compared to over 12 flashes per square kilometer in some parts of Florida (Vaisala, 2021).

Figure 3.3.9-1: U.S. Cloud-to-Ground Flash Density 2020 (Vaisala, 2021)



Records from the NCEI show that there were 89 lightning events in the 55 counties across West Virginia between 1950 and 2021. A

lightning "event" is defined as a lightning strike that results in fatality, injury, and/or property or crop damage (NOAA NWS, 2021).

There have been several hazardous hailstorms reported in the region. According to NCDC Event Records, 63 hail events of 0.5 inch or greater have been reported in Jefferson County since 1968. The largest reported hail in the area occurred during a hailstorm in Morgan County on May 6, 2002. It produced hail the size of a baseball, 2.75 inches in diameter (NCDC, 2021). Hail events from both 1968 to present for the county can be viewed in Table 3. Damages from these events totaled $10,000.00.

Table 3.3.9-3: Hail Events in Jefferson County 1968-2023

Location	Date	Magnitude	Property Damage ($)	Location	Date	Magnitude	Property Damage ($)
	7/10/1975	1.75	0	HARPERS FERRY	8/14/2008	0.75	0
	6/16/1982	0.75	0	HARPERS FERRY	8/14/2008	0.88	0
	5/16/1988	1.75	0	BOLIVAR	8/14/2008	0.75	0
	6/9/1990	1	0	KEARNEYSVILLE	4/25/2010	1	0
	9/18/1991	1	0	HALLTOWN	4/25/2010	1	0
	8/11/1992	0.75	0	MT PLEASANT	4/25/2010	1	0
	8/11/1992	0.75	0	MECHANICSTOWN	4/25/2010	1	0
	4/1/1993	0.88	0	MIDDLEWAY	4/25/2010	1	0
CHARLES TOWN	5/12/1993	1.75	0	KEARNEYSVILLE	05/26/2011	1	0
HARPERS FERRY	8/17/1993	1.25	5000	MIDDLEWAY	6/21/2011	1	0
	5/29/1995	0.75	0	MIDDLEWAY	7/11/2011	1	0
	7/10/1995	0.88	0	LEETOWN	9/14/2011	1	0
KABLETOWN	7/25/1999	1	0	SHEPHERDSTOWN	5/3/2012	1	0
SHEPHERDSTOWN	5/10/2000	1	0	SHEPHERDSTOWN	6/7/2012	1	0
SUMMIT PT	5/13/2000	1.25	0	BOLIVAR	7/8/2012	1	0
SHEPHERDSTOWN	7/14/2000	1	0	MT PLEASANT	6/23/2015	1	0
SHEPHERDSTOWN	7/16/2000	1.75	0	CHARLES TOWN	6/16/2016	1	0
KEARNEYSVILLE	5/26/2002	2.75	0	MT PLEASANT	5/18/2017	1	0
SHEPHERDSTOWN	5/26/2002	1.75	0	CHARLES TOWN ARPT	5/10/2018	1	0
HARPERS FERRY	6/14/2003	0.75	0	MT PLEASANT	5/14/2018	1.75	0
HARPERS FERRY	8/26/2003	0.75	0	MIDDLEWAY	5/14/2018	1.5	0
RANSON	5/23/2004	0.75	0	CHARLES TOWN ARPT	5/14/2018	1	0
HARPERS FERRY	5/25/2004	1.75	5000	CHARLES TOWN	5/14/2018	2.5	0
HARPERS FERRY	7/28/2007	0.88	0	MANNINGS	5/14/2018	1.75	0
SUMMIT PT	8/25/2007	1	0	CHARLES TOWN	5/14/2018	1	0
CHARLES TOWN	6/10/2008	0.75	0	SHEPHERDSTOWN	6/2/2019	1	0
BARDANE	6/23/2008	0.75	0	SHEPHERDSTOWN	6/2/2019	0.75	0
MECHANICSTOWN	6/28/2008	0.75	0	SHEPHERDSTOWN	6/2/2019	0.75	0

Table 3.3.9-3: Hail Events in Jefferson County 1968-2023							
Location	Date	Magnitude	Property Damage ($)	Location	Date	Magnitude	Property Damage ($)
MECHANICSTOWN	7/26/2008	0.88	0	CHARLES TOWN ARPT	6/2/2019	0.88	0
BOLIVAR	7/26/2008	1	0	HARPERS FERRY	6/2/2019	0.75	0
MIDDLEWAY	8/10/2008	0.75	0	HARPERS FERRY	6/2/2019	1	0
MANNINGS	8/14/2008	0.75	0				

The most recent occurrence of sizeable hail was reported in Charles Town on May 14, 2018, with hail up to 2.5 inches in diameter. No damages were claimed. The most recent hail occurrence that caused property damage in the county is from Harpers Ferry in 2004, which resulted in $5,000 in losses.

Future Occurrence

Lightning strikes the earth about 100 times every second. Each year in the United States, approximately 400 people are struck (about one for every 86,000 lightning flashes in the U.S.), and 17,400 fires are caused by lightning. July is the peak month for lightning strikes in the United States. The probability of a lightning strike on a given building is a function of the object's lightning-attractive area (e.g., a tall metal pole is more likely to be struck by lightning than a shorter non-conductive objects).

The future occurrence of lightning and thunderstorm activity in Jefferson County is anticipated, and the susceptibility to damage from these severe storms will remain unchanged. The number of lightning events is influenced by the frequency of a severe thunderstorm occurrence. Therefore, potential future changes in climate and weather conditions may impact the future occurrences of lightning strike.

The future occurrence of hailstorm activity in Jefferson County is expected, and the susceptibility to damage from hail will remain unchanged. The past occurrences in the region indicate that this event is one that can happen several times in any given year, most likely during the late spring and summer months. However, the probability of hailstorm events resulting in multiple casualties and extensive structural damage can be considered *unlikely,* while the probability of nondamaging hail can be considered *possible,* according to the Risk Factor Methodology (see Table 4.4.1-1).

Range of Magnitude

Because lightning damage is largely unreported, statistics vary considerably. The insurance industry, however, estimates 6.5 percent of all property/casualty claims are related to lightning strikes (Credit Union National Association, 2015). While it is difficult to quantify lightning losses, it is estimated that $4-5 billion damage occurs each year. Likewise, the cost of lightning protection to safeguard critical equipment and facilities from lightning strikes during severe weather is enormous. In statistics kept from 1997-2012, West Virginia was reported as having an average of 210,169 cloud-to-ground flashes per year

(NWS, 2016). The worst-case scenario for casualties from a lightning strike is envisioned to occur during a capacity sports game, crowded outdoor festival, or another outdoor event with a dense crowd. While to date there have been few casualties in the United States from direct lightning strikes to dense groups of people or from the mass movement of panicked individuals when lightning threatens, it is important to recognize this potential, albeit extremely low risk, event. Other worst-case scenarios could involve thunderstorms leading to car crashes, downed trees, and mass power outages.

Hail can vary significantly in its size and impact, but to be considered hail frozen precipitation must be greater than 0.2 inches in diameter. Table 4.3.5-1 demonstrates the range of reported hail sizes, with severe hail identified as being 1 inch or greater in diameter. The most severe hail experienced by Jefferson County is between 1.5-2.5 inches in diameter (NSSL NOAA, 2021).

Hailstorms can cause significant damage to crops, livestock, and property. Damage is dependent on the size, duration, and intensity of hail precipitation. Automobiles and aircraft are particularly susceptible to damage. Also, people are at risk for serious injury if they do not seek immediate shelter. Since hail precipitation usually occurs during thunderstorm events, the impacts of other hazards associated with thunderstorms (i.e. strong winds, intense precipitation, etc.) often occur simultaneously (NOAA NSSL, 2021).

A potential worst-case scenario of a hailstorm would be if a storm carrying hail of over two inches were to occur over a prolonged period in a predominantly agricultural area. Because hail can cause significant crop damage, a storm of this magnitude would potentially destroy agricultural yields and result in significant lost revenue, as well as property damage and injuries.

Table 3.3.9-4: Reference Object Used to Estimate Hail Size and Corresponding Scale of Hail Diameters (NSSL NOAA, 2020)

Hailstone Size	Measurement (Inches)	Updraft Speed (mph)
BB	< 0.25	< 24
Pea	0.25	24
Marble	0.50	35
Dime	0.70	38
Penny	0.75	40
Nickel	0.88	46
Quarter	1.00	49
Half Dollar	1.25	54
Walnut	1.50	60
Golf Ball	1.75	64
Hen Egg	2.00	69
Tennis Ball	2.50	77
Baseball	2.75	81
Teacup	3.00	84

Hailstone Size	Measurement (Inches)	Updraft Speed (mph)
Grapefruit	4.00	98
Softball	4.50	103

Vulnerability Assessment

According to FEMA, vulnerability is a description of which assets, including structures, systems, populations, and other assets as defined by the community, within locations identified to be hazard prone, are at risk from the effects of the identified hazard(s). As part of this plan update, the analysis of vulnerability to community assets was expanded. In addition, impacts from climate change, social vulnerability, and changes in land use have been included. Information has been integrated from FEMA's recently updated National Risk Index, which according to FEMA has changed the way risk is assessed.

Using data and analysis from FEMA's National Risk Index, Jefferson County's risk index is very low compared to other counties to the United States, in fact 45% of U.S. counties have a lower risk index than Jefferson County. The risk index rating for neighboring jurisdictions is relatively low for Berkeley County (West Virginia) and Loudoun County (Virginia), while Clarke County (Virginia) is very low.

Thunderstorm is a hazard that can be said to affect the entire region equally (i.e., all structures in the region are at risk). In many ways, the cascading effects of thunderstorms are more damaging than the storm itself. For example, as mentioned above, lightning strikes may cause power surges that result in damage. Thunderstorm winds may down trees that fall onto personal property. Tracking these types of damages is difficult as many people may not turn such claims into their insurance. Outdoor activities and events are particularly vulnerable to thunderstorms, but when lightning threatens a large outdoor venue, the game or event itself is usually postponed. The environmental impacts most often associated with lightning strikes include damage to or death of trees and ignition of wildfires. During the years of 2000 – 2020, the NOAA NCEI Storm Events Database reported 64 lightning events in West Virginia which caused two deaths, 17 injuries, property damage of $3,447,000 and $0 in crop damage (NOAA NCEI, 2021).

Losses due to lightning can be lessened by installing surge protection on critical electronic, lightning, or information technology systems. Lightning protection devices and methods, such as lightning rods and grounding, can be installed on a community's communications infrastructure and other critical facilities to reduce losses.

All of Jefferson County, including all critical infrastructure, is vulnerable to the effects of hail, as the storm cells that produce this hazard are spread over a large area. The area of damage due to these storms is relatively small, in that a single storm does not cause widespread devastation but may cause damage in a focused area of the storm. However, stakeholders have reported that hail damage can be especially damaging to tree orchards and other crops. According to the USDA Risk Management Agency (RMA) Federal Crop Insurance Corporation, which provides crop insurance to American farmers, over $2.5 million has been issued to farmers in Jefferson County from 2010 to 2023. Even though not all crops are insured through RMA, these records provide some insight into how damaging hail can be. The National Weather

Service and other meteorological forecasters can predict severe hail and warn residents and farmers. Vulnerability will vary by community, and people who are outdoors and property that is not protected by a strong roof will be most vulnerable.

People

This section specifically focuses on how people are impacted by the thunderstorm and hail hazard, including underserved communities and socially vulnerable populations. During storm event, people and first responders run the risk of sustaining injuries related to saving people and property. One of the primary health-related concerns is power outages caused by downed trees which impacts people who are reliant on power to run life-sustaining medical equipment; this is an example of a medically and socially vulnerable population.

Socially vulnerable populations are most susceptible due to their physical and financial ability to react and respond during storm events. This population includes the elderly, young, and individuals with disabilities or access or functional needs who may be unable to evacuate in the event of an emergency. The elderly is considered most vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention that might not be readily available due to isolation during a storm event. The vulnerable population also includes those who would not have adequate warning from an emergency warning system (e.g., television or radio); this would include residents and visitors. The population adversely affected by storm events may also include those beyond the disaster area that rely on affected roads for transportation.

Economically disadvantaged people are at high risk for bracing for storm events because of the potential inability to afford up-to-code homes and buildings that are deemed safe from storms passing through. They also may pose health issues, such as exposure to mold and other health issues that water seepage may cause. These populations may also lack access to vehicles for any necessary evacuations.

Structures

Utility infrastructure could suffer damage from high winds associated with falling tree limbs or other debris, resulting in the loss of power. Loss of service can impact residents and business operations alike. Interruptions in heating or cooling utilities can affect populations such as the young and elderly, who are particularly vulnerable to temperature-related health impacts. Loss of power can impact other public utilities, including potable water, wastewater treatment, and communications. In addition to public water services, property owners with private wells might not have access to potable water due to pump failure until power is restored.

Systems

Systems in this section refer to networks and capabilities. Storm events often disrupt many systems including power, sewer, water, communications, and road access. Lacking these, it is difficult to continue critical services to the community. Damage to property, facilities, and infrastructure can range from

minimal to total loss. The cost of recovery from thunderstorms and hail can vary for everyone. Homeowners and businesses can claim insurance benefits if they have them but may not be able to continue working due to storm-related damages within the community or of their own property.

Overall, all critical facilities are exposed to severe storm events. Transportation routes are vulnerable to severe storms and have the potential to be wiped out or blocked, creating isolation issues from responders. This includes all roads and bridges in the path of a severe storm event. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand high wind speeds and excessive precipitation. Utility infrastructure is also vulnerable; interruption of services may not only impact vulnerable populations but may also impact critical facilities that need to be in operation during a disaster. Because power interruption can occur, backup power is recommended for critical facilities and infrastructure. Full functionality of critical facilities such as police, fire, and medical services is essential for response during and after a severe storm event

Environmental resources, including critical habitat (or habitats that are known to be essential for an endangered or threatened species), wetlands, parks, and reserves are particularly vulnerable to severe storms. Destroyed habitats could displace and kill organisms reliant on these habitats. The impacts of intense windstorms and precipitation on the environment typically take place over a larger area. Where these events occur, widespread, severe damage to plant species is likely. This includes uprooting or destruction of trees and an increased threat of wildfire in areas where dead trees are not removed.

Natural, Historic, and Cultural Resources

Environmental resources, including critical habitat (or habitats that are known to be essential for an endangered or threatened species), wetlands, parks, and reserves are particularly vulnerable to storm events. Destroyed habitats could displace and kill organisms reliant on these habitats. The impacts of high wind, hail and precipitation on the environment typically take place over a larger area. Where these events occur, widespread, severe damage to plant species is likely. This includes uprooting or destruction of trees and an increased threat of wildfire in areas where dead trees are not removed.

Jefferson County is ranked fourth in the State as having the most historical buildings in the high-risk to thunderstorms and hail. Most of these historical buildings are in the towns of Shepherdstown and Harpers Ferry. The unincorporated area of Jefferson County is ranked first among all unincorporated areas in the State of West Virginia with 26 historical buildings.

Community Activities

Potential economic impacts include loss of agriculture, business, and tourism. In addition, losses of buildings and infrastructure also take a toll on the economic condition of West Virginia. Similarly, damages to buildings can displace people from their homes, threaten life safety and impact a community's economy and tax base. Severe storms can also damage utilities and communication towers, which are costly because they need to be repaired almost immediately after damages occur, and these repairs can cost millions of dollars to fix for a single event.

Activities that have value to the community could potentially be impacted by thunderstorm events and hail. When these activities are delayed or cancelled due to thunderstorm events and hail, the economy of the community is affected. Numerous activities are scheduled within Jefferson County and its municipalities. Below are community activities that occur throughout the year or annually.

- Jefferson County Fair – July and August at Jefferson County Fairgrounds
- Historical Walking Tours of Harpers Ferry, WV – Available All Year
- Hollywood Casino Horse Races – Reoccurring – Located in Charles Town
- Mountain Heritage Arts & Craft Festival at Jefferson County Fairgrounds – September 22-24
- Freedoms Run (Note: This event is held in part in Harpers Ferry.) – October 7

Impacts to community events would be dependent upon the event type and location

3.3.10 Severe Windstorm & Tornado

This profile discusses two types of wind that stem from severe thunderstorms (see Section XXXX Severe Thunderstorms), severe wind and tornadoes.

Severe Wind: Non-tornadic, damaging winds from thunderstorms include four common types (NWS & FEMA, 2001).

- Straight-Line Winds or Derechos: Winds having little or no curvature or rotation, capable of affecting a larger geographic area than a tornado.
- Downbursts: Localized downward gusts of air from a thunderstorm. These winds can be very damaging on and near the ground and tend to cover areas of just a few miles.
- Microbursts: Minimized downbursts affecting areas less than 2.5 miles in diameter. Microbursts induce a strong wind shear and can produce winds over 150 mph.
- Gust Fronts: Cool, gusty air that flows out of the base of a thunderstorm and spreads along the ground ahead of the thunderstorm cell.

One of the first scales to estimate wind speeds and the effects was created by Britain's Admiral Sir Francis Beaufort (1774-1857). He developed the scale in 1805 to help sailors estimate the winds via visual observations. The scale starts with 0 and goes to a force of 12. The Beaufort scale illustrated in Table 3.3.10-1 is still used today to estimate wind strengths (NOAA, n.d.).

Table 3.3.10-1: Beaufort Wind Scale

Force	Wind Speed			Appearance of Wind Effects	
	(mph)	(knots)	Description	On the Water	On Land
0	0-1	0-1	Calm	Sea surface smooth and mirror-like	Calm, smoke rises vertically
1	1-3	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-7	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move
3	8-12	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	13-18	11-16	Moderate Breeze	Small waves 1-4 ft. becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted, small tree branches move
5	19-24	17-21	Fresh Breeze	Moderate waves 4-8 ft taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway
6	25-31	22-27	Strong Breeze	Larger waves 8-13 ft, whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	32-38	38-33	Near Gale	Sea heaps up, waves 13-19 ft, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind

Table 3.3.10-1: Beaufort Wind Scale					
Force	Wind Speed			Appearance of Wind Effects	
	(mph)	(knots)	Description	On the Water	On Land
8	39-46	34-40	Gale	Moderately high (18-25 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks	Twigs breaking off trees, generally impedes progress
9	47-54	41-47	Strong Gale	High waves (23-32 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	55-63	48-55	Storm	Very high waves (29-41 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	64-72	56-63	Violent Storm	Exceptionally high (37-52 ft) waves, foam patches cover sea, visibility more reduced	
12	72-83	64-71	Hurricane	Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced	

Tornado: A tornado is a violently rotating column of air extending from a thunderstorm to the ground. Normally thunderstorms and associated tornadoes develop in warm, moist air in advance of strong eastward-moving cold fronts in late winter and early spring. Tornadoes can also occur along a "dryline" which separates very warm, moist air to the east from hot, dry air to the west. Both of these scenarios are common in the Central Plains. Another way that tornadoes can be created occurs when warm moist air flows upslope. Under the right temperature and moisture conditions, intense thunderstorms can produce tornadoes in higher terrain. Tornadoes can occur in every state, although the mid-west states have by far the greatest potential for this type of event. Tornadoes are ranked by intensity using the Enhanced Fujita (EF) Scale, replacing the original Fujita Scale devised by Dr. Theodore Fujita at the University of Chicago in 1971. The EF scale is broken into six categories from F-0 to F-5. F-0 relates to a tornado having a wind speed up to 72 miles per hour, while an F-5 tornado would have winds up to 318 mph.

Location and Extent

Both tornado and windstorm events can occur throughout Jefferson County. Tornado events are usually localized. However, severe thunderstorms may result in conditions favorable to the formation of numerous or long-lived tornadoes. Tornadoes can occur at any time during the day or night but are most frequent during late afternoon into early evening, the warmest hours of the day, and most likely to occur during the spring and early summer months of March through August. Tornado movement is characterized in two ways: direction and speed of spinning winds and forward movement of the tornado, also known as the storm track. Rotational wind speeds of the vortex can range from 100 mph to more than 250 mph. In addition, the speed of forward motion can be zero to 45 or 50 mph. Therefore, some estimates place the maximum velocity (combination of ground speed, wind speed, and upper winds) of tornadoes at about 300 mph.

Severe winds are experienced on a region-wide scale and often accompany tornados and are caused by the movement of air from areas of higher pressure to areas of lower pressure – the greater the difference in pressure, the stronger the winds. Windstorms are generally defined as sustained wind speeds of 40 mph or greater lasting for one hour or longer, or winds of 58 mph or greater for any duration.

Figure 3.3.10-1: Wind Zones of the United States (FEMA, 2014)

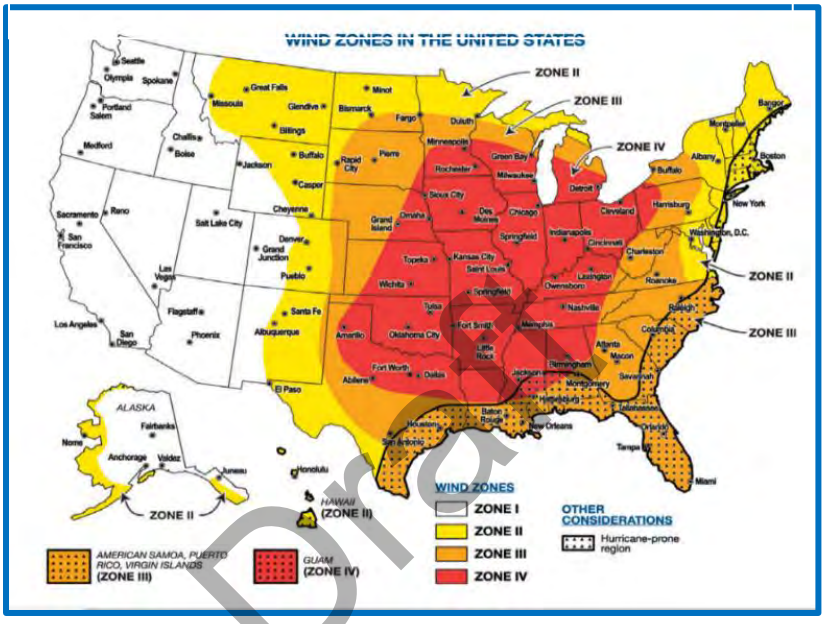


Figure 3.3.10-1 shows the wind speed zones developed by the American Society of Civil Engineers based on tornado and hurricane historical events. These wind speed zones are intended to guide the design and evaluation of the structural integrity of shelters and critical facilities. The whole of the Eastern Panhandle falls within Zone III, meaning the region is susceptible to winds up to 200 miles per hour. The hurricane susceptibility shown in the map is discussed in Section 4.3.6. The whole Eastern Panhandle falls within Zone III, meaning that shelters and critical facilities should be able to withstand a 3-second gust of up to 200 mph, regardless of whether the gust is the result of a tornado, coastal storm, or windstorm event. Therefore, these structures should be able to withstand the wind speeds experienced in an F3 tornado event.

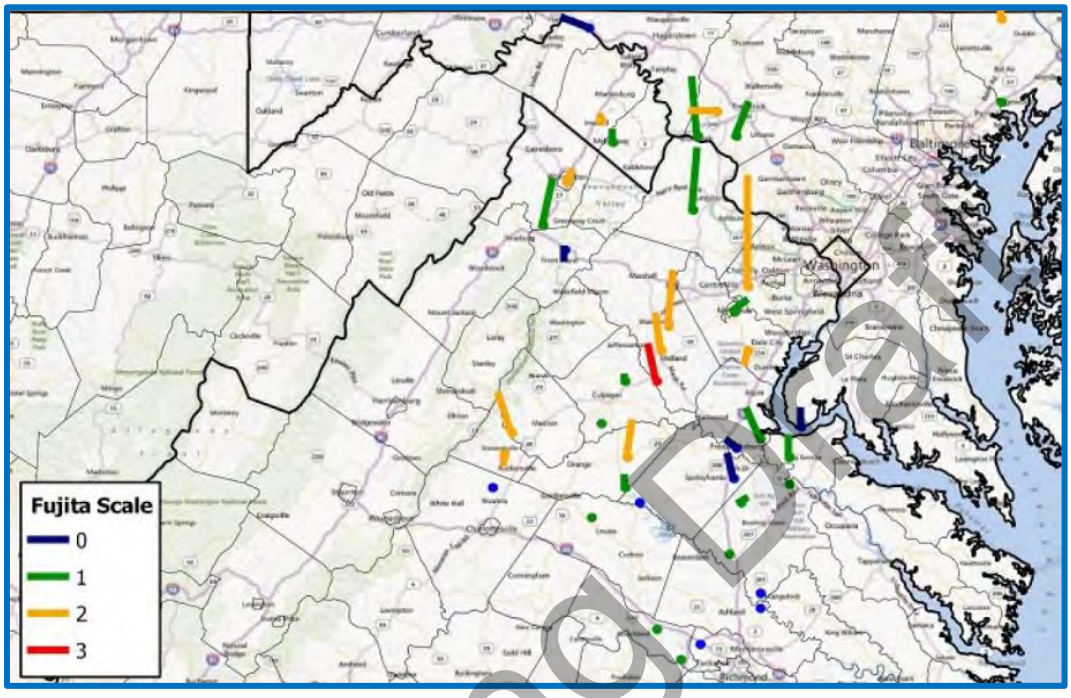
Past Occurrence

There have been five tornado events in Jefferson County since 1990, as seen in Table 3.3.10-2. They have all occurred between the months of May and September, and two tornados have inflicted injuries on the Jefferson County population since 1990. The first one occurred on July 2, 1997 and injured four people. The second one spawned by the Hurricane Ivan weather system on September 17, 2004, injured one person. The most severe documented tornado occurrence in the area had an F1 magnitude. The damage it caused was described in the 2013 WV Statewide HMP, stating that the tornado caused extensive damage to house and businesses and overturned vehicles on I-81. The path of this tornado can be seen in Figure 2 alongside other tornadoes in the region.

Hurricane Ivan resulted in the most recent severe tornadoes identified in the region. However, a recent severe windstorm did occur on May 3, 2021. Severe winds swept through the Eastern Panhandle, displacing several families. The National Weather Service confirmed a tornado hit Ranson, WV with peak winds at 90 mph. Emergency Officials reported severe damage in the Ranson area as well as the areas of Bunker Hill and Inwood in neighboring Berkeley County. A list of other hazardous windstorms from 1991

to March 2023 can be seen in Table 3.3.10-3.

Figure 3.3.10-2: Tornado Tracks of Hurricane Ivan (Prociv, 2004) OAA NWS, 2016)



On June 29, 2012, a type of violent windstorm system, called a derecho, moved eastward impacting Indiana, Ohio, West Virginia, Virginia, Washington DC, Maryland, and part of New Jersey, as seen in Figure 3. The storm carried thunder and wind gusts ranging between 60 and 100 mph. Thirteen people were killed as a result of this windstorm, three in West Virginia, with widespread power outages across the impacted area leaving 1.6 million people without power. Damages from the storm were reported in the Eastern Panhandle. Meteorologists theorize that the derecho event occurred in part thanks to the above average temperatures being experienced across the impacted region, which helped to fuel the storm (Daniel, 2012).

Figure 3.3.10-3: 6/29/12 Derecho Windstorm

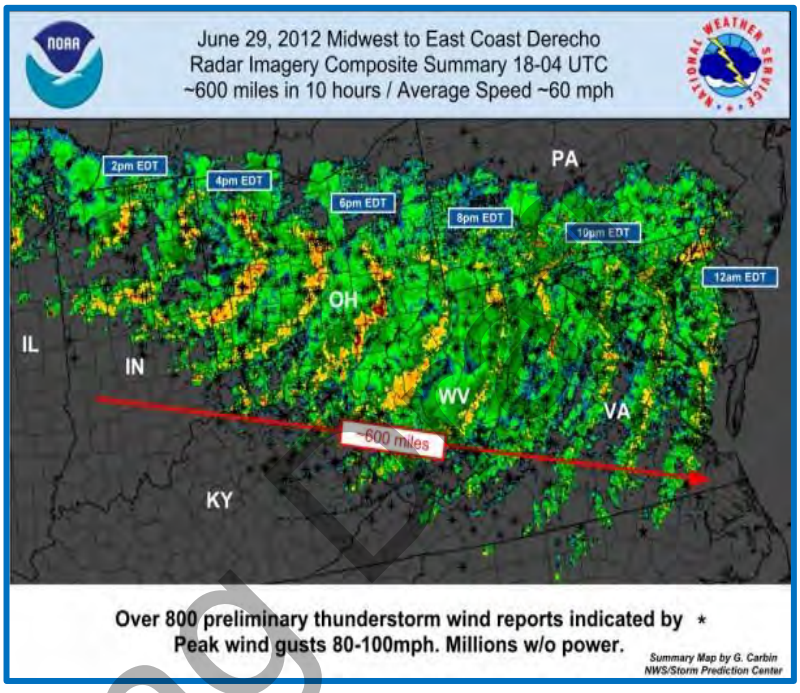


Table 3.3.10-2: Tornado Events Jefferson County, 1990 – March 2023, (NCEI NOAA, 2023)

Location	Date	Magnitude	Property Damage ($)	Crop Damage ($)	Injuries
Unknown (State Plan)	7/2/1997	F0	250,000	0	4
Summit Point (NCEI)	7/9/2003	F0	0	0	0
Middleway (NCEI)	9/17/2004	F1	250,000	0	0
Charles Town (NCEI)	7/5/2017	EF0	0	0	0
Charles Town (NCEI)	5/3/2021	EF1	100,000	0	1

In addition to tornadoes, Jefferson County has also endured considerable damage from countless hazardous wind events, shown in Table 3.3.10-3.

Table 3.3.10-3: Hazardous Wind Events in Jefferson County 1990 - March 2023 (NOAA, 2023)

Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)	Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)
4/9/1991	T-Storm Wind	50	0	0	0	6/12/2011	T-Storm Wind	56	0	3000	0
1/14/1992	T-Storm Wind	53	0	0	0	7/11/2011	T-Storm Wind	56	0	500	0
3/10/1992	T-Storm Wind	0	0	0	0	7/11/2011	T-Storm Wind	61	0	100000	0

Table 3.3.10-3: Hazardous Wind Events in Jefferson County 1990 - March 2023 (NOAA, 2023)											
Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)	Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)
7/17/1992	T-Storm Wind	0	0	0	0	7/11/2011	T-Storm Wind	61	0	5000	0
7/23/1992	T-Storm Wind	0	0	0	0	7/11/2011	T-Storm Wind	56	0	5000	0
4/16/1993	T-Storm Wind	0	0	5000	0	7/19/2011	T-Storm Wind	52	0	1000	0
8/17/1993	T-Storm Wind	0	0	5000	0	7/19/2011	T-Storm Wind	56	0	2000	0
8/13/1994	T-Storm Wind	0	0	500	0	9/14/2011	T-Storm Wind	52	0	0	0
9/13/1994	T-Storm Wind	0	0	500	0	5/27/2012	T-Storm Wind	52	0	0	0
11/1/1994	T-Storm Wind	0	0	5000	0	6/29/2012	T-Storm Wind	60	0	0	0
4/9/1995	T-Storm Wind	0	0	0	0	6/29/2012	T-Storm Wind	61	0	10000	0
6/3/1995	T-Storm Wind	0	0	3000	0	6/29/2012	T-Storm Wind	57	0	5000	0
6/11/1995	T-Storm Wind	0	0	0	0	6/29/2012	T-Storm Wind	57	0	1000	0
7/6/1995	T-Storm Wind	0	0	25000	0	10/29/2012	High Wind	52	0	0	10000
7/10/1995	T-Storm Wind	0	0	10000	0	5/22/2013	T-Storm Wind	52	0	1000	500
7/16/1995	T-Storm Wind	0	0	15000	0	6/10/2013	T-Storm Wind	52	0	0	250
7/30/1996	T-Storm Wind	-	0	10000	0	6/24/2013	T-Storm Wind	52	0	5000	500
9/6/1996	High Wind	-	0	50000	25000	6/25/2013	T-Storm Wind	52	0	500	500
3/6/1997	Strong Wind	-	0	0	0	6/25/2013	T-Storm Wind	52	0	0	500
3/31/1997	Strong Wind	-	0	15000	0	6/25/2013	T-Storm Wind	52	0	0	500
6/26/1997	T-Storm Wind	-	0	25000	0	6/25/2013	T-Storm Wind	52	0	0	500
7/28/1997	T-Storm Wind	-	0	3000	0	7/7/2013	T-Storm Wind	52	0	0	250
2/24/1998	Strong Wind	-	0	0	0	7/2/2014	T-Storm Wind	52	0	1000	1000
6/13/1998	T-Storm Wind	56	0	20000	0	7/2/2014	T-Storm Wind	52	0	3000	500
6/16/1998	T-Storm Wind	-	0	5000	0	7/2/2014	T-Storm Wind	52	0	0	1000
7/21/1998	T-Storm Wind	71	0	35000	15000	7/2/2014	T-Storm Wind	52	0	0	250
3/3/1999	T-Storm Wind	-	0	3000	0	7/2/2014	T-Storm Wind	52	0	2000	2000
5/12/1999	T-Storm Wind	-	0	500	0	7/2/2014	T-Storm Wind	52	0	1000	250
7/24/1999	T-Storm Wind	-	0	5000	0	7/8/2014	T-Storm Wind	52	0	0	250
7/28/1999	T-Storm Wind	-	0	3000	0	7/13/2014	T-Storm Wind	52	0	0	250
8/26/1999	T-Storm Wind	-	0	4000	0	7/13/2014	T-Storm Wind	52	0	0	500
9/29/1999	T-Storm Wind	-	1	40000	0	7/13/2014	T-Storm Wind	52	0	0	250
5/10/2000	T-Storm Wind	-	0	2000	0	7/13/2014	T-Storm Wind	52	0	0	250
5/13/2000	T-Storm Wind	-	0	500	0	7/13/2014	T-Storm Wind	52	0	0	250
5/13/2000	T-Storm Wind	-	0	5000	0	7/13/2014	T-Storm Wind	52	0	0	500
5/13/2000	T-Storm Wind	-	1	2000	0	7/23/2014	T-Storm Wind	52	0	0	500
5/13/2000	T-Storm Wind	-	0	2000	0	7/23/2014	T-Storm Wind	52	0	0	1000
6/15/2000	T-Storm Wind	-	0	1000	0	9/6/2014	T-Storm Wind	52	0	0	250
7/14/2000	T-Storm Wind	-	0	500	0	5/16/2015	T-Storm Wind	50	0	1000	0
8/9/2000	T-Storm Wind	-	0	2000	0	5/16/2015	T-Storm Wind	50	0	1000	0

Table 3.3.10-3: Hazardous Wind Events in Jefferson County 1990 - March 2023 (NOAA, 2023)											
Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)	Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)
12/12/2000	Strong Wind	-	0	0	0	6/30/2015	T-Storm Wind	52	0	2000	0
12/17/2000	Strong Wind	-	0	0	0	8/4/2015	T-Storm Wind	52	0	1000	0
1/27/2001	Strong Wind	-	0	0	0	4/2/2016	High Wind	50	0	0	0
2/9/2001	Strong Wind	-	0	0	0	6/16/2016	T-Storm Wind	50	0	0	0
3/6/2001	Strong Wind	-	0	0	0	8/15/2016	T-Storm Wind	50	0	0	0
3/13/2001	T-Storm Wind	-	0	10000	0	8/15/2016	T-Storm Wind	50	0	0	0
3/13/2001	T-Storm Wind	-	0	2000	0	9/7/2016	T-Storm Wind	50	0	0	0
3/13/2001	T-Storm Wind	-	0	30000	0	2/12/2017	High Wind	52	0	0	0
6/12/2001	T-Storm Wind	-	0	500	0	3/1/2017	T-Storm Wind	52	0	0	0
6/30/2001	T-Storm Wind	-	0	500	0	3/1/2017	T-Storm Wind	52	0	0	0
2/1/2002	Strong Wind	-	0	0	0	7/22/2017	T-Storm Wind	50	0	0	0
3/21/2002	Strong Wind	-	0	0	0	7/22/2017	T-Storm Wind	50	0	0	0
4/28/2002	T-Storm Wind	-	0	5000	0	7/22/2017	T-Storm Wind	50	0	0	0
4/28/2002	T-Storm Wind	-	0	20000	0	8/3/2017	T-Storm Wind	50	0	0	0
5/14/2002	T-Storm Wind	-	0	10000	0	8/12/2017	T-Storm Wind	50	0	0	0
5/14/2002	T-Storm Wind	-	0	5000	0	3/2/2018	High Wind	50	0	0	0
5/26/2002	T-Storm Wind	-	0	10000	0	5/14/2018	T-Storm Wind	50	0	0	0
6/6/2002	T-Storm Wind	-	0	5000	0	5/14/2018	T-Storm Wind	50	0	0	0
6/6/2002	T-Storm Wind	-	0	2000	0	7/27/2018	T-Storm Wind	50	0	0	0
7/9/2002	T-Storm Wind	-	0	5000	0	8/17/2018	T-Storm Wind	50	0	0	0
9/27/2002	T-Storm Wind	50	0	2000	0	8/21/2018	T-Storm Wind	50	0	0	0
1/8/2003	Strong Wind	40	0	100	0	2/25/2019	High Wind	50	0	0	0
2/23/2003	Strong Wind	30	0	100	0	6/27/2019	T-Storm Wind	50	0	0	0
6/1/2003	Strong Wind	40	0	1000	0	6/27/2019	T-Storm Wind	61	0	0	0
6/12/2003	T-Storm Wind	50	0	2000	0	6/29/2019	T-Storm Wind	50	0	0	0
7/4/2003	T-Storm Wind	50	0	500	0	6/29/2019	T-Storm Wind	50	0	0	0
7/6/2003	T-Storm Wind	50	0	2000	0	6/29/2019	T-Storm Wind	50	0	0	0
8/22/2003	T-Storm Wind	50	0	2000	0	6/29/2019	T-Storm Wind	61	0	0	0
8/26/2003	T-Storm Wind	55	0	5000	0	7/22/2019	T-Storm Wind	50	0	0	0
9/18/2003	High Wind	50	1	300000	50000	7/22/2019	T-Storm Wind	50	0	0	0
10/15/2003	Strong Wind	44	0	3000	0	8/6/2019	T-Storm Wind	50	0	0	0
11/13/2003	Strong Wind	45	0	3000	0	8/22/2019	T-Storm Wind	50	0	0	0
5/21/2004	T-Storm Wind	55	0	0	0	9/2/2019	T-Storm Wind	50	0	0	0
5/21/2004	T-Storm Wind	53	0	3000	0	3/3/2020	T-Storm Wind	56	0	3000	0
5/21/2004	T-Storm Wind	55	0	2000	0	3/3/2020	T-Storm Wind	56	0	20000	0
5/21/2004	T-Storm Wind	53	0	2000	0	3/3/2020	T-Storm Wind	56	0	3000	0
6/1/2004	T-Storm Wind	55	0	5000	0	4/7/2020	T-Storm Wind	60	0	30000	0

Table 3.3.10-3: Hazardous Wind Events in Jefferson County 1990 - March 2023 (NOAA, 2023)											
Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)	Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)
11/24/2005	Strong Wind	40	0	100000	0	4/7/2020	T-Storm Wind	60	0	30000	0
11/29/2005	T-Storm Wind	50	0	100000	0	4/13/2020	T-Storm Wind	50	0	0	0
1/14/2006	T-Storm Wind	60	0	100000	0	4/13/2020	T-Storm Wind	50	0	0	0
1/14/2006	High Wind	50	0	100000	0	5/29/2020	T-Storm Wind	55	0	10000	0
6/22/2006	T-Storm Wind	50	0	10000	0	6/5/2020	T-Storm Wind	50	0	5000	0
7/12/2006	T-Storm Wind	50	0	13000	0	6/25/2020	T-Storm Wind	50	0	1000	0
8/26/2006	T-Storm Wind	50	0	27000	0	7/6/2020	T-Storm Wind	65	0	50000	0
12/1/2006	Strong Wind	45	0	10000	0	7/6/2020	T-Storm Wind	50	0	5000	0
5/27/2007	T-Storm Wind	50	0	1000	0	7/22/2020	T-Storm Wind	50	0	2000	0
6/13/2007	T-Storm Wind	50	0	3000	0	9/3/2020	T-Storm Wind	50	0	2000	0
6/21/2007	T-Storm Wind	50	0	1000	0	11/15/2020	T-Storm Wind	55	0	20000	0
7/28/2007	T-Storm Wind	50	0	2000	0	5/3/2021	T-Storm Wind	50	0	3000	0
7/29/2007	T-Storm Wind	50	0	0	0	5/3/2021	T-Storm Wind	50	0	1000	0
12/16/2007	High Wind	50	0	0	0	5/3/2021	T-Storm Wind	50	0	1000	0
2/10/2008	High Wind	50	0	25000	0	5/3/2021	T-Storm Wind	55	0	10000	0
5/31/2008	T-Storm Wind	50	0	1000	0	5/26/2021	T-Storm Wind	65	0	25000	0
6/4/2008	T-Storm Wind	70	0	20000	0	5/26/2021	T-Storm Wind	55	0	3000	0
6/4/2008	T-Storm Wind	70	0	20000	0	6/3/2021	T-Storm Wind	50	0	2000	0
6/4/2008	T-Storm Wind	74	0	0	0	6/21/2021	T-Storm Wind	50	0	4000	0
6/4/2008	T-Storm Wind	70	0	75000	0	6/21/2021	T-Storm Wind	50	0	3000	0
6/4/2008	T-Storm Wind	50	0	1000	0	6/21/2021	T-Storm Wind	50	0	2000	0
6/4/2008	T-Storm Wind	50	0	5000	0	6/30/2021	T-Storm Wind	45	0	1000	0
6/4/2008	T-Storm Wind	50	0	8000	0	7/12/2021	T-Storm Wind	50	0	1500	0
6/16/2008	T-Storm Wind	50	0	4000	0	7/12/2021	T-Storm Wind	50	0	5000	0
6/28/2008	T-Storm Wind	50	0	8000	0	7/17/2021	T-Storm Wind	55	0	3000	0
6/28/2008	T-Storm Wind	50	0	8000	0	8/10/2021	T-Storm Wind	50	0	1000	0
7/23/2008	T-Storm Wind	50	0	1000	0	8/10/2021	T-Storm Wind	50	0	1000	0
2/11/2009	T-Storm Wind	52	0	0	0	8/10/2021	T-Storm Wind	50	0	1000	0
2/11/2009	T-Storm Wind	50	0	0	0	8/11/2021	T-Storm Wind	50	0	1000	0
2/12/2009	High Wind	50	0	0	0	8/13/2021	T-Storm Wind	50	0	20000	0
8/21/2009	T-Storm Wind	52	0	0	0	8/13/2021	T-Storm Wind	55	0	12000	0
2/26/2010	High Wind	50	0	0	0	8/13/2021	T-Storm Wind	50	0	1000	0
7/25/2010	T-Storm Wind	70	0	10000	0	8/25/2021	T-Storm Wind	50	0	6000	0
7/25/2010	T-Storm Wind	62	0	10000	0	8/28/2021	T-Storm Wind	50	0	2000	0
11/16/2010	T-Storm Wind	61	0	0	0	6/16/2022	T-Storm Wind	50	0	1000	0
11/16/2010	T-Storm Wind	61	0	0	0	6/22/2022	T-Storm Wind	55	0	10000	0
11/16/2010	T-Storm Wind	61	0	0	0	6/22/2022	T-Storm Wind	55	0	10000	0

Table 3.3.10-3: Hazardous Wind Events in Jefferson County 1990 - March 2023 (NOAA, 2023)											
Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)	Date	Type	Wind Speed (Knots)	Injuries	Property Damage ($)	Crop Damage ($)
11/17/2010	T-Storm Wind	56	0	10000	0	7/1/2022	T-Storm Wind	50	0	1000	0
2/25/2011	High Wind	50	0	0	0	8/4/2022	T-Storm Wind	43	0	1000	0
3/10/2011	T-Storm Wind	50	0	500	0	9/25/2022	T-Storm Wind	52	0	2000	0
6/12/2011	T-Storm Wind	52	0	1000	0	3/23/2023	T-Storm Wind	52	0	3000	0
6/12/2011	T-Storm Wind	56	0	1000	0						

Future Occurrence

For the period between 1990 and March 2023, four tornadoes were reported in Jefferson County by NCEI. Therefore, the annual probability of being in the path of a tornado in the region is relatively minor. While the chance of being hit by a tornado is small, the damage that results when the tornado arrives can be potentially devastating. An F4 tornado, with a 0.01-percent-annual probability of occurring, can carry wind velocities of 200 mph, resulting in a force of more than 100 pounds per square foot of surface area. This is a "wind load" that exceeds the design limits of most buildings. While most of the recent windstorms and tornadoes have occurred outside of the county, their proximity contributes to future risk. Because more windstorms have been seen in the region, it is possible that an increasing number of tornadoes will be seen in Jefferson County.

According to these NCEI records, there have been 237 hazardous wind events in Jefferson County. The region experiences severe windstorm events more commonly than tornadoes, which causes power failures, loss of communication networks, and residents requiring temporary shelters and provision of supplies.

Range of Magnitude

The destruction caused by tornadoes ranges from light to inconceivable depending on the intensity, size, and duration of the storm. Typically, tornadoes cause the greatest damages to structures of light construction such as mobile homes. The impact of tornado hazards is ultimately dependent on the population or amount of property present in the area in which the tornado occurs. Tornado events are often so severe that property loss or human fatality is typically inevitable if evacuation or proper construction standards are not implemented.

Since 2007, enhanced Fujita Tornado Scale (or the -EF-Scale) has been used in the United States to describe the magnitude of tornadoes. Prior to 2007, the Fujita Scale (F-Scale) was commonly used to describe magnitude. This scale is based on new information about the relationship between wind speed given in miles per hour (mph) and corresponding damages. The EF Scale categorized tornadoes from EF0 to EF5 with EF0 being the most commonly occurring type of tornado. Table 3.3.10-4 shows the enhanced Fujita Tornado Scale and associated damages.

Table 3.3.10-4: Enhanced Fujita Scale (EF-Scale) Categories with Associated Wind Speeds and Expected Damage			
Ef-Scale Number	**Wind Speed (mph)**	**F-Scale Number**	**Type of Damage Possible**
EF0	65–85	F0-F1	**Minor damage**: Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.
EF1	86-110	F1	**Moderate damage**: Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111–135	F1-F2	**Considerable damage**: Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136–165	F2-F3	**Severe damage**: Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166–200	F3	**Devastating damage**: Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	>200	F3-F6	**Extreme damage**: Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (300 ft.); steel reinforced concrete structure badly damaged; high-rise buildings have significant structural deformation.

Since tornado and severe wind events are typically localized, environmental impacts are rarely widespread. However, where these events occur, severe damage to buildings and plant species is likely. This includes loss of trees and an increased threat of wildfire in areas where dead trees are not removed. Hazardous material facilities should meet design requirements to withstand a 3-second gust of up to 160 mph in order to prevent release of hazardous materials into the environment.

The worst-case scenario for windstorm and tornado events in Jefferson County would be an EF5 tornado that strikes the Charles Town area. This is the most densely developed and populated area in the county and a severe tornado here could cause maximum property damage and casualties. Most tornadoes only remain on the ground for around 5 minutes and travel a few miles, but some have tornadoes have remained grounded for over an hour and traveled 70 miles. An EF5 tornado can level houses, throw cars, and deform reinforced or high-rise buildings. An event of this severity is exceptionally unlikely to occur and represents an extreme scenario only, but the possibility should be considered. More typical wind hazard events in Jefferson County involve tree and limb damage, with fallen trees and limbs possibly resulting in damage to nearby vehicles or structures.

Vulnerability Assessment

For tornadoes or high winds, aged and dilapidated structures or structures not built to applicable building codes are more susceptible to damage. Mobile homes and campgrounds are especially susceptible to damage due to tornado or high wind. Strong winds can rip roofs off any dilapidated structures and overturn mobile homes. Past experiences with tornadoes in the region show that, while rara, death and injury are indeed possibilities. Vulnerability to the effects of a tornado or high wind is somewhat dependent upon the age of a structure because as building codes become more stringent, buildings are capable of enduring greater wind forces.

In Jefferson County, high winds occur almost annually. The most common detrimental effects are interruptions in power supply and communications services due to downed wires and blocked roadways due to downed trees. Most severe power failures or outages are regional events. With the loss of power, electrical-powered equipment and systems will not be operational. Examples include lighting, HVAC and ancillary support equipment, communication systems, ventilation system, refrigerators, sterilizers, and medical equipment. This can cause food spoilage, loss of heat or air conditions, basement flooding (sump pump failure), lack of light, loss of water (well pump failure), lack of phone service, or lack of internet. While it is most often a short-term nuisance rather than a catastrophic hazard, utility interruptions can cause challenges for communications and response, particularly in more rural areas of the county. A worst-case scenario for utility interruption in the region would involve a power outage during winter snow or ice storms, which have the potential to cause power outages for prolonged periods of time.

High winds often occur during hurricanes and tropical storms. Information about potential annualized losses due to hurricane winds can be found in Section 4.3.7.

All structures and infrastructure might be exposed to the effects of a tornado or other high winds. Depending upon the severity of a tornado or high wind, any existing structures might be damaged to some extent. Any future structures might be exposed to tornados or high winds as this hazard does not occur in specific locations. However, future buildings will be somewhat protected from the effects of tornado or high wind as they will meet the most current State building code requirements for bracing and roof design.

Manufactured housing (i.e. mobiles homes or trailers) is particularly vulnerable to high winds and tornadoes. The U.S. Census Bureau defines manufactured homes as “movable dwellings, eight feet or wider and 40 feet or longer, design to be towed on its own chassis, with transportation gear integral to the unit when it leaves the factory, and without need of a permanent foundation (U.S. Census Bureau, 2021).” They can include multi-wide and expandable manufactured homes but exclude travel trailers, motor homes, and modular housing. Due to their lightweight and often unanchored design, manufactured housing is extremely vulnerable to high winds and will generally sustain the most damage.

Table 3.3.10-5 below displays the number of manufactured housing units in Jefferson County, which account for a little more than 6% of the area’s housing stock.

Table 3.3.10-5: Mobile Homes in Jefferson County (U.S. Census Bureau, 2021)		
Total Housing Units	**Number Mobile Homes**	**Percent Mobile Homes**
23,607	1,448	6.1%

According to the NOAA Storm Events Database, Jefferson County has reported $2,235,000 in property damages due to tornados and extreme wind events, and $112,000 in crop damage from wind events (NOAA NCEI, 2023).

People

For the purpose of this plan, the entire population of Jefferson County is exposed to the severe windstorm and tornado hazards. Residents may be displaced or require temporary and long-term housing and sheltering. In addition, damages caused by a severe windstorm or tornado can lead to severe injuries and loss of life.

Socially vulnerable populations are most susceptible due to their physical and financial ability to react and respond during severe wind events and tornadoes. This population includes the elderly, young, and individuals with disabilities or access or functional needs who may be unable to evacuate in the event of an emergency. The elderly is considered most vulnerable because they require extra time and are more likely to seek or need medical attention that might not be readily available due to isolation during a storm event.

Vulnerable population also includes those who would not have adequate warning from an emergency warning system (e.g., television or radio); this would include residents and visitors. The population adversely affected by severe storms may also include those beyond the disaster area that rely on affected roads for transportation.

Economically disadvantaged people are at high risk for bracing severe wind events and tornadoes because of the potential inability to afford up-to-code homes and buildings that are deemed safe. They also may pose health issues, such as exposure to mold and other health issues that water seepage may cause.

In 2021, nearly 1500 mobile homes resided in Jefferson County. As mentioned previously, manufactured housing is more susceptible to physical deterioration from tornadoes and severe wind events than more secure structures. Still, severe wind events have caused considerable damage to structures considered “well-constructed,” meaning that every person within proximity of the hazard faces varying levels of harm.

Severe wind events and tornadoes can also cause respiratory illnesses or exacerbate their negative impacts on human health. In addition, tornadoes can knock down trees or structures, which can cause severe injury or death.

In 2018, Jefferson County residents identified severe wind events and tornadoes are one of their top

hazard concerns. Often, tornado events require people to take shelter in sturdy structure or to evacuate the area, so not having the access to one can further endanger the population. Unfortunately, lacking the adequate resources to seek safety can cause anxiety in vulnerable populations on top of the dangers severe wind events and tornadoes already pose.

Structures

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For severe wind events and tornadoes, the entirety of Jefferson County has been identified as the hazard area. Therefore, all assets in the County (population, structures, critical facilities, and lifelines), are vulnerable.

The most vulnerable structures during severe wind events or tornadoes include manufactured housing, historic buildings, and general structure finishings.

Systems

Overall, all critical facilities are exposed to severe storm events. Transportation routes are vulnerable to severe wind and tornadoes and have the potential to be wiped out or blocked, creating isolation issues from responders. This includes all roads and bridges in the path of a storm event or tornado. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand high wind speeds and excessive precipitation.

Utility infrastructure is also vulnerable; interruption of services may not only impact vulnerable populations but may also impact critical facilities that need to be in operation during a disaster. Because power interruption can occur, backup power is recommended for critical facilities and infrastructure. Full functionality of critical facilities such as police, fire, and medical services is essential for response during and after a severe storm event.

Loss of service can impact residents and business operations alike. Interruptions in heating or cooling utilities can affect populations such as the young and elderly, who are particularly vulnerable to temperature-related health impacts. Loss of power can impact other public utilities, including potable water, wastewater treatment, and communications. In addition to public water services, property owners with private wells might not have access to potable water due to pump failure until power is restored.

One of the dangers of severe wind events or tornadoes lies in their high capacity to cause secondary or cascading consequences, as intense winds can topple over trees, scatter debris, or damage home finishings. Moreover, these consequences can interrupt necessary utility connections, block roads or train tracks, and damage crops.

Natural, Historic and Cultural Resources

Environmental resources, including critical habitat (or habitats that are known to be essential for an

endangered or threatened species), wetlands, parks, and reserves are particularly vulnerable to severe storms. Destroyed habitats could displace and kill organisms reliant on these habitats. The impacts of intense windstorms and precipitation on the environment typically take place over a larger area. Where these events occur, widespread, severe damage to plant species is likely. This includes uprooting or destruction of trees and an increased threat of wildfire in areas where dead trees are not removed.

According to Jefferson County's Historic Landmarks Commission, 71 nationally registered landmarks can be found within the boundaries of the county. These sites are particularly vulnerable to destruction, as they already require specialized care to stay in good condition for preservation.

Animals and vegetation are also prone to harm, injury, or death in the event of severe wind or tornado.

Community Activities

Potential economic impacts include loss of agriculture, business, and tourism. In addition, losses of buildings and infrastructure also take a toll on the economic condition of Jefferson County. Similarly, damages to buildings can displace people from their homes, threaten life safety and impact a community's economy and tax base. Severe windstorms and tornadoes can also damage utilities and communication towers, which are costly because they need to be repaired almost immediately after damages occur, and these repairs can cost millions of dollars to fix for a singular event.

Activities that have value to the community could potentially be impacted by severe windstorms or tornados. When these activities are delayed or cancelled due to severe windstorms or tornadoes, the economy of the community is affected. Numerous activities are scheduled within Jefferson County and its municipalities. Below are community activities that occur throughout the year or annually.

- Jefferson County Fair – July and August at Jefferson County Fairgrounds
- Historical Walking Tours of Harpers Ferry, WV – Available All Year
- Hollywood Casino Horse Races – Reoccurring – Located in Charles Town
- Mountain Heritage Arts & Craft Festival at Jefferson County Fairgrounds – September 22-24
- Freedoms Run (Note: This event is held in part in Harpers Ferry.) – October 7

Impacts to community events would be dependent upon the event type and location.

3.3.11 Severe Winter Storm

Winter storms are often erratic, affecting different areas unevenly; they often develop, dissipate, and reform with two to three centers, often delivering snow in only one quadrant, while places not too far away from a blizzard may experience rain or fog, or nothing at all. There are three elements that must be present to generate a winter storm (NSSL, n.d.).

- **Cold Air**: Below freezing temperatures in the clouds and near the ground are necessary to make snow and/or ice.
- **Lift**: Something to raise the moist air to form the clouds and cause precipitation. An example of lift is warm air colliding with cold air and being forced to rise over the cold dome. The boundary between the warm and cold air masses is called a front. Another example of lift is air flowing up a mountainside.
- **Moisture**: To form clouds and precipitation. Air blowing across a body of water, such as a large lake or the ocean, is an excellent source of moisture.

Location and Extent

Winter storms tend to encompass the entire county whereas flooding generally occurs within predictable boundaries along the regulatory SFHA and its main branches and tributaries. Nor'easters typically develop as extra-tropical storms which can produce winds equivalent to hurricane or tropical storm force as well as heavy precipitation, sometimes in the form of snow. These storms are regional events that can impact very large areas hundreds to thousands of miles across over the life of the storm. Risks associated and identified with severe winter storms include but are not limited to the following:

- Emergency medical evacuation of the sick, elderly, and infirmed to shelters.
- Power outages to those on life support systems.
- Communications interruptions and/or outages.
- Loss of the ability to heat homes.
- Interruption of the delivery of home supplies and food.

These above-described events fall within 2 general categories 1) road closures due to snow drifts and 2) utility failures (such as damaged supply lines). Additionally, data indicates that structural damage has occurred in several instances in the past as a result of extremely heavy snowfall. Structures damaged were usually buildings such as barns, garages, carports, etc. Additionally, because of the county's mountainous terrain, severe winter storms frequently result in dangerous driving conditions.

According to the 2018 WV Statewide HMP, Jefferson County averaged 1.1 to 2.4 days per year with snowfall equal or greater than 10.0 inches. Ten inches of snowfall in a day represents a winter storm of significant magnitude.

Winter storms consist of cold temperatures, heavy snow or ice and sometimes strong winds. They begin as low-pressure systems that move through West Virginia either following the jet stream or developing as extra-tropical cyclonic weather systems over the Atlantic Ocean called nor'easters. Due to their regular occurrence, these storms are considered hazards only when they result in damage to specific structures or cause disruption to traffic, communications, electric power, or other utilities.

A winter storm can adversely affect roadways, utilities, business activities, and can cause loss of life, frostbite, and freezing conditions. These storms may include one or more of the following weather events:

1. **Heavy Snowstorm:** Accumulations of four inches or more in a six-hour period, or six inches or more in a twelve-hour period.

2. **Sleet Storm:** Significant accumulations of solid pellets which form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces posing hazards to pedestrians and motorists.

3. **Ice Storm:** Significant accumulations of rain or drizzle freezing on objects (trees, power lines, roadways, etc.) as it strikes them, causing slippery surfaces and damage from the sheer weight of ice accumulation.

4. **Blizzard:** Wind velocity of 35 miles per hour or more, temperatures below freezing, considerable blowing snow with visibility frequently below one-quarter mile prevailing over an extended period of time.

5. **Severe Blizzard:** Wind velocity of 45 miles per hour, temperatures of 10 degrees Fahrenheit or lower, a high density of blowing snow with visibility frequently measured in feet prevailing over an extended period time.

Any of the above events can result in the closing of secondary roads, particularly in rural locations, loss of utility services and depletion of oil heating supplies. Environmental impacts often include damage shrubbery and trees due to heavy snow loading, ice build-up and/or high winds which can break limbs or even bring down large trees. An indirect effect of winter storms is the treatment of roadway surfaces with salt, chemicals, and other de-icing materials which can impair adjacent surface and ground waters. Another important secondary impact for winter storms is building or structure collapses; if there is a heavy snowfall or a significant accumulation over time, the weight of the snow may cause building damage or even collapse. Winter storms have a positive environmental impact as well; gradual melting of snow and ice provides groundwater recharge. However, abrupt high temperatures following a heavy snowfall can cause rapid surface water runoff and severe flooding.

Past Occurrence

Winter storms are one of the most frequently occurring hazard in the Eastern Panhandle. Tables 1 and 2 illustrate the number of winter storm (i.e., snow, ice, and blizzard) events in Jefferson County between 1997 and May 2023. Some of these instances may have also been categorized as nor'easters; however, this was not differentiated within the database. According to the 2018 WV Statewide HMP, there are 6.5 annualized events in Jefferson County, totaling $2,000 from 2000-2016.

Over the last three decades, Jefferson County has faced numerous severe winter storm events with varying consequences. Some of the most notable are described below.

January 18, 1998

Warm moist air overrunning a shallow polar surface air mass produced winter weather; precipitation began as a mix of sleet and snow but quickly changed to rain and freezing rain across much of the area. Freestanding structures such as trees, power poles/wires, and exposed bridges received between ¼ and ½ inch of ice accretion. A strip of higher elevation areas (roughly between 500 and 1000 feet above sea level) in Jefferson County received the most icing. In this area, spotty power outages, and a few large limbs and small trees snapped under the weight of the ice.

January 17, 1999

A strong arctic cold front moved slowly southeast across the Mid-Atlantic region bringing a thin layer of sub-freezing air to the lowest levels of the atmosphere, but just off the surface, warmer air moved in. A low-pressure system developed over the Tennessee Valley. The low moved into the Mid-Atlantic region over the next few days, spreading precipitation region-wide. The precipitation started as snow but melted into rain as it fell through the warm layer of air in the mid-levels of the atmosphere. Unfortunately, the ground was below freezing during the period, so the rain froze on every surface it came in contact with. This created ice accumulations of ¼ to ½ inch. The storm caused several car accidents, slip and fall injuries, downed trees, and power outages. Winds gusted over 40 mph after the precipitation ended and some trees weighed down by ice fell onto roads and power lines.

February 1, 2008

An area of low pressure over the Lower Mississippi River Valley moved up the Appalachians; warmer temperatures aloft combined with subfreezing temperatures at the surface to produce widespread freezing rain across the Mid Atlantic. A quarter of an inch of ice was reported across the eastern panhandle of West Virginia. Numerous traffic accidents and power outages were reported across the region. Rain continued as warmer temperatures slowly filtered across the region.

December 18, 2009

Two systems combined to develop a strong area of low pressure that slowly tracked up the Mid-Atlantic Coast. The low-pressure system was able to tap into moisture from the Gulf of Mexico and the Atlantic Ocean causing copious amounts of precipitation to develop. High pressure to the north kept plenty of cold air in place causing the precipitation to fall in the form of snow.

February 5, 2010

A potent area of low pressure strengthened over the central portion of the nation and slowly moved through the Mid-Atlantic before redeveloping off the Mid-Atlantic coast. Strong high pressure continued to pump in plenty of cold air across the region for the entire event. Due to the slow movement of the

storm, there was a prolonged period of precipitation. The storm system ushered in copious amounts of moisture from the Gulf of Mexico and the Atlantic Ocean. The deep moisture combined with the forcing from the storm system to bring a period of heavy precipitation to the. Most of the precipitation fell in the form of snow due to the cold air that was already in place. West Virginia experienced major snow accumulations.

'January, 2016

The January 2016 snow storm caused closures and cancellations throughout Jefferson County and stretched resources. According to NOAA, the snowstorm was the fourth most impactful storm in the Northeastern U.S. since 1950. Jefferson County was ground zero for much of the heaviest snow patterns, receiving as much as 40.5 inches in some sections of the county. This storm was a category 4 (crippling) on the NESIS (Miller, 2018).

December, 2020

The January 2016 snowstorm was the most severe snowstorm in recent memory, but a December 16, 2020 snowstorm also impaired Jefferson County, which was also labeled as a nor'easter. WV Metro News meteorologists claimed there was as much as 12 to 18 inches of snow in Jefferson County.

The 2020 storm resulted in about 16 inches of snowfall across the Eastern Panhandle. The Jefferson County Council President declared a state of emergency and State Senator John Unger requested that Governor Earl Tomblin issue a state of emergency for Jefferson County to deploy additional assistance in snow removal and bring in other emergency services. Many businesses and schools were forced to close, and the governor told non-essential state employees not to report to work (Francis, 2020).

Table 3.3.11-1: Winter Storm Events Impacting Jefferson County from 1997 to May 2023 (NCEI NOAA, 2023)

Date	Type	Injuries	Property Damage ($)	Crop Damage ($)	Date	Type	Injuries	Property Damage ($)	Crop Damage ($)
1/9/1997	Winter Storm	0	0	0	12/26/2012	Winter Weather	0	0	0
2/8/1997	Heavy Snow	0	0	0	1/15/2013	Winter Weather	0	0	0
2/13/1997	Winter Weather	0	0	0	1/25/2013	Winter Weather	0	0	0
12/27/1997	Winter Weather	0	0	0	1/28/2013	Winter Weather	0	0	0
12/29/1997	Winter Storm	0	0	0	2/22/2013	Winter Weather	0	0	0
1/15/1998	Ice Storm	0	8000	0	3/6/2013	Winter Storm	0	0	0
1/24/1998	Winter Weather	0	0	0	3/18/2013	Winter Weather	0	0	0
1/27/1998	Winter Weather	0	0	0	3/24/2013	Winter Storm	0	0	0
2/4/1998	Winter Storm	0	0	0	11/26/2013	Winter Weather	0	0	0
1/2/1999	Winter Storm	0	0	0	12/8/2013	Winter Storm	0	0	0

Table 3.3.11-1: Winter Storm Events Impacting Jefferson County from 1997 to May 2023 (NCEI NOAA, 2023)									
Date	Type	Injuries	Property Damage ($)	Crop Damage ($)	Date	Type	Injuries	Property Damage ($)	Crop Damage ($)
1/8/1999	Winter Storm	0	0	0	12/10/2013	Winter Storm	0	0	0
1/14/1999	Ice Storm	0	10000	0	12/14/2013	Winter Weather	0	0	0
3/3/1999	Winter Weather	0	0	0	1/2/2014	Winter Weather	0	0	0
3/9/1999	Winter Storm	0	0	0	1/5/2014	Ice Storm	0	0	0
3/14/1999	Winter Storm	0	0	0	1/10/2014	Winter Weather	0	0	0
1/20/2000	Winter Weather	0	0	0	1/21/2014	Winter Storm	0	0	0
1/25/2000	Winter Storm	0	0	0	2/3/2014	Winter Weather	0	0	0
1/30/2000	Winter Storm	0	0	0	2/4/2014	Winter Storm	0	0	0
2/18/2000	Winter Storm	0	0	0	2/12/2014	Winter Storm	0	0	0
12/13/2000	Ice Storm	0	0	0	2/19/2014	Winter Weather	0	0	0
12/19/2000	Winter Storm	0	0	0	3/2/2014	Winter Storm	0	0	0
1/5/2001	Winter Weather	0	0	0	3/16/2014	Winter Storm	0	0	0
1/20/2001	Winter Storm	0	0	0	3/19/2014	Winter Weather	0	0	0
2/5/2001	Winter Weather	0	0	0	3/25/2014	Winter Weather	0	0	0
2/22/2001	Winter Storm	0	0	0	3/30/2014	Winter Weather	0	0	0
3/5/2001	Winter Weather	0	0	0	11/26/2014	Winter Weather	0	0	0
1/6/2002	Winter Weather	0	0	0	12/2/2014	Winter Weather	0	0	0
1/19/2002	Winter Weather	0	0	0	12/8/2014	Winter Weather	0	0	0
12/5/2002	Winter Storm	0	0	0	12/22/2014	Winter Weather	0	0	0
12/11/2002	Ice Storm	0	0	0	1/3/2015	Winter Weather	0	0	0
12/24/2002	Winter Weather	0	0	0	1/6/2015	Winter Weather	0	0	0
1/5/2003	Winter Weather	0	0	0	1/11/2015	Winter Weather	0	0	0
2/6/2003	Winter Weather	0	0	0	1/26/2015	Winter Weather	0	0	0
2/14/2003	Winter Storm	0	0	0	2/16/2015	Winter Weather	0	0	0
2/26/2003	Winter Weather	0	0	0	2/21/2015	Winter Storm	0	0	0
3/30/2003	Winter Weather	0	0	0	3/1/2015	Winter Weather	0	0	0
12/4/2003	Winter Storm	0	0	0	3/3/2015	Winter Weather	0	0	0
1/17/2004	Winter Weather	0	0	0	3/5/2015	Winter Storm	0	0	0

Table 3.3.11-1: Winter Storm Events Impacting Jefferson County from 1997 to May 2023 (NCEI NOAA, 2023)									
Date	Type	Injuries	Property Damage ($)	Crop Damage ($)	Date	Type	Injuries	Property Damage ($)	Crop Damage ($)
1/23/2004	Winter Storm	0	0	0	3/20/2015	Winter Weather	0	0	0
1/25/2004	Winter Storm	0	0	0	1/22/2016	Winter Storm	0	0	0
2/3/2004	Winter Storm	0	0	0	2/9/2016	Winter Weather	0	0	0
2/5/2004	Winter Storm	0	0	0	2/14/2016	Ice Storm	0	0	0
2/24/2005	Winter Storm	0	0	0	12/12/2016	Winter Weather	0	0	0
2/28/2005	Winter Storm	0	0	0	1/5/2017	Winter Weather	0	0	0
12/5/2005	Winter Weather	0	0	0	1/10/2017	Winter Weather	0	0	0
12/9/2005	Winter Weather	0	0	0	1/14/2017	Winter Weather	0	0	0
12/15/2005	Ice Storm	0	0	0	3/13/2017	Winter Storm	0	0	0
2/11/2006	Heavy Snow	0	0	0	1/8/2018	Winter Weather	0	0	0
1/21/2007	Winter Weather	0	0	0	2/3/2018	Winter Weather	0	0	0
2/6/2007	Winter Weather	0	0	0	2/4/2018	Winter Weather	0	0	0
2/12/2007	Winter Storm	0	0	0	2/17/2018	Winter Weather	0	0	0
2/24/2007	Winter Storm	0	0	0	11/15/2018	Winter Storm	0	0	0
3/7/2007	Winter Weather	0	0	0	11/24/2018	Winter Weather	0	0	0
3/16/2007	Winter Storm	0	0	0	1/12/2019	Winter Storm	0	0	0
12/5/2007	Winter Weather	0	0	0	1/29/2019	Winter Weather	0	0	0
12/15/2007	Winter Storm	0	0	0	2/1/2019	Winter Weather	0	0	0
1/17/2008	Winter Weather	0	0	0	2/10/2019	Winter Weather	0	0	0
2/1/2008	Ice Storm	0	5000	0	2/17/2019	Winter Weather	0	0	0
2/12/2008	Winter Storm	0	0	0	2/20/2019	Winter Storm	0	0	0
2/20/2008	Winter Weather	0	0	0	3/1/2019	Winter Weather	0	0	0
12/16/2008	Winter Weather	0	0	0	3/1/2019	Winter Weather	0	0	0
1/6/2009	Winter Weather	0	0	0	3/3/2019	Winter Weather	0	0	0
1/19/2009	Winter Weather	0	0	0	12/13/2019	Winter Weather	0	0	0
1/27/2009	Winter Storm	0	0	0	12/16/2019	Winter Weather	0	0	0
12/5/2009	Winter Weather	0	0	0	12/16/2019	Winter Weather	0	0	0
12/8/2009	Winter Weather	0	0	0	1/7/2020	Winter Weather	0	0	0

Table 3.3.11-1: Winter Storm Events Impacting Jefferson County from 1997 to May 2023 (NCEI NOAA, 2023)									
Date	Type	Injuries	Property Damage ($)	Crop Damage ($)	Date	Type	Injuries	Property Damage ($)	Crop Damage ($)
12/13/2009	Winter Weather	0	0	0	1/18/2020	Winter Weather	0	0	0
12/18/2009	Winter Storm	0	0	0	12/16/2020	Winter Storm	0	0	0
12/25/2009	Winter Weather	0	0	0	1/25/2021	Winter Weather	0	0	0
1/30/2010	Winter Storm	0	0	0	1/31/2021	Winter Storm	0	0	0
2/2/2010	Winter Storm	0	0	0	2/7/2021	Winter Weather	0	0	0
2/5/2010	Winter Storm	0	2000	0	2/10/2021	Winter Weather	0	0	0
2/9/2010	Winter Storm	0	0	0	2/13/2021	Winter Weather	0	0	0
12/16/2010	Winter Weather	0	0	0	2/18/2021	Winter Storm	0	0	0
1/11/2011	Winter Weather	0	0	0	2/18/2021	Winter Weather	0	0	0
1/17/2011	Winter Weather	0	0	0	2/22/2021	Winter Weather	0	0	0
1/26/2011	Winter Storm	0	0	0	1/3/2022	Winter Weather	0	0	0
2/1/2011	Winter Weather	0	0	0	1/6/2022	Winter Storm	0	0	0
2/5/2011	Winter Weather	0	0	0	1/9/2022	Winter Weather	0	0	0
2/21/2011	Winter Weather	0	0	0	1/16/2022	Winter Storm	0	0	0
3/6/2011	Winter Weather	0	0	0	2/24/2022	Winter Weather	0	0	0
10/28/2011	Winter Storm	0	0	0	3/12/2022	Winter Storm	0	0	0
1/20/2012	Winter Weather	0	0	0	4/18/2022	Winter Weather	0	0	0
1/22/2012	Winter Weather	0	0	0	12/14/2022	Winter Weather	0	0	0
12/24/2012	Winter Weather	0	0	0	12/22/2022	Winter Weather	0	0	0

Table 3.3.11-2: Number of Winter Storm Events per year in Jefferson County (NOAA NCEI, 2023)			
Year	Number of Storms	Year	Number of Storms
1996	4	2010	5
1997	6	2011	9
1998	4	2012	6
1999	6	2013	13
2000	6	2014	17
2001	5	2015	12
2002	6	2016	11
2003	6	2017	6

Table 3.3.11-2: Number of Winter Storm Events per year in Jefferson County (NOAA NCEI, 2023)			
Year	**Number of Storms**	**Year**	**Number of Storms**
2004	6	2018	8
2005	7	2019	13
2006	3	2020	8
2007	14	2021	9
2008	5	2022	9
2009	8	**Total**	**212**

Future Occurrence

Data from NOAA shows that winter storms are a regular occurrence in Jefferson County. So, the probability of the occurrence of a damaging heavy snow or ice storm in the region in any given year is 100 percent. The severity and frequency of major winter storms and nor'easters is expected to remain fairly constant. However, due to increased dependence on various modes of transportation and use of public utilities for light, heat, and power, the disruption from these storms is more significant today than in the past. The future occurrence of climatic events cannot be predicted exactly. As noted in the table above, the County has been affected by 3 to 17 winter storm events each year from 1996 to 2022. Given this record of reported events, it is safe for planning purposes to assume that in an average year the county can expect to experience on average eight winter storm events.

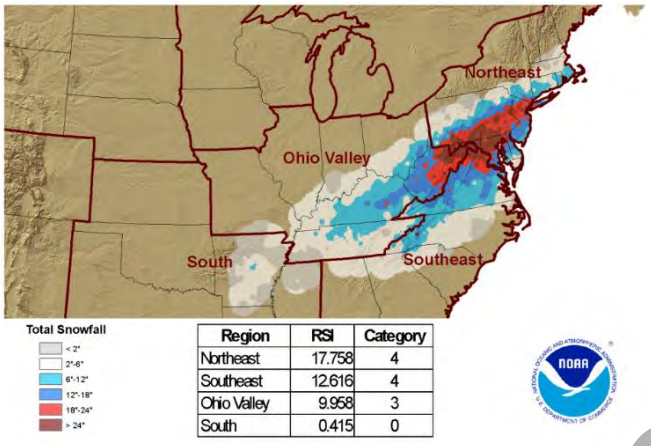
Temperatures in West Virginia have risen 1°F since the beginning of the 20th century and are projected to continue rising in all seasons of the year (NCICS 2022). This overall increase in temperature leads to more water vapor being stored in the atmosphere. During winter months, despite a warmer temperature, this increase in water vapor can spur more frequent, intense winter weather. The frequency of large snowfall years has increased in the northern United States. Analysis of storm tracks indicates that there has been an increase in winter storm frequency and intensity since 1950, with a slight shift in tracks toward the poles (CSSR 2018). If current projections remain, the State of West Virginia can expect more frequent and intense winter weather events.

Range of Magnitude

Severe winter weather will affect several counties in a region at one time with varying intensities depending on temperature and moisture in the area. The heavily populated region between Washington D.C., Philadelphia, New York and Boston, the "I-95 Corridor," is especially impacted by Nor'easters (NWS, n.d.).

A snowstorm on January 22, 2016, represents the largest impact Jefferson County has encountered Watertown, New York 13601 from a winter storm hazard. During this event, 25 to 40 inches of heavy snow fell across the Eastern Panhandle in less than two days. More specifically, Jefferson County recorded 27 ½ inches of snow in just 24 hours, making it the County's "biggest snowfall" to date. An image of the regional snowfall index can be seen in Figure 1. The governor issued a state of emergency, and it took until the evening of January 23 to reopen one lane on both Interstate 81N and 81S, temporarily paralyzing travel. The amount of snow put a strain on critical operations as well, and local emergency management officials were tasked with transporting local medical professionals safely to the medical centers they were employed at. The National Guard was activated to transport emergency responders using Humvees (West Virginia Press Association, 2016). A storm of this magnitude could be considered a worst-case scenario winter storm for Jefferson County. This is the most recent winter storm of this magnitude. Several other large winter storms have occurred since 2016, but none of this magnitude.

Figure 3.3.11-1: Regional Snowfall Index January 22-24, 2016



Region	RSI	Category
Northeast	17.758	4
Southeast	12.616	4
Ohio Valley	9.958	3
South	0.415	0

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Vulnerability Assessment

While the Fujita and Saffir-Simpson Scales characterize tornadoes and hurricanes respectively, there is no widely used scale to classify snowstorms. Paul Kocin and Louis Uccellini of the National Weather Service developed the Northeast Snowfall Impact Scale (NESIS) that characterizes and ranks high-impact Northeast snowstorms. These storms have large areas of 10-inch snowfall accumulations and greater. The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus NESIS indicates a storm's societal impacts. This scale was developed because of the impact Northeast snowstorms can have on the rest of the country in terms of transportation and economic impact.

NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The aerial distribution of snowfall and population information are combined in an equation that calculates a NESIS score which varies from around one for smaller storms to over ten for extreme storms. The raw score is then converted into one of the five NESIS categories (NOAA, n.d.).

Since winter storms are a regular occurrence in Jefferson County, as well as other counties throughout West Virginia, strategies have been developed to respond to these events. Snow removal and utility repair equipment is present to respond to typical events. The use of auxiliary heat and electricity supplies such

as wood burning stoves, kerosene heaters, and gasoline power generators reduces the vulnerability of specific structures. Locations lacking adequate equipment to protect against cold temperatures or significant snow and ice are more vulnerable to winter storm events. Even for communities that are prepared to respond to winter storms, severe events involving snow accumulations that exceed six or more inches in a twelve-hour period can cause a large number of traffic accidents, interrupt power supply and communications, and cause the failure of inadequately designed and/or maintained roof systems. Some rural areas of the region are susceptible to isolation due to the loss of telephone communications and road closings. Power failure and interruption of water supplies are common from ice storms, heavy snow, and blizzard conditions. All critical facilities in the region are vulnerable to winter storms

According to the NSSL (n.d.), most deaths from winter storms are not directly related to the storm itself; people die in traffic accidents on icy roads, of heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold. During severe winter storms, everyone is potentially at risk; the actual threat depends on specific situations. Recent observations show that of injuries related to ice and snow, about 70% occur in automobiles, about 25% are people caught out in the storm, and the majority of victims are males over 40 years old. Of injuries related to exposure to cold, 50% are people over 60 years old, over 75% are males, and about 20% occur in the home.

Another reason these blizzards are dangerous is the cold temperatures that follow behind the Arctic front. Anyone stranded in their vehicle or forced to walk outside is at risk of frostbite or hypothermia (NWS, n.d.).

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 (NWS, n.d.).

Ice storms also tend to occur several times per year. These storms usually cause temporary icy conditions that result in increased numbers of traffic accidents and falls, but little other impact. Severe ice storms bring a significant accumulation of ice, which can pull down branches, trees, and power lines. These can cause widespread power outages and it can take hours to days to restore service to all customers.

Areas of vulnerability include low-income and elderly populations, mobile homes, and infrastructure such as roadways and utilities that can be damaged by such storms and the low-lying areas that can be impacted by flooding related to rapid snow melt.

People

For the purpose of this plan, the entire population of Jefferson County is exposed to the winter weather hazard. Residents may be displaced or require temporary and long-term housing and sheltering. In addition, damages caused by severe winter weather can lead to severe injuries and loss of life. Socially vulnerable populations are most susceptible due to their physical and financial ability to react and respond during extreme winter weather. In the 26-year period between 1996 and 2022, Jefferson County

experienced 212 winter weather events, varying in severity. As of June 2023, severe winter storms have not caused any deaths in the county.

Socially vulnerable populations are susceptible based on many factors, including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Economically disadvantaged populations are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to prepare for or respond to a winter weather event.

In relation to the hazard of winter weather, socially vulnerable populations will experience a disproportionate disadvantage. For example, the elderly are considered susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice. In addition, harsh winter weather can reduce the ability of these populations to access emergency services. Residents with low incomes may not have access to housing, or their housing may be less able to withstand cold temperatures. Populations with physical disabilities may not be able to leave their houses or maneuver outdoors due to covered walkways and ramps.

The aftermath of winter weather events present numerous threats to public health and safety, including weighted powerlines and tree branches, power outages, snow- and ice-covered walkways and roadways, and cold temperatures.

Structures

All facilities in Jefferson County are exposed and vulnerable to the winter storm hazard. High snow accumulation may cause structural failure and possible collapse. In general, structural impact damage may include damage to roofs and building frames, as well as damage to building contents. Structural failure from increased snow accumulation on roofs can be linked to several different causes, including but not limited to:

- Actual snow load significantly exceeds design snow load
- Drifting and sliding snow conditions
- Deficient workmanship
- Insufficient operation and maintenance
- Improper design
- Inadequate drainage design
- Insufficient design: in older buildings, insufficient design is often related to inadequate snow load design criteria in the building code in effect when the building was designed (FEMA 2020).

Vulnerability to the effects of winter storms on buildings is somewhat dependent on the age of a building. As building codes become more stringent, buildings can support heavier loads and as buildings age, various factors may deteriorate their structural integrity. Vulnerability also depends upon the type of construction and the degree to which a structure has been maintained. It is assumed that older structures are more vulnerable, but additional information on construction type and building codes enforced at time

of construction would allow a more thorough assessment of the vulnerability of structures to winter storm impacts such as severe wind and heavy snow loading.

The most vulnerable structures are those that were poorly built or are dilapidated. The weight of heavy snow or ice may lead to structural collapse or to minor damage. Some shed roofs that protect township and borough road maintenance or firefighting equipment have large span roofs that may collapse under the weight of especially heavy snow or ice although none have collapsed due to recent heavy snow or ice storms.

Systems

Critical facilities would be impacted by a storm event, but these structures are largely constructed of concrete and masonry; therefore, they should only suffer minimal structural damage. Because power interruption can occur, backup power is recommended for critical facilities and infrastructure. Motorists may occasionally become stranded on WV Route 9, during these storms. People must then be rescued and provided with shelter until conditions improve. Stranded motorists are also likely on US Route 340 and in remote and mountain locations.

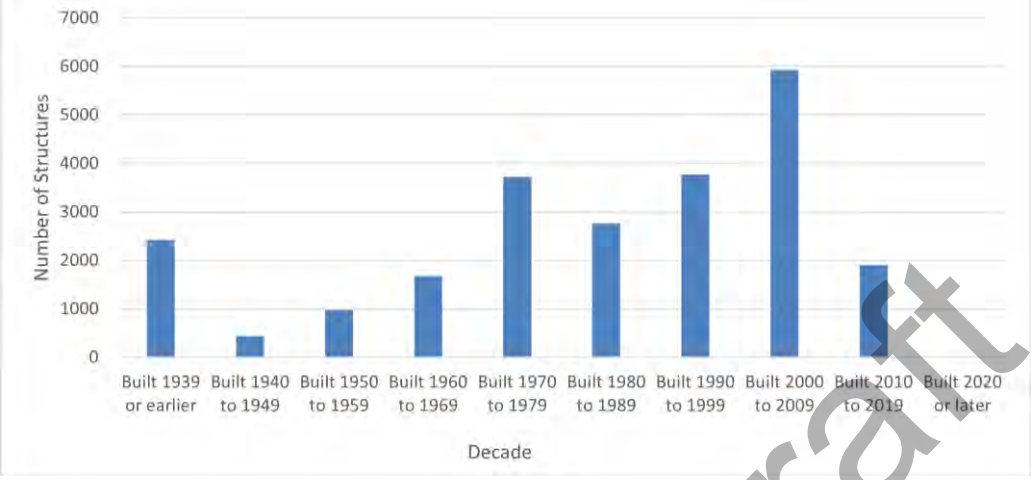
Natural, Historic and Cultural Resources

Environmental impacts from winter weather often includes damage to trees and shrubs caused by heavy snow loading, ice buildup, and/or high winds, which can break limbs and down large trees. Environmental resources, including critical habitat (or habitats that are known to be essential for an endangered or threatened species), wetlands, parks, and reserves are particularly vulnerable to severe winter weather. Destroyed habitats could displace and kill organisms reliant on these habitats to survive and reproduce. An indirect effect of winter storms is impairment of surface and groundwater adjacent to roadway surfaces treated with salt, chemicals, and other de-icing materials. These added pollutants can runoff into bodies of water and cause eutrophication, creating issues for ecosystems present in those water bodies

Winter storms can also have a positive environmental impact: gradual melting of snow and ice provides groundwater recharge. However, abrupt high temperatures following a heavy snowfall can cause accelerated snowmelt, rapid surface water runoff, and severe flooding (USGS 2019).

All structures and infrastructure in Jefferson County are exposed to heavy snow and ice. For this analysis, structures built prior to 1940 are identified as being potentially at risk of being somewhat weakened and more susceptible to damage due to heavy snow or ice. Figure XXXX shows the distribution of building ages in Jefferson County; a little more than 10 percent (more than 2000) of all housing structures buildings were constructed prior to 1940 in Jefferson County.

Figure 3.3.11-2: Number of Housing Structures Built by Decade in Jefferson County (U.S. Census Bureau, 2019)



Community Activities

Potential economic impacts include loss of agriculture, business, and tourism. In addition, losses of buildings and infrastructure also take a toll on the economic condition of Jefferson County. Similarly, damages to buildings can displace people from their homes, threaten life safety, and impact a community's economy and tax base. Severe winter weather can also damage utilities and communication towers, which are costly because they need to be repaired almost immediately after damages occur and these repairs can cost millions of dollars to fix for a singular event.

Infrastructure at risk from the winter weather hazard also includes roadways that could be damaged by application of salt and intermittent freezing and warming conditions that can damage roads over time and cause potholes. Costs of snow and ice removals, as well as repairs of roads undergoing freeze/thaw cycles, can drain local financial resources quickly. A quick thaw or rain event after a heavy snow can cause substantial flooding, especially along small streams and in urban areas, which can become expensive to mitigate.

Activities that have value to the community could potentially be impacted by severe snow events. When these activities are delayed or cancelled due to snow, the economy of the community is affected. Numerous activities are scheduled within Jefferson County and its municipalities. Below are community activities that occur throughout the year or annually.

- Historical Walking Tours of Harpers Ferry, WV – Available All Year
- Handmade Christmas in Shepherdstown - November
- New Year's Eve Celebration

Impacts to community events would be dependent upon the event type and location.

3.3.12 Wild and Urban Fire

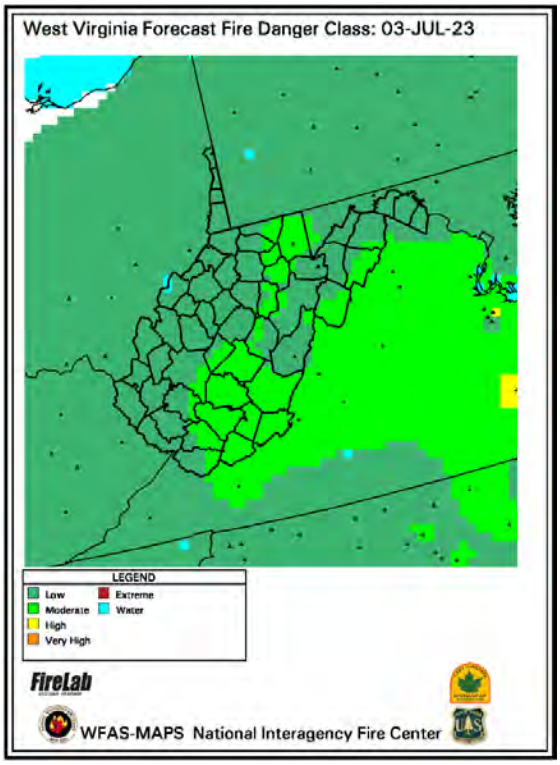
Wildfire is an uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures. Wildfires often begin unnoticed and can spread quickly, creating dense smoke clouds. A wildland fire is a wildfire in an area in which development is essentially nonexistent, except for roads, railroads, power lines, and similar facilities. An urban-wildland interface fire is a wildfire in a geographical area where structures and other human development meet or intermingle with wildland or vegetative fuels.

Location and Extent

Wildland fires are most common in the spring (March to May) and fall (October to November) months. During spring months, the lack of leaves on the trees allows the sunlight to heat the existing leaves on the ground from the previous fall. The same theory applies for the fall; however, the dryer conditions are a more crucial factor.

Wildfire events can occur at any time of the year but are most likely to occur in the region during a drought. Wildland fires in West Virginia can occur in fields, grass, and brush as well as in the forest itself. Under dry conditions or drought, wildfires have the potential to burn forests as well as croplands. Any small fire in a wooded area, if not quickly detected and suppressed, can get out of control. Most wildland fires are caused by human carelessness, negligence, and ignorance. They are usually signaled by dense smoke that fills the area for miles around. The size of a wildfire is contingent on the amount of fuel available, weather conditions, and wind speed and direction. The West Virginia Division of Forestry tracks and maps fire hazard daily with their Wildland Fire Assessment System, as seen for a day in July 2023 in Figure 3.3.12-1.

Figure 3.3.12-1 West Virginia Forecasted Fire Danger (WV Division of Forestry, July 2023)



The size of a wildfire is contingent on the amount of fuel available, weather conditions, and wind speed and direction. The Wildland Fire Assessment System (WFAS)-Maps, Fire Behavior Research produces maps that show the fire danger in the United States; these fluctuate as the weather changes. Figure 3.3.12-2 shows that Jefferson County is at a low risk of fire danger in July. Generally, the entire State of West Virginia has a low or moderate risk of fire danger, as evidenced by the number of fires recorded (see historical occurrences section for detailed information on the number of fires in Jefferson County.

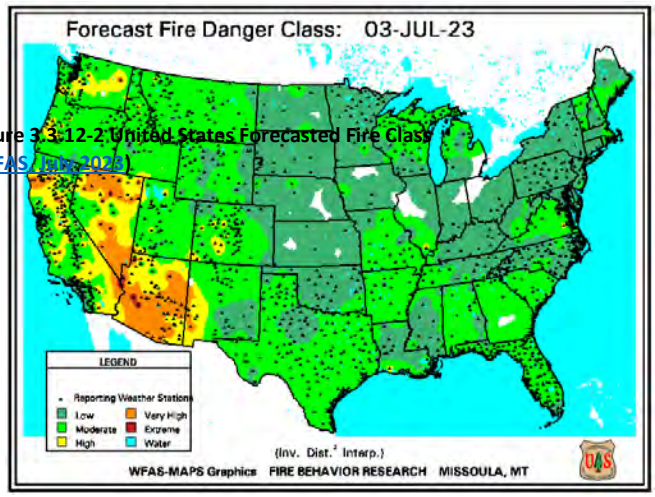


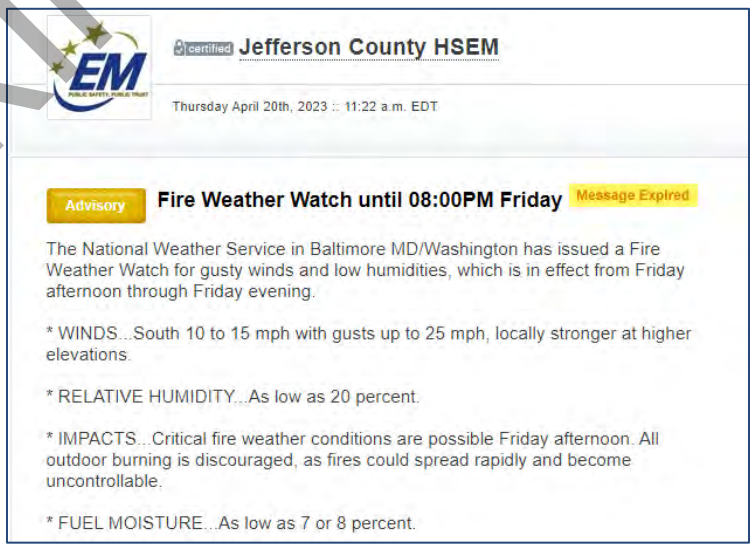
Figure 3.3.12-2 United States Forecasted Fire Class (WFAS, July 2023)

Just because a single wildfire has been reported, one should not assume that vegetation fires do not occur frequently. Representatives from local fire departments throughout the region confirm that brush fires, ranging in size from a single acre to hundreds of acres occur each year. Many of these fires are extinguished before becoming a major problem. Additionally, most of these events occur in rural areas rather than in areas of urban-wildland interface.

According to the U.S. Fire Administration (USFA), overall trends for residential building fires and losses for the 10-year period of 2012 to 2021 have a 5% decrease in fires, an 8% increase in deaths, a 7% decrease in injuries, and an 11% increase in dollar loss (USFA, 2023). Fire loss reported through the National Fire Incident Reporting System (NFIRS) in 2021 for West Virginia, there were 5.2 deaths and 9.1 injuries per 1,000 all fire casualties. In 2021, the national average was 2.3 deaths and 7.2 injuries per 1,000 fires. Residential structure fire casualties reported in 2021 were 13.2 deaths and 18.8 injuries per 1,000 fires. In 2021, the national average was 6.5 deaths and 20.9 injuries per 1,000 fires.

The National Weather Service issues red flag warnings to inform area firefighters (Firefighter, 2023) and the public about conditions that are favorable for wildland fires. These include the amount of water held by small vegetation such as grass, leaves, and mulch, the relative humidity, and the winds. Jefferson County Sheriff's Office and JCHSEM issue these warnings for their residents on social media; an example of this is shown to the right.

Figure 3.3.12-3 Jefferson County HSEM Nixle Message



Areas that are most vulnerable to wildfires include agricultural and forest lands in the county. As for urban fires, as the name suggests, areas that are more densely populated or have houses that are older and do not have up-to-code fire protection are more vulnerable.

Past Occurrence

No major wildfires have been identified in the Eastern Panhandle, but this does not mean that vegetation fires do not occur frequently. Representatives from local fire departments throughout the region confirm that brush fires, ranging in size from a single acre to hundreds of acres occur each year. Many of these fires are extinguished before becoming a major problem. Additionally, most of these events occur in rural areas rather than in areas of urban-wildland interface.

One of the largest wildfires in West Virginia during the last 40 years occurred in the fall of 1987. A 19,560-acre wildfire blazed through Raleigh County, while another forest fire burned 15,192 acres in Boone County. The 1987 fire season proved to be the state's second worst year on record for forest fires, with more than 416,687 acres damaged (Steelhammer, 2013).

The following table presents data provided by the WV Division of Forestry. It shows the number of fires per season in Jefferson County and the acres burned. It then compares it to the data from West Virginia.

Table 3.3.12-1 Wildfires In Jefferson County

Year	Number of Fires	Brush Fire	Outside Fire	Structure Fire	Transformer Fire	Downed Utility Line Fire	Total Acres Burned
2010							
2011							
2012							
2013							
2014							
2015							
2016							
2017							
2018							
2019							
2020							
2021							
2022							
June 2023							

It is more difficult to determine the exact number of urban fires that have occurred in the county. However, there is one event that stands out and occurred within the last three years. On July 23, 2018, a fire destroyed several businesses in Harpers Ferry's historic area. The fire broke out around 3 a.m. and three alarms brought in resources from Maryland and Virginia to help get the fire under control. The fire reached three buildings that contained two apartments and eight businesses. No tenants or responders were injured.

Future Occurrence

The WV State 2023 Hazard Mitigation Plan states Future conditions, including warming temperatures, have the potential to significantly increase vulnerability to wildfire in the state. The state has experienced longer droughts, an increase in consecutive dry days, and a decrease in the days of intense rainfall. Warm temperatures and drought create perfect conditions for wildfire outbreak throughout the state.

Previous events indicate that annual wildfire occurrences in the region are expected. In some cases, an increase in wildfires or acreage burned follows significant drought. Droughts in 1987, 1991 and 1999 had that effect. There were effects of drought visible during the 2001 fire season when 94,233 acres burned, the largest number of acres consumed since 2000.

Any fire, without the quick response or attention of fire-fighters, forestry personnel, and/or the public, has the potential to become a wildfire. The eastern border of the county will likely face more wildfires as a result of its rural nature. Therefore, the probability of a wildfire occurring in Jefferson County is considered *possible* as defined by the Risk Factor Methodology probability criteria (see Table 4.4.1-1).

Range of Magnitude

Wildfire events can range from small fires that can be managed by local firefighters to large fires impacting many acres of land. Large events may require evacuation from one or more communities and necessitate regional or national firefighting support. The impact of a severe wildfire can be devastating. While some fires are not human-caused and are part of natural succession processes, a wildfire can kill people, livestock, fish, and wildlife. They often destroy property, valuable timber, forage, and recreational and scenic values.

Vegetation loss is often an environmental concern with wildfires, but it typically is not a serious impact since natural re-growth occurs with time. The most significant environmental impact is the potential for severe erosion, silting of stream beds and reservoirs, and flooding due to ground-cover loss following a fire event.

Wildfires also have a positive environmental impact in that they burn dead trees, leaves, and grasses to allow more open spaces for new and different types of vegetation to grow and receive sunlight. Another positive effect of a wildfire is that it stimulates the growth of new shoots on trees and shrubs, and a fire's heat can open pinecones and other seed pods.

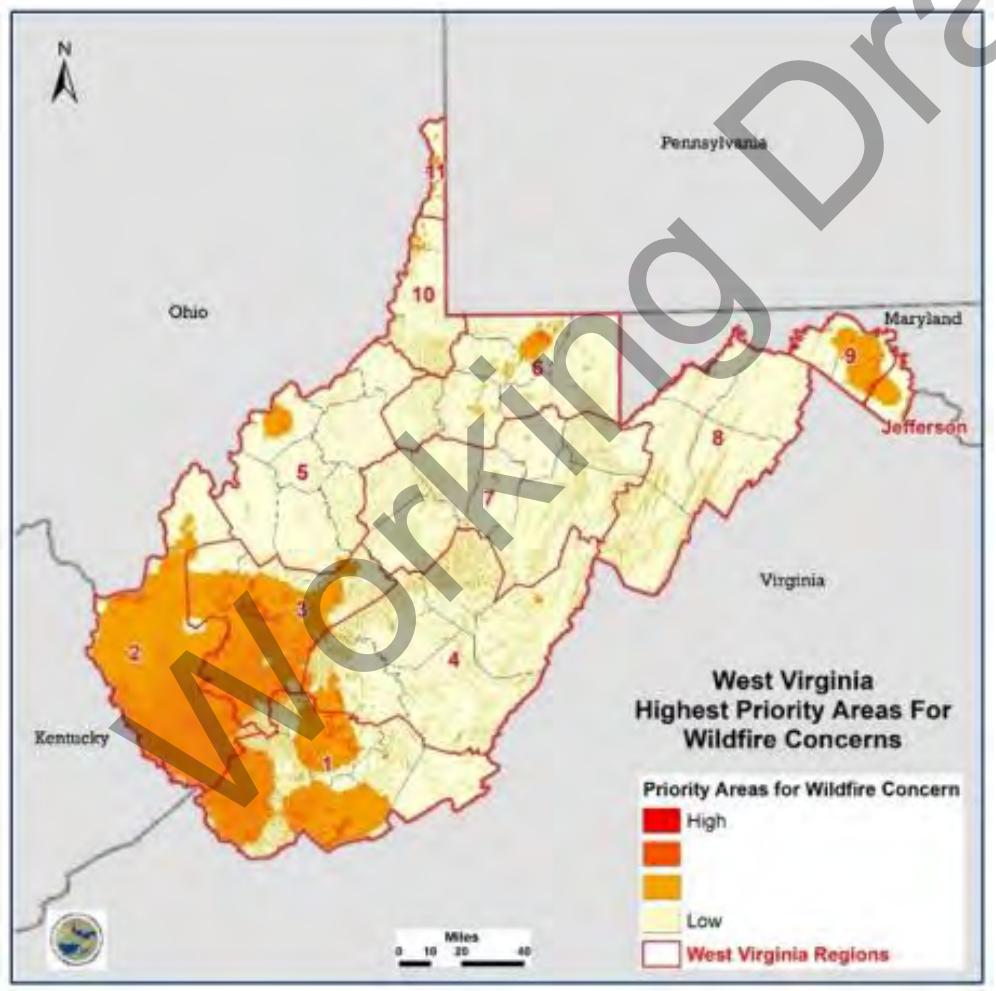
In addition to the risk wildfires post to the public and property owners, the safety of firefighters is also a concern. Although loss of life among firefighters does not occur often in West Virginia, it is always a risk. More common firefighting injuries include falls, sprains, abrasions, or heat-related injuries such as dehydration. Response to wildfires also exposes emergency responders to the risk of motor vehicle incidents and can place them in remote acres away from the communities that they are chartered to protect.

Vulnerability Assessment

Nationally, the National Park Service lists several possible causes of wildfires including human-caused and nature-caused. Human-caused fires "result from campfires left unattended, the burning of debris, negligently discarded cigarettes and intentional acts of arson", which account for up to 90% of fires. Lightning or lava causes the remaining 10% of fires (NPS). This is also true in West Virginia where "in the spring of 2015, 43% of all forest fires were the result of escaped debris fires. Equipment use was the second highest cause of forest fires in W.Va., causing 29% of all wildfires.

The State of West Virginia 2023 Hazard Mitigation Plan provided a map of the state's highest priority areas for wildfire concerns, Figure 3.3.12-4. As shown in the figure, Jefferson County has a low to medium low priority area for wildfire concern.

Figure 3.3.12-4 Highest Priority Areas for Wildfire Concern (WV HMP, 2023)



However, based on the wildfire history of the area, Jefferson County appears to have a low vulnerability to severe wildfire. The wildfire hazard was defined based on conditions that affect wildfire ignition and/or behavior such as fuel, topography, and local weather. These conditions are constantly changing, so the

region's vulnerability will fluctuate over time.

In addition, the State of West Virginia 2023 Hazard Mitigation Plan conducted an analysis based on Wildland-Urban Interface (WUI) and WUI Intermix Wildfire Hazard Area for state facilities, critical facilities, population, and state roadways. The plan defines a wildland-urban interface (WUI) fire as a wildfire occurring in the WUI. The WUI is described as the area where structures and other human improvements meet and intermingle with undeveloped wildland or vegetative fuels. Due to the rural nature of the state, with over 80 percent of the state composed of forest land, most communities in the state are in the WUI. A total of 576,466 acres in the state are located in the interface wildfire hazard area, and a total of 3,758,488 acres are located in the intermix wildfire hazard area. Jefferson County specifically has a total of 13,178 acres in the interface wildfire area and a total of 14, 008 acres in the intermix wildfire area.

Table 4.3.12-1 Total Acres of Land Area Located in the Wildfire Hazard Areas by County (WV HMP, 2023)

County	Total Acres of Land Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Wildfire Hazard Areas			
		Total Acres Located in the WUI Interface Wildfire Hazard Area	Percent of Total	Total Acres Located in the WUI Intermix Wildfire Hazard Area	Percent of Total
Jefferson	134,920	13,178	9.8%	14,008	10.4%

People

Aside from the obvious effects on humans such as burns and injuries, the smoke from fires is of great concern. "The smoke produced by wildfires can produce effects ranging from airway and eye irritation to death, especially among individuals with conditions that make them more susceptible to inhalational exposures" (Clements, 2009, p.283).

The U.S. Fire Administration Topical Fire Report Series released October 2021 provided highlights on important findings from data collected in the U.S. Fire Administration's National Fire Incident Reporting System. Findings for this topical report are as follows:

- Risk by age:
    - Adults ages 55 or older had a greater relative risk of fire death than the general population.
    - Adults ages 85 or older had the highest relative risk of fire death.
    - Children ages 4 and younger had a relative risk of fire death that was 50% less than that of the general population, the lowest relative risk for this age group since the mid-1970s; however, these children had an elevated risk of both fire death and injury when compared to older children (ages 5 to 14).

    - Adults ages 25 to 64 and 80 or older had a greater relative risk of fire injury than the general population.
- Risk by region: People living in the Midwest and South had the greatest relative risk of dying in a fire when compared to populations living in other regions of the United States.
- Risk by gender: Males were 1.7 times more likely to die in fires than females.
- Risk by race: African Americans and American Indians/Alaska Natives were at a greater relative risk of dying in a fire than the general population.

According to Section 1.3 Population and Demographics of the plan, adults ages 65 and older were the fastest growing between 2017 and 2021 with a population increase of 13.3%. The percentage of Jefferson County's population that is age 65 and older increased from 15.7 percent of the population in 2017 to 17.3 percent in 2021. The Topical Fire Report indicated that this age group has a greater relative risk of fire than the general population. This age group should be targeted for outreach on fire safety. The Federal Emergency Management Agency along with the U.S. Fire Administration release Fire Safety for Older Adults in October 2018, which could be distributed via the JCOHSEM monthly newsletter and social media.

The WV State 2023 Hazard Mitigation Plan estimated population living in the high wildfire risk hazard areas (both Interface and Intermix) that could be impacted should a wildfire occur. Based on the overall analysis for the state, an estimated 422,175 residents are located in the wildland urban interface (WUI) hazard area and 23.34 percent are highly vulnerable. In addition, an estimated 1,807,426 residents are located in the WUI hazard area, with 6.18 percent being highly vulnerable. Results also indicate that Jefferson County does not have a highly vulnerable population within the WUI interface area and only 206 people in the WUI intermix area.

Structures

The WV State 2023 Hazard Mitigation Plan analyzed critical facilities located in wildfire hazard areas. Facilities at risk from being impacted by wildfire incidents include locations that provide services for vulnerable populations (i.e., schools and senior facilities) and emergency response agencies (i.e., fire and police). Medical facilities, fire/EMS, schools, and shelters could all sustain damages from wildfire events depending on the intensity of wind and pathway of the burn. Statewide, there are 51 facilities in the WUI Interface Wildfire Hazard area and 28 facilities in the WUI intermix wildfire hazard area. However, Jefferson County does not have any critical facilities in either WUI interface or intermix wildfire hazard areas.

The National Fire Protection Association studied the causes and circumstances of home structure fires reported to local fire departments in the United States from 2016 through 2020. The study found that most home fires and fire casualties result from five causes: cooking, heating, electrical distribution and lighting equipment, intentional fire setting, and smoking materials. Cooking equipment was the leading cause and accounted for 44% of home structure fires.

Loss estimations for urban fires are difficult to ascertain due to the unseen costs that go beyond fire suppression alone such as loss of life, injury, loss of property and livelihood. For this reason, loss and damage are calculated for wildfires only in Jefferson County.

Systems

According to the WV State 2023 Hazard Mitigation Plan, when post-fire flooding overwhelms the transportation, infrastructure failures inevitably occur, and communities have varying levels of risk depending on the nature of the infrastructure that exists, its vulnerability to post-fire flooding, and the level of redundancy in the transportation infrastructure for that community. Roads provide a vital transportation link between populated areas. Road closures, as a result of a wildfire event, will have significant impacts on the county and its communities. The State Plan indicated that Jefferson County has a total of 1.84 miles of state roads located within the WUI Interface Wildfire Hazard Area, while a total of 19.18 miles in the Intermix Wildfire Hazard Area.

Natural, Historic and Cultural Resources

Wildfires cause more than just the direct damage to structures, vegetation, or air quality; when a fire removes much or all of the vegetation in a watershed, subsequent rains will have much greater erosive potential, which in turn produces large quantities of sediment and plant debris that affect the water quality of streams and lakes (Keller, Devecchio, 2015, p.459).

However, wildfires can also have benefits to the soil; they "tend to leave an accumulation of carbon on the surface in the form of ash and increase the nutrient content of a soil. Under the right conditions when erosion does not remove the ash from the environment, a nutrient reservoir may form that is beneficial to local plants" (Keller & Devecchio, 2015, p 159).

In terms of historic structures, most structures at-risk to wildfires are those within the WUI. These structures are also more likely to be constructed from wood. The July 2018 structural fire that destroyed several businesses in Harpers Ferry's historic area is an example of how fires can spread quickly through an area, specifically with older structures.

Community Activities

Activities that have value to the community could potentially be impacted by wildfires, however this location of the activity. In addition, poor air quality due to smoke generated by the wildfire can impact outdoor activities. Wildfires also release significant amounts of mercury into the air, which can impact both people and the environment.

3.3.13 Dam Failure

The West Virginia Department of Environmental Protection (WVDEP) defines a dam as "an artificial barrier or obstruction that impounds, or will impound, water." In West Virginia, for a dam to be regulated by the state, it must be equal to or greater than 25 feet in height and contain 15 or more acre-feet of water volume or be greater or equal to 6 feet in height and contain 50 or more acre-feet of water volume. Some federally owned dams, dams that do not normally impound water (such as some culverts), and dams built for agricultural purposes that have been demonstrated not to cause loss of life if the dam were to fail, may be exempted from state regulation (WVDEP, 2009). The full regulation can be found in the Dam Control and Safety Act – W. Va. Code 22-14-3(f), and in the Dam Safety Rule (47CSR34-2.12).

Failure of these structures results in an uncontrolled release of impounded water. Dam failures most often occur during or after a massive rainfall, flooding, or spring thaws, sometimes with little to no warning. Depending on the size of the water body where the dam is constructed, water contributions may come from distant upstream locations.

Location and Extent

Dam failures can pose a serious threat to communities located downstream from major dams. The impact of a dam failure is dependent on dam and reservoir characteristics and the amount and distance of population or assets located downstream. Catastrophic failures are characterized by the sudden, rapid, and uncontrolled release of impounded water or any other fluid or semi-fluid.

Dams that meet the definition of a 'High Hazard Potential Dam' (HHPD) are a subset of the dams managed by the West Virginia DEP's Dam Safety Program. Following FEMA's definition, a HHPD meets the following guidelines:

- Dam is located in a state with a state dam safety program
- Dam is classified as "high hazard potential" by the state dam safety program
- Dam has an Emergency Action Plan (EAP) approved by the state dam safety program
- Dam fails to meet minimum state dam safety standards and poses an unacceptable risk to the public (as determined by the state)
- Dam is not:
  - Federally owned,
  - A hydroelectric dam licensed by the FERC, or
  - Built under the authority of the Secretary of Agriculture.

Dams are used for a variety of purposes (recreation, flood control, water storage, irrigation, mine tailings, electrical generation, debris control or navigation); described by FEMA.

- **Flood Control**: Prevent loss of life and property caused by flooding. They impound floodwater and either release it under control to the river below or sore or divert the water for other uses.

- **Recreation**: Facilities designed for boating, skiing, camping, picnic areas, and boat launches can all be supported by dams.
- **Navigation**: Provide a stable system of inland river transportation.
- **Mine Tailings**: Allow the mining and processing of coal and other minerals while protecting the environment.

The primary hazard surrounding dam failure is the swift, unpredictable flooding of those areas immediately downstream. While general inundation areas can be determined, it is often impossible to know exactly how and where water held back by a dam will flow during a rapid failure of the dam. Generally, there are three (3) types of dam failures: hydraulic, seepage, and structural.

- **Hydraulic Failure:** Hydraulic failures result from the uncontrolled flow of water over the dam, around and adjacent to the dam, and the erosive action of water on the dam and its foundation. Earthen dams are particularly vulnerable to hydraulic failure since earth erodes at relatively small velocities.
- **Seepage Failure:** All dams exhibit some seepage that must be controlled in velocity and amount. Seepage occurs both through the dam and the foundation. If uncontrolled, seepage can erode material from the foundation of an earthen dam to form a conduit through which water can pass. This passing of water often leads to a complete failure of the structure, known as piping.
- **Structural Failure:** Structural failures involve the rupture of the dam and/or its foundation. This is particularly a hazard for large dams and for dams built of low strength materials.

Dam failures generally result from a complex interrelationship of several failure modes. Uncontrolled seepage may weaken the soil and lead to a structural failure. Structural failure may shorten the seepage path and lead to a piping failure. Surface erosion may lead to structural or piping failures.

Dam Safety requires that each dam be evaluated for its hazard potential downstream. Hazard potential is not related to the structural integrity of a dam, but strictly to the potential for downstream flooding. The hazard potential evaluation places the dam in one of four classifications that are defined in the West Virginia DEP's Dam Safety Regulations (47CSR34-3.5.b.). These classifications can be found in Table 3.3.13-1.

Table 3.3.13-1 Dam Hazard Potential Classifications (WV DEP)

CLASS	DESCRIPTION
1 (High Hazard)	Dams located where failure may cause loss of human life or major damage to dwellings, commercial or industrial buildings, main railroads, important public utilities, or where a high-risk highway may be affected or damaged. This classification must be used if failure may result in the loss of human life.
2 (Significant Hazard)	Dams located where failure may cause minor damage to dwellings, commercial or industrial buildings, important public utilities, main railroads,

Table 3.3.13-1 Dam Hazard Potential Classifications (WV DEP)	
CLASS	DESCRIPTION
	or cause major damage to unoccupied buildings, or where a low-risk highway may be affected or damaged. The potential for loss of human life resulting from failure of a Class 2 dam must be unlikely.
3 (Low Hazard)	Dams located in rural or agricultural areas where failure may cause minor damage to nonresidential and normally unoccupied buildings, or rural or agricultural land. Failure of a Class 3 dam would cause only a loss of the dam itself and a loss of property use, such as use of related roads, with little additional damage to adjacent property. The potential for loss of human life resulting from failure of a Class 3 dam must be unlikely. An impoundment exceeding forty (40) feet in height, or four hundred (400) acre-feet storage volume shall not be classified as a Class 3 dam. A waste disposal dam, the failure of which may cause significant harm to the environment, shall not be classified as a Class 3 dam.
4 (Negligible Hazard)	Dams where failure is expected to have no potential for loss of human life, no potential for property damage and no potential for significant harm to the environment. Examples of Class 4 dams include: dams across rivers, failure of which under any conditions will not flood areas above normal streambank elevations; dams located in the reservoir of another dam which, under any conditions, can contain water released by failure of the Class 4 dam; and dams in series where the toe of the Class 4 dam(s) is in close proximity to the reservoir of a dam which can contain failure of the Class 4 dam(s) under any condition. In considering a request for a Class 4 designation, the director may require written concurrence from the owner(s) of downstream dams that may be affected by failure of the Class 4 dam. Approval for use of this classification is vested in the director and will be based on engineering evaluation of the dam(s) and downstream areas in question.

Information about the hazard level and specific threats posed by a dam failure are often not shared with the general public. Owners of HHPDs are required to develop an Emergency Action Plan (EAP) as well, which is not shared publicly. Local emergency management personnel will be able to obtain this information from the WV DEP (WV DEP, 2021). Table 2.4.13-2 indicates whether a dam has developed an EAP or not.

There are four (4) dams profiled for Jefferson County in the United States Army Corp of Engineers (USACE) National Inventory of Dams (NID) (USACE, 2023). Table 3.3.13-2 lists all the dams in Jefferson County that the USACE maintains information. The location of all known existing dams and an evaluation of their hazard level can be seen in Figure 3.3.13-1.

Table 3.3.13-2 Jefferson County Dam Inventory (USACE, 2023)

Dam Name	Owner	River	EAP?	Hazard Potential Classification	Year Built	Longitude	Latitude
Keyes Ferry Acres Lake No.1	H.W. Speaks	UT Shenandoah	No	High (See Note 1 below)	1960	-77.77666667	39.291669999999996
Shannondale Club Ltd. Dam	Shannondale Club, Limited	Furnace Run	Yes	Significant	1965	-77.81361111	39.212219999999995
Lake Forest Dam	American Acreage, LLC	Furnace Run	Not Required	Low		-77.82555556	39.180279999999996
Millville	PE Hydro Generation, LLC	Shenandoah River	Not Required	Low	1905	-77.7823	39.2688

Source: USACE National Dam Inventory

In addition to these four (4) dams, the WV GIS Technical Center (WVGISTC) data for dams include two (2) other dams: Keyes Ferry Acres Lake No. 2 and Keyes Ferry Acres Lake No. 3. Detailed information on these two (2) dams was not available.

Aaron Tonkery, WVDEP-Dam Safety Program Manager, verified that the USACE information has not been updated for the majority of West Virginia for several years and that includes Jefferson County. Mr. Tonkery provided the following information on dams located in Jefferson County.

- Note 1 - Jefferson County has all of the Keyes Ferry Acres Lake Dams (including No. 1 listed above) recorded as non-jurisdictional. Therefore, WVDEP-Dam Safety has no regulatory authority over those dams. The Keyes Ferry Acres Lake No.1 Dam is below dimensions (height/volume) to be considered a "jurisdictional" dam and none of the Keyes Ferry Acres Lake Dams have an EAP given that any of them are of jurisdictional size. The hazard classification for Keyes Ferry Acres Lake Dam #1 should be reviewed given that it is below jurisdictional size.

- Information regarding Shannondale Lake and Lake Forest Dam are correct.

- The Millville Dam is hydro power, so WVDEP-Dam Safety does not regulate that structure.

- There are two high hazard dams not included in the NID that were discovered in 2018. The owner has decided to remove the dams and are in the final application stage at this point. They

plan to have them removed before the end of the calendar year, 2023. The dams are listed as follows:

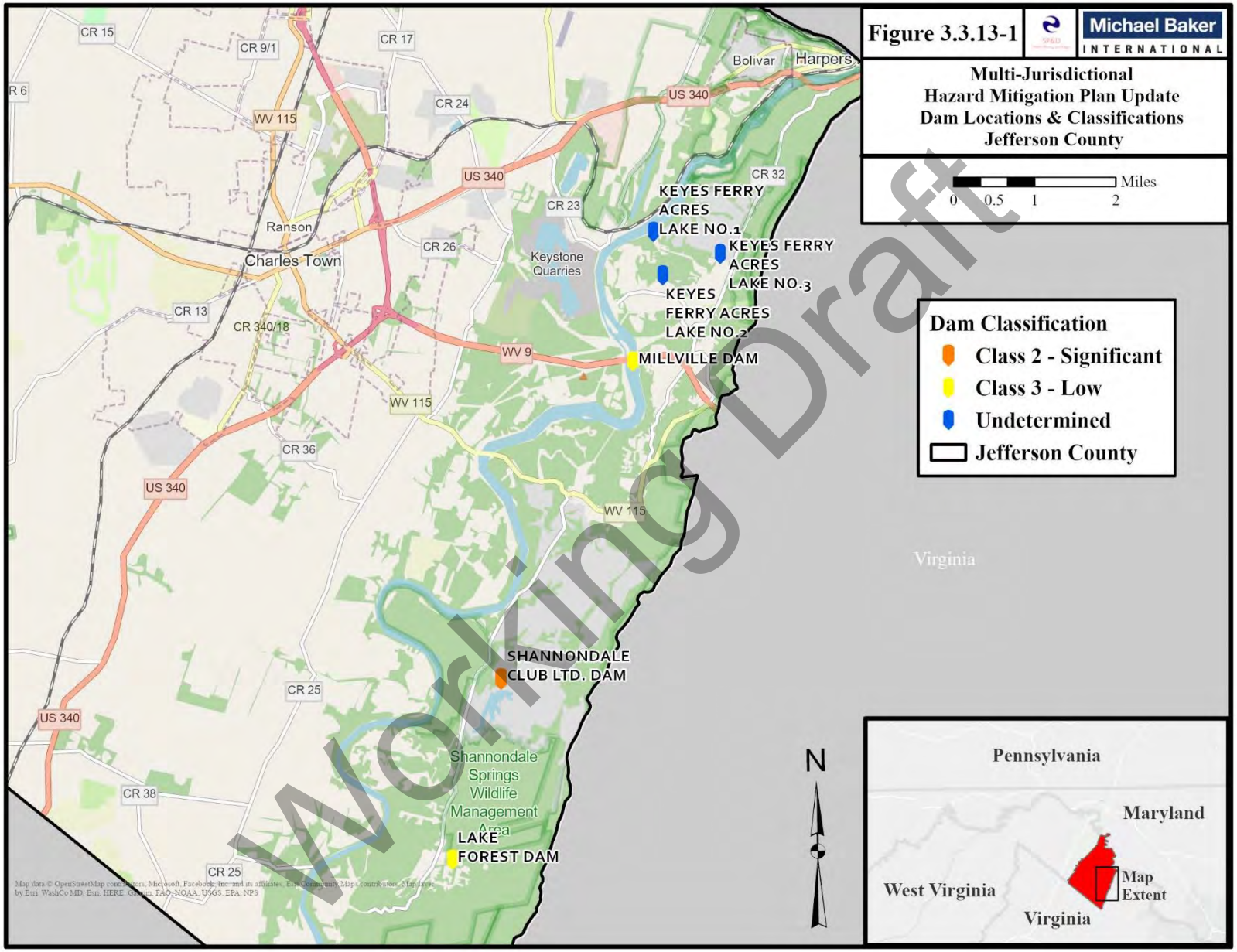
- Izaak Walton League Dam No. 1
  - Owner: Izaak Walton League of America - Jefferson County Chapter
  - Located on Dry Run
  - EAP is required
  - High Hazard
  - Lat: 39.3436 - Long: -77.9456

- Izaak Walton League Dam No. 2
  - Owner: Izaak Walton League of America - Jefferson County Chapter
  - Located on Dry Run
  - EAP is required
  - High Hazard
  - Lat: 39.3416 - Long: -77.9461

- Shannondale Lake Dam (03701) is the only one that requires Monitoring and Emergency Action Plans (MEAP) even though it is a Class 2. This is because there is a road downstream (low traffic) that would be affected if the dam was to fail. The MEAP has an inundation map for that dam.

- Lake Forest (03708), which is a Class 3 and does not require a MEAP. There is no inundation map for this dam.

- Other dams in the County, like the Keyes Ferry Acres Lake Dams, are below jurisdiction (too small to be "dams").



Past Occurrence

Several research methods to identify any past occurrences of dam failures in Jefferson County yielded no evidence of any historic or recent dam failures in the county. However, a catastrophic dam failure has occurred in West Virginia. On February 25th, 1972, a dam in Buffalo Creek Hollow, Logan County, that was used to contain waste from a coal mining operation failed. The failure was a result of heavy precipitation, a lack of safety features, and poor maintenance. The dam was also not permitted by the state. The disaster killed 123 people, injured 1,000 more, and left 4,000 people homeless (Choi, 1999).

Future Occurrence

The WV DEP, Division of Water and Waste Management (DWWM), Dam Safety Program maintains an inventory of dams in West Virginia within the jurisdiction of the Dam Control and Safety Act. DWWM regulates dams:

- 25 feet or more in height and capable of impounding 15 or more acre-feet of water;
- Or 6 feet or more in height and capable of impounding 50 or more acre-feet of water

The construction, operation, maintenance, modification, and abandonment of dams regulated by the DEP is reviewed and monitored by the Department's Program of Dam Safety. Dams are evaluated based on categories such as slope stability, undermining seepage, and spillway adequacy. The presence of structural integrity and inspection programs significantly reduces the potential for major dam failure events to occur. Minor dam failures are more common since low hazard structures are minimally regulated, but the impact of these events is minimal.

Emergency Action Plans (EAPs) drafted in accordance with the Federal Guidelines for Dam Safety identify the risk related information including the inundation area and the time lapse between dam failure and flooding reaching specific destinations downstream. These plans are also reviewed and approved by the West Virginia Division of Water and Waste Management Environmental Enforcement (DWWM EE).

Dams which are federally owned and regulated are subject to the dam safety offices of the regulating agency. The FERC Office of Energy Projects' Dam Safety and Inspections division conducts construction, operation, exemption, special, pre-license, and environmental and public use inspections of energy production dams to minimize risk associated with FERC dams. USACE dams are inspected and maintained by the district in which the dam is located.

According to the Army Corps of Engineers – Baltimore District, a catastrophic failure of the Jennings Randolph Lake Dam on the border of Garrett County, Maryland and Mineral County, West Virginia which impounds a 952-acre lake, could create a hazard to life and property and could cause significant downstream river flooding along the Potomac River in **small portions Shepherdstown** and **Harpers Ferry**. The dam was completed in 1981 and has a height of 296 feet and a maximum storage capacity of 130,900 acre-feet. The U.S. Army Corps of Engineers, Baltimore District, has installed a year-round early warning system at Jennings Randolph Lake intended to notify downstream public users of impending rapid increases in water levels, and to evacuate the river immediately to higher ground for their safety. Accordioning to the USACE NID, the worst-case scenario of failure for this dam "could involve situations such as: a rare, extreme rainfall event resulting in water flowing over the earthen dam, eroding the dam,

and leading to a breach of the dam, or; unexpected behavior of seepage through the dam eroding soil from within the embankment leading to a breach. If a breach were to occur, an uncontrolled surge of water would flow out of the reservoir, flooding downstream communities. Bloomington, Luke, Westernport, Piedmont, Keyser, Cumberland, and adjacent communities are in the most immediate danger in the event of a flood. Other communities along the North Branch Potomac River would also be impacted" (USACE 2021a). The NID does not include inundation mapping or vulnerable population estimates as of June 2023.

Range of Magnitude

Dam failures can pose a serious threat to communities located downstream from major dams. The impact of a dam failure is dependent on the volume of water impounded by the dam and the amount and distance of population or assets located downstream. Catastrophic failures are characterized by the sudden, rapid, and uncontrolled release of impounded water or any other fluid or semi-fluid from a dammed impoundment or water body. Dams are inspected yearly or sooner as necessary.

Dam failures may or may not leave enough time for evacuation of people and property, depending on their abruptness. Seepages in earth dams usually develop gradually, and, if the embankment damage is detected early, downstream residents have at least a few hours or days to evacuate. Failures of concrete or masonry dams tend to occur suddenly, sending a wall of water and debris down the valley at more than 100 miles per hour. Survival would be a matter of having the good fortune not to be in the flood path at the time of the break. Dam failures due to overtopping of a dam normally give sufficient lead time for evacuation. Dam failures may also be intentional, as their potential to cause serious destruction may make them a potential terrorism target.

The environmental impacts of dam failures can be devastating. Depending on the size of the event and number or type of structures located in the inundation area, water contamination from hazardous material facilities could occur. Water velocities could result in total destruction of trees and other vegetation. Severe erosion both during and after the failure event are probable. Additionally, if the dam's purpose is water supply, downstream communities will lose access to potable water.

Vulnerability Assessment

Vulnerability is defined by identifying the location of dams having high hazard potential. Specifically, those dams in Class 1 in which loss of life is possible should a failure occur and/or where economic loss would be excessive to extensive for residential, commercial, or agricultural resources and would cause substantial public inconvenience.

DEP completes an annual inspection of high hazard dams and notes safety concerns. Safety concerns include stability, flood flow issues, and poor maintenance. When a dam has safety concerns, DEP places them on an unsafe dam list and contacts the owners to work on resolving the issues. The list is not publicly released in order to provide the dam owner with an opportunity for due process to resolve the concerns. DEP has also reviewed the dams deemed unsafe to confirm that they meet the other requirements for HHPD based on updated EAPs and ownership.

Dam permittees are responsible for conducting a dam breach analysis and inundation mapping. This data is not typically publicly available nor is it provided in a geospatial data format making further analysis challenging. The extent of downstream inundation areas varies based on dam and reservoir characteristics. Structures and critical facilities are vulnerable to the volume and velocity of water, and the population in these structures at the time of inundation is vulnerable to these impacts. In addition, while dams of any size may fail and cause damage, smaller dams do not have inundation areas delineated and reported to the DEP. Depending on the time of day of a dam failure, the population in residential structures could be especially vulnerable to a dam failure; if the failure took place at night those in an inundation area would be unaware of the failure before the inundation waters impacted their residences. Jurisdictional losses associated with exposed building value could not be estimated with the available information.

Should Region 9 or dam owners need dam inundation data moving forward, they will need approval from the local sponsors (e.g., the municipality, the Eastern Panhandle Conservation District, and the State Conservation Committee) and can then obtain the data from the Natural Resources Conservation Service (NRCS) via Andy Deichert (andy.deichert@wv.usda.gov).

According to the West Virginia Statewide Assessment, there are three "major" high-hazard dams located outside of Region 9 counties (Morgan, Berkeley, and Jefferson) that have the potential to impact Region 9 communities.

- **Jennings Randolph Dam** (Border of Mineral County, WV and Garett County, MD): The Jennings Randolph dam, located on the North Branch Potomac River in Garrett County, Maryland and Mineral County, West Virginia, is one of the largest dams in the region. Completed in 1981, the Jennings Randolph flood-control dam has a height of 296 feet and a maximum storage of 130,900 acre-feet. A dam failure of Jennings Randolph dam would affect downstream five counties (Mineral, Hampshire, Morgan, Berkeley, and **Jefferson**) and 12 jurisdictions, or from the unincorporated town of Barnum on the North Branch Potomac River downstream to **Harpers Ferry** at the confluence of the Potomac and Shenandoah Rivers. The U.S. Army Corps of Engineers, Baltimore District, has installed a year-round early warning system at Jennings Randolph Lake

intended to notify downstream public users of impending rapid increases in water levels, and to evacuate the river immediately to higher ground for their safety.

- **Savage River Dam** (Garrett County, MD): Completed by the U.S. Army Corps of Engineers (USACE) in 1952, the dam is 184 feet high with a maximum storage of 31,800 acre-feet of water. Five miles downstream of the dam, the Savage River flows into the Potomac River near the town of Piedmont, Mineral County, WV. The Savage River Dam, maintained by the U.S. Army Corps of Engineers, is classified as a "large", "high" hazard structure.

- **Lake Holiday Dam** (Frederick County, VA): The privately owned Lake Holiday Dam in Frederick County, Virginia, is located approximately 13 miles upstream from the Berkeley County border. In Virginia, the lake flows into Isaacs Creek, an east-flowing tributary of Back Creek, which flows north through Berkeley County to the Potomac River. This high hazard dam is 102 feet high and stores 10,166 acre-feet of water.

People

Dam failures themselves do not pose a threat to public health; the cascading effects that occur after a failure are more concerning. When a dam fails, it causes flooding downstream that can cause death, injury, and illnesses relating to water-borne diseases and standing water. As a result of flooding, people might have to evacuate and be displaced from their homes.

Inundation areas and vulnerable populations are being developed by the WV GIS Technical Center with concurrence with USACE. Future updates should more fully incorporate this data once completed. USACE is also updating its database and associated website to include dam-specific risk information and inundation maps for USACE dams.

Table 3.3.13-3 lists dams that would affect Jefferson County if a failure would occur. Areas that could be potentially impacted are provided. Both the towns of Shepherdstown and Harpers Ferry are downstream of the Jennings Randolph Lake Dam, while Harpers Ferry also is downstream of the Millville Hydroelectric Dam. Using the 2020 census data, Shepherdstown's population is 1,494 people, while Harpers Ferry has a population 269 people. A dam failure at either dam could potentially impact on these populations.

Table 3.3.13-3 Dams Affecting Jefferson County

Name of Dam	Class	Type	Stream / Downstream Area
Jennings Randolph Lake Dam	II	Rolled Earth & Rock Fill	North Branch Potomac River and Potomac River / Shepherdstown and Harpers Ferry.
Millville Hydroelectric-Dam	IV	Concrete	Shenandoah River / Areas along the river in the Millville area and potentially the lower town of Harpers Ferry.
Lake Shannondale Dam	II	Rolled Earth & Rock Fill	Furnace Run / Properties located along Mission Road and Riverside Drive

Structures

There have been no losses of life or property in Jefferson County due to a dam failure. However, this does not mean that there will never be any losses due to this type of event.

> *"Dam safety risk assessment is like a stool that stands on three legs. These legs quantify the likelihood that various initiating events (hydrologic, seismic, structural/internal, mechanical, or human error) will occur; the likelihood that the dam would fail given these initiating events; and the likelihood that, given a failure, the resulting flood wave would result in various levels of damage. The meaningful quantification of risk depends on credible estimates of the damage that would result from each significant failure scenario. Loss of human life is generally accepted as the most important consequence, so it often dominates dam-safety decisions. Unfortunately, the confidence with which life loss can currently be estimated is low. This high level of uncertainty applies to both statistical confidence limits and to expert opinion. As such, this single limitation is a critical hindrance to the credibility and value of dam-safety risk assessment results. Indeed, some would like to push the stool over on its weak leg and abandon probabilistic risk assessment altogether" (USACE, 2002).*

Jefferson County has one dam that could present the possibility of significant flood damage to the residents and businesses located near or downstream from the dam. Lakeside Properties, LLC privately owns the Lake Shannondale Dam which impounds a 50.5-acre lake, with a maximum depth of 86 feet. The dam was constructed in 1965. There are approximately 12 residential properties that could incur significant flooding if the dam were to fail catastrophically, all of which are located along Mission Road and Riverside Drive.

The owner of the Lake Shannondale Dam indicated that the dam is inspected annually by the West Virginia Department of Environmental Protection – Dam Safety Division, and a Monitoring and Emergency Action Plan (MEAP) was developed for the dam, that was updated in October 2021.

The current Jefferson County Emergency Operations Plan contains a dam failure incident specific annex.

Systems

Systems in this section refer to networks and capabilities. Dam failures could disrupt many systems including power, sewer, water, communications, and road access. The Millville Hydroelectric Dam is connected to the Millville Hydro Station, which is an energy plant that converts energy into bulk electrical power. The Power Plant distributes electrical power to the Jefferson County area electrical grid, which delivers it to electricity consumers. A failure at this dam is rated as a low hazard dam, however a dam failure incident would cause significant disruption to the systems in Jefferson County.

Natural, Historic and Cultural Resources

The National Register of Historic Places was used to assess the vulnerability of natural, historic, and cultural resources. For more complete information about the historical designations, refer to the National Register WV Listings. Historic structure locations were overlayed with dam locations. This assessment concluded no historic or culture structures are located in or around dams located in Jefferson County.

Community Activities

Activities that have value to the community could potentially be impacted by dam failures, however the identified dams are located in rural areas. Therefore, community activities would be unlikely to occur in these areas.

Definitions

Eligible High Hazard Potential Dam (Source: 33 USC § 467(4)(A))

(E) a non-federal dam that—

(vii) is located in a state with a state dam safety program;

(viii) is classified as "high hazard potential" by the state dam safety agency in the state in which the dam is located;

(ix) has an emergency action plan approved by the relevant state dam safety agency; and

(x) the state in which the dam is located determines—

(III) fails to meet minimum dam safety standards of the state; and

(IV) poses an unacceptable risk to the public.

(F) Exclusion: The term "eligible high hazard potential dam" does not include—

(xi) a licensed hydroelectric dam; or

(xii) a dam built under the authority of the Secretary of Agriculture.

All Dam Risk

For the purposes of the HHPD program, all dam risk includes the incremental risk, non-breach risk, and residual risk associated with each eligible high hazard potential dam, as well as the reason(s) the state has determined the dam is an eligible high hazard potential dam.

Incremental Risk

The risk (likelihood and consequences) to the pool area and downstream floodplain occupants that can be attributed to the presence of the dam should the dam breach prior or subsequent to overtopping or undergo component malfunction or mis operation, where the consequences considered are over and above those that would occur without dam breach. The consequences typically are due to downstream inundation, but loss of the pool can result in significant consequences in the pool area upstream of the dam.

Non-Breach Risk

The risk in the reservoir pool area and affected downstream floodplain due to 'normal' dam operation of the dam (e.g., large spillway flows within the design capacity that exceed channel capacity) or 'overtopping of the dam without breaching' scenarios.

Residual Risk (Source: ER 1110-2-1156)

The risk that remains after all mitigation actions and risk reduction actions have been completed. With respect to dams, FEMA defines residual risk as "risk remaining at any time" (FEMA, 2015, p A-2). It is the

risk that remains after decisions related to a specific dam safety issue are made and prudent actions have been taken to address the risk. It is the remote risk associated with a condition that was judged to not be a credible dam safety issue.

Population at Risk (PAR) (Source: USACE ER 1110-2-1156)

The population downstream of a dam that would be subject to risk from flooding in the instance of a potential dam failure; usually documented in numbers of persons at risk.

3.3.14 Civil Disturbance

Location and Extent

Civil disturbance is a broad term that is typically used by law enforcement to describe one or more forms of disturbance caused by a group of people. Civil disturbances are typically a symptom of, and a form of protest against, major socio-political problems. Civil disturbance hazards include the following:

- **Famine:** Involving a widespread scarcity of food leading to malnutrition, increased mortality, and a period of psychosocial instability associated with the scarcity of food, such as riots, theft of food, and the falls of governments caused by political instability borne of an inability to deal with the crisis caused by famine
- **Economic Collapse, Recession:** Very slow or negative growth
- **Misinformation:** Erroneous information spread unintentionally
- **Civil Disturbance, Public Unrest, Mass Hysteria, Riot**: Group acts of violence against property and individuals, for example
- **Strike, Labor Dispute:** Controversies related to the terms and conditions of employment, for example

Typically, the severity of the action coincides with the level of public outrage. In addition to a form of protest major socio-political problems, civil disturbances can also arise out of union protest, institutional population uprising, or from large celebrations that become disorderly. The scale and scope of civil disturbance events varies widely. However, government facilities, landmarks, prisons, and universities are common sites where crowds and mobs may gather.

Past Occurrences

According to the *Berkeley and Morgan County 2022 Hazard Mitigation Plan Update*, an uprising against racism and police brutality swept the nation, in May of 2020. Triggered by the murder of George Floyd by Minneapolis Police in Minnesota, groups in cities and towns across the country hosted protests for several weeks, including Berkeley and Morgan County. Peaceful protests and riots occurred throughout the region during the summer months of 2020, in Berkeley Springs, Martinsburg, and other communities. In one instance at a Berkeley Springs protest in August 2020, thirty to fifty people gathered to show support for the Black Lives Matter protest but were met with hundreds of counter protesters carrying Confederate flags and overpowering the speakers of the rally with chants of “U.S.A” and “all lives matter.” Police intervened and created a barricade with riot shields when counter protesters advanced towards the gazebo holding the speakers.

Jefferson County monitored this aforementioned "peaceful protest" event in Berkeley County and other communities throughout the panhandle according to Stephen Allen, Director, Office of Homeland Security and Emergency Management. The West Virginia Fusion Center monitors and disseminates information to Jefferson County Fusion Liaison Officers. Finally, the Jefferson County Counter Terrorism Committee meets monthly to discuss and monitor civil disturbances.

Future Occurrences

Civil disturbance is always a possibility as long as there is discrimination or other perceived social or economic injustices. However, it may be possible to recognize the potential for an event to occur in the near-term. For example, an upcoming significant sporting event or other large public gathering in the State may result in gathering of large crowds or immediately after significant national news involving political or social debates. Local law enforcement should anticipate these types of events and be prepared to handle a crowd so that peaceful gatherings are prevented from turning into unruly public disturbances. Therefore, the probability of civil disturbance occurring in the region is considered *possible* as defined by the Risk Factor Methodology probability criteria (see Table 4.4-1).

Range of Magnitude

Civil disturbances can take the form of small gatherings or large groups blocking or impeding access to a building or disrupting normal activities by generating noise and intimidating people. They can range from a peaceful sit-in to a full-scale riot, in which a mob burns or otherwise destroys property and terrorizes individuals. Even in its more passive forms, a group that blocks roadways, sidewalks, or buildings interferes with public order. There are two types of large gatherings typically associated with civil disturbances: a crowd and a mob. A crowd may be defined as a casual, temporary collection of people without a strong, cohesive relationship. Crowds can be classified into four categories (Juniata County, PA MJHMP, 2008):

1. **Casual Crowd:** A casual crowd is a group of people who happen to be in the same place at the same time. Violent conduct does not occur.
2. **Cohesive Crowd:** A cohesive crowd consists of members who are involved in some type of unified behavior. Members of this group are involved in some type of common activity, such as worshipping, dancing, or watching a sporting event. They require substantial provocation to arouse to action.
3. **Expressive Crowd:** An expressive crowd is one held together by a common commitment or purpose. Although they may not be formally organized, they are assembled as an expression of common sentiment or frustration. Members wish to be seen as a formidable influence. One of the best examples of this type is a group assembled to protest for a cause.
4. **Aggressive Crowd:** An aggressive crowd is comprised of individuals who have assembled and are visibly angry or violent. This crowd often has leaders who attempt to arouse the members or motivate them to action. Members are noisy and threatening and will taunt authorities. They may be more impulsive and emotional and require only minimal stimulation to arouse violence.

A mob can be defined as a large disorderly crowd or throng. Mobs are usually emotional, loud, tumultuous, violent, and lawless. Similar to crowds, mobs have different levels of commitment and can be classified into four categories:

- **Aggressive Mob*:*** An aggressive mob is one that attacks, riots and terrorizes. The object of violence may be a person, property, or both. An aggressive mob is distinguished from an aggressive crowd only by lawless activity. Examples of aggressive mobs are the inmate mobs in prisons and jails, mobs that act out their frustrations after political defeat, or violent mobs at political protests or rallies.
- **Escape Mob:** An escape mob is attempting to flee from something such as a fire, bomb, flood, or other catastrophe. Members of escape mobs are generally difficult to control and can be characterized by unreasonable terror.
- **Acquisitive Mob:** An acquisitive mob is one motivated by a desire to acquire something. Riots caused by other factors often turn into looting sprees. This mob exploits a lack of control by authorities in safeguarding property.
- **Expressive Mob:** An expressive mob is one that expresses fervor or revelry following some sporting event, religious activity, or celebration. Members experience a release of pent-up emotions in highly charged situations.

The worst-case scenario for the region would be an aggressive crowd or expressive mob protesting on or within a major thoroughfare, most likely formed near a major population hub, like Martinsburg. This scenario would also involve property damage

Vulnerability Assessment

Jefferson County is most vulnerable to civil disturbance in their most populated municipalities: Charles Town and the Town of Ranson. However, response training and anticipation to disturbances may minimize associated impacts and damages.

People

Jurisdictional losses for civil disturbance events are difficult to predict and can vary significantly in range. The two communities identified in this section are locations where such events are more likely to occur and therefore should be considered more vulnerable.

Impacts from violent acts to survivors most likely include common stress reactions that may last several days to a few weeks. These reactions may include the following:

- **Emotional Reactions:** Shock, fear, grief, anger, guilt, shame, helplessness, numbness, sadness.
- **Cognitive Reactions:** Confusion, indecisiveness, worry, shortened attention span, trouble concentrating.
- **Physical Reactions:** Tension, fatigue, edginess, insomnia, body aches, easily startled, tachycardia, nausea, loss of appetite.

- **Interpersonal Reactions:** distrust, conflict, withdrawal, irritability, loss of intimacy, feeling abandoned.

Social Vulnerability

Deciding which groups are vulnerable is challenging. There will always be variation between groups and the people within them in relation to the risks they face. However, the elderly, children, homeless persons, people with disabilities, religious groups and members of the LGBTQ community experience higher rates of exposure to violence.

Source: Social Vulnerability to Disasters, 2nd Edition, Edited by Deborah S.K. Thomas, Brenda D. Phillips, William E. Lovekamp, Alice Fothergill

Structures

In the case of small and large civil disturbance events, the county may incur losses related to work stoppages in addition to any acts of vandalism that my occur. Structures may be damaged, specifically commercial and government property. Damages to structures may result in short to long-term closures and disruption of services.

Systems

Adequate law enforcement minimizes the changes of a small assembly of people turning into a significant disturbance. This will ensure improved response times, optimal communications, and containment of the event as during these events major roadways can be blocked and disturb traffic and larger events may involve the interruption or removal of communication.

Resources and Community Activities

Public places are most often used for protest. These locations are chosen to attract the most attention for the issue at the center of the protest. By holding a protest in public or community centered area, organizers are hoping to draw attention to their cause or issue from passersby or even the media who may not be aware of its significance. The usage of parks and other community areas may result in the cancellation of planned community events.

3.3.15 Hazardous Materials Incident

A hazardous material may be defined as a substance or material which, because of its chemical, physical, or biological nature, poses a threat to life, health, or property if released from a confined setting. A release may occur by spilling, leaking, emitting toxic vapors, or any other process that enables the material to escape its container, enter the environment, and create a potential hazard. Hazardous materials can include toxic chemicals, infectious substances, bio-hazardous waste, and any materials that are explosive, corrosive, flammable, or radioactive. Related combustible hazardous materials include oxidizers and reactive materials, while toxins produced by etiological (biological) agents are types of poison that can cause disease.

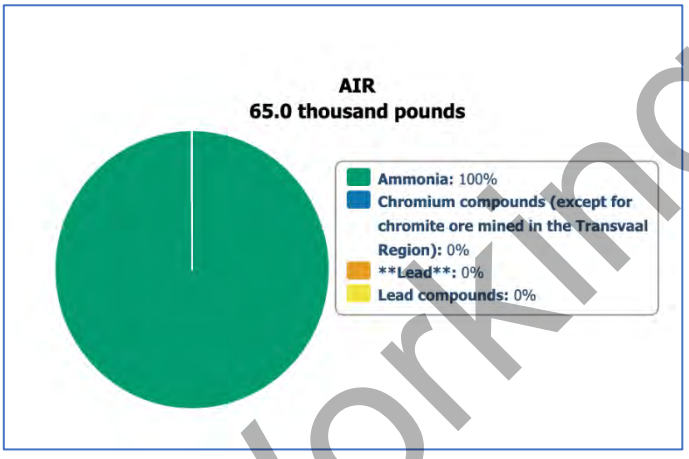
Hazardous material releases pose threats to the natural environment, the built environment, and public safety through the diffusion of harmful substances, materials, or products. Hazardous material releases can occur wherever hazardous materials are manufactured, used, stored, or transported. Such releases can occur along transportation routes, including road and rail, or at fixed-site facilities. Hazardous material releases can result in human and wildlife injury, property damage, and contamination of air, water, and soils.

Location and Extent

Fixed-site facilities that use, manufacture, or store hazardous materials in Jefferson County pose risk and must comply with both Title III of the federal Superfund Amendments and Reauthorization Act (SARA), also known as the Emergency Planning and Community Right-to-Know Act (EPCRA). This legislation requires that all owners or operators of facilities that manufacture, produce, use, import, export, store, supply, or distribute any extremely hazardous substance, as defined by the EPA, at or above the threshold planning quantity, as established by EPA, shall report to the county where the facility is located and to the State that the facility is subject to the requirement to assist the Local Emergency Planning Committee (LEPC) in the development of an Off-site Emergency Response Plan. The community right-to-know reporting requirements keep communities abreast of the presence and release of chemicals at individual facilities. Due to the sensitive nature of SARA facility information, Berkeley and Morgan County will not release information regarding specific SARA facilities for this plan. However, reports from facilities that have release toxic material into the environment are accessible by the public under the Toxic Release Inventory (TRI). TRI was established under EPCRA and expanded under the Pollution Prevention Act of 1990. The Toxics Release Inventory (TRI) tracks the management of certain toxic chemicals that may pose a threat to human health and the environment. Certain industrial facilities in the U.S. must report annually how much of each chemical is recycled, combusted for energy recovery, treated for destruction, and disposed of or otherwise released on- and off-site. This information is collectively referred to as production-related waste managed. Some notable facilities which report through the EPA TRI are listed in Table 3.3.15-1.

Table 3.3.15-1 Top Five Facilities by Total Releases, Jefferson County, WV, 2021		
Facility/ Location	**Industry Sector**	**Thousands of Pounds**
US CBP Advanced Training Center 440 Koonce Road Harpers Ferry, WV, 25425	Sector 999-Other	**712**: Off-Site Disposal or Other Releases *Note: 1,700 Off Site Disposal or Other Releases reported in 2020*
Rockwool USA 665 Northport Avenue Kearneysville, WV, 25430	Sector 327-Non-Metalic Mineral Product	**85,345**: Air & Off-Site Disposal or Other Releases *Note: Not reported as a top-five facility by total releases in 2020.*
Ox Paperboard LLC 164 Eyster Rd Harpers Ferry, WV, 25425	Sector 322-Paper	Annual release **did not exceed 500 pounds** for the reporting year, 2021. *Note- 11 Off-Site Disposal or Other Releases reported in 2020*
Griffith Energy Services Inc. 110066 Middleway Pike Charles Town, WV, 25414	Sector 4247-Petroleum Bulk Terminals	Annual release **did not exceed 500 pounds** for the reporting year, 2021. *Note- Annual release did not exceed 500 pounds for the reporting year, 2020*
UFP Ranson LLC 249 16th Avenue Ranson, WV, 25438	Sector 321-Wood Products	Annual release **did not exceed 500 pounds** for the reporting year, 2021. *Note- Not reported as a top-five facility by total releases in 2020.*

Source: 2021 National Analysis Dataset (updated May 2023, released May 2023)



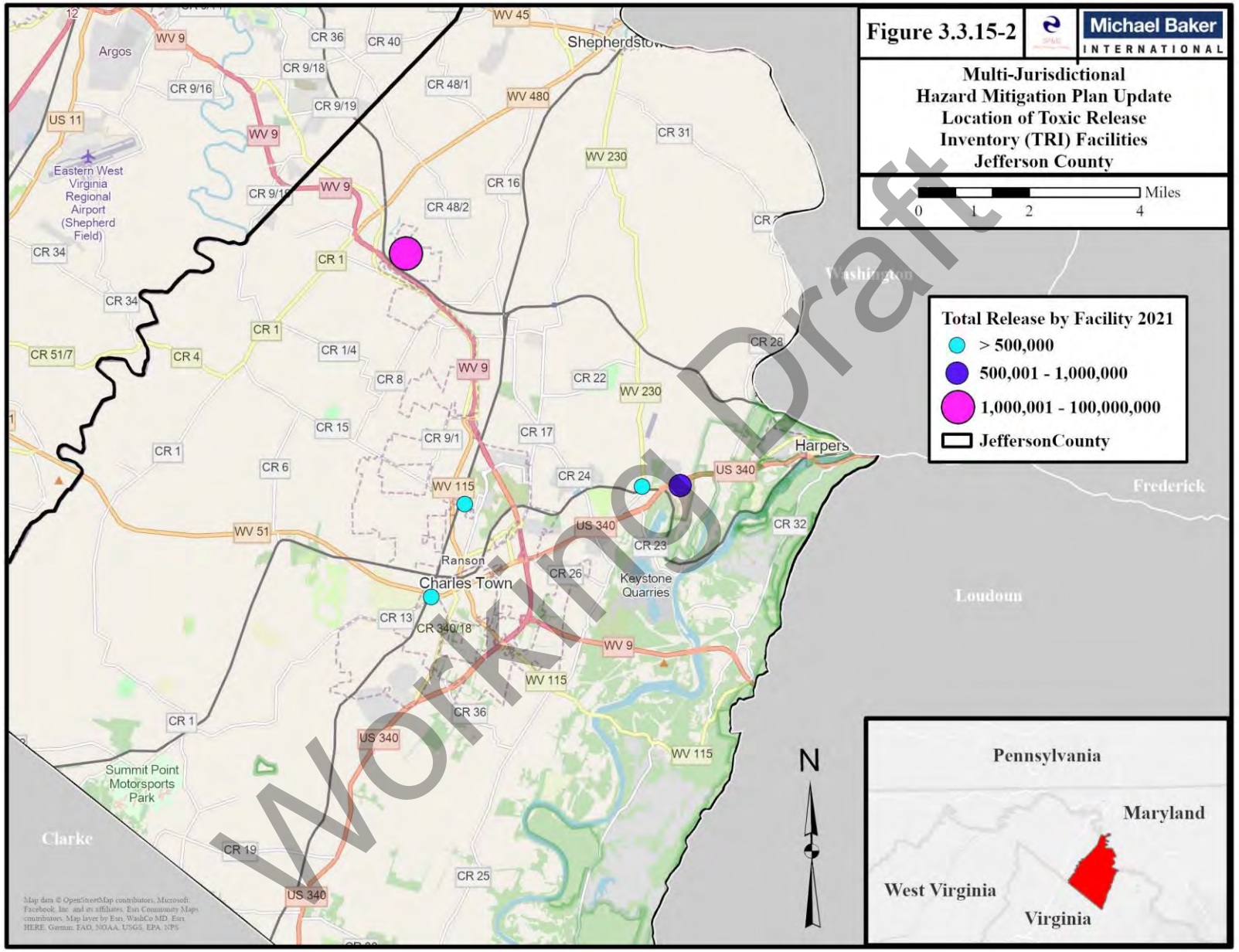
Ammonia, which is a Carcinogenic Chemical, was the top chemical released into the air in Jefferson County according to the 2021 TRI Factsheet: County – Jefferson, WV.

West Virginia ranks **16 out of 56** states/territories nationwide based on total releases per square mile (Rank 1 = highest releases.)

Figure 3.3.15-1 Top Chemicals Released into the Air, 2021 TRI – Jefferson County, WV

The extent of the damage from hazmat can be localized to just a cleanup on the road, or widespread, to include hazardous materials reaching source water via storm drains, and the river. In general, facilities that utilize hazardous materials are located near major thoroughfares and in more developed areas of each county.

In addition to fixed-site hazardous materials release, there are increasingly large numbers of chemicals, oils, radioactive materials, and other hazardous substances spilled because of highway, rail, and waterway accidents, storage tank leakage, pipeline break, and/or other accidents. On occasion, these events become a major disaster and force people to evacuate and/or lose their homes and businesses.



Past Occurrence

Since 2009, PHMSA has not reported any incidents occurring in Jefferson County. The National Response Center (NRC), by contrast, has reported 33 occurrences of hazmat incidents since 2010. The table on the following page details the type of incident, its cause, the date, and the location, when available.

Table 3.3.15-2 highlights all HazMat Incident Reports reported by the U.S. Department of Transportation from 2000- May 2023.

Table 3.3.15-2 NRC HazMat Occurrences

Type of Incident	Incident Cause	Incident Date	Location Nearest City
Fixed	Other/Unknown	3/4/2010	Harpers Ferry
Fixed	Other/Unknown	6/25/2010	Charles Town
Fixed	Dumping	11/5/2010	Charles Town
Storage Tank	Equipment Failure	4/29/2011	Shepherdstown
Mobile	Other/Unknown	11/29/2011	Morgan
Unknown Sheen	Other/Unknown	12/18/2011	Millville
Fixed	Other/Unknown	12/30/2011	Harpers Ferry
Storage Tank	Other/Unknown	6/10/2012	Shenandoah Junction
Railroad	Equipment Failure	8/26/2012	Shenandoah Junction
Mobile	Other/Unknown	11/1/2012	Charles Town
Unknown Sheen	Other/Unknown	3/7/2013	Shepherdstown
Fixed	Other/Unknown	1/4/2014	Ranson
Fixed	Natural Phenomenon	2/6/2014	Harpers Ferry
Fixed	Other/Unknown	3/1/2014	Charles Town
Railroad	Equipment Failure	5/2/2014	Shepherdstown
Railroad	Equipment Failure	6/15/2014	Charles Town
Fixed	Other/Unknown	7/30/2014	Charles Town
Fixed	Dumping	10/28/2014	Harpers Ferry
Fixed	Other/Unknown	2/9/2015	Kearneysville
Pipeline	Operator Error	6/9/2015	Charles Town
Fixed	Equipment Failure	11/11/2015	Charles Town
Aircraft	Other/Unknown	12/16/2015	Charles Town
Storage Tank	Other/Unknown	1/7/2016	Harpers Ferry
Railroad	Equipment Failure	10/13/2016	Charles Town
Railroad	Equipment Failure	2/13/2017	Harpers Ferry
2023 Plan Update			
Storage Tank	Unknown	1/26/2018	Summit Point
Fixed	Operator Error	3/17/2018	Harpers Ferry
Fixed	Dumping	4/28/2018	Harpers Ferry
Fixed	Dumping	8/17/2018	Kearneysville
Mobile	Equipment Failure	11/1/2018	Charles Town
Fixed	Other	1/3/2019	Ranson
Fixed	Dumping	7/30/2019	Charlestown

Table 3.3.15-2 NRC HazMat Occurrences			
Type of Incident	**Incident Cause**	**Incident Date**	**Location Nearest City**
Fixed	Other	10/7/2019	Halltown
Unknown Sheen	Unknown	3/20/2020	Shepherdstown
Railroad	Derailment	1/25/2021	Ranson
Fixed	Other	3/20/2021	Charles Town
Fixed	Unknown	8/15/2021	Shepherdstown
Fixed	Equipment Failure	8/17/2021	Shepherdstown
Fixed	Operator Error	6/4/2023	Charles Town

Source: National Response Center 2010-2023

Note: In 2022 only one incident was recorded in the database, which involved a trespasser on railroad, which was not a release.

JCHSEM reached out to their neighboring jurisdictions to ask about hazards that originate in Jefferson County and affect the surrounding, and hazards that originate in surrounding counties and affect Jefferson County. The Loudoun County Office of Emergency Management (OEM) in Virginia expressed concern for incidents originating in Jefferson County that affect Loudoun; a train derailment in Harpers Ferry could affect the county. The Washington County Division of Emergency Services (DES) in Maryland mentioned that there are numerous rail lines along the Sandy Hook area (South Washington County) where Washington and Jefferson meet at the Potomac; if a train derailed or spill hazardous materials, there would be a potential impact to both counties.

Future Occurrence

While some hazardous material release incidents have occurred in Jefferson County in the past, they are generally considered difficult to predict. An occurrence is largely dependent upon the accidental or intentional actions of a person or group. Intentional acts are addressed under Section 3.3.16, Terrorism. Future occurrences could take place at any facility making use of or storing hazardous materials or any thoroughfare for hazardous materials into, out of, or through the county.

Many steering committee members indicated their predictions for an increase in hazardous materials realted incidents moving forward. Overall, the probability of future hazardous materials incidents is *likely* as defined by the Risk Factor Methodology (See Section 4.4.1).

Range of Magnitude

The hauling, storage, and use of hazardous materials play a vital role in the economy of our nation. These materials are stored and handled at fixed facilities and are transported over highway, railway, and water transportation systems, as well as pipelines. It is estimated that over four billion tons of hazardous materials are transported annually and that 100,000 trucks haul hazardous materials on the country's highways each day. Almost half of all freight trains carry hazardous materials. The majority of the transportation infrastructure utilized to move hazardous materials through Jefferson County is located in the central portion of the county; this is also the most populated area of the county, and the location for the majority of the high hazard areas for natural hazards, thus increasing the chance of a release. An incident causing the accidental release of a hazardous material is spontaneous, with little time of

warning. Further, the recovery and clean-up activities involved in a hazmat incident may require several hours, days, or even weeks to complete.

Hazardous materials can be released as a secondary result of a natural disaster like an earthquake or flood. In either case, buildings or vehicles can release their hazardous materials inventories when structurally compromised or involved in traffic accidents. Additional potential causes of hazardous material releases may include terrorist incident and illegal drug labs or dumping. Illegal drug labs present a special concern because each must be treated as a chemical hazard site and decontaminated before the property can be used again. Illegal drug labs can be set up in homes, apartments, vacant buildings, shacks in the forest or even in a van parked on the street.

Vulnerability Assessment

Due to the wide variety of substances that are used, transported, and stored in the area, it is difficult to assign an overall impact of these substances to public health, the environment, the economy, and the infrastructure. Some spills cause minor if any damage to the area. For example, spilling a few gallons of gasoline on concrete during transfer causes minimal economic impact; rarely does the spilled substance cause any environmental impacts. This is not to say that all spills are minor, some can be very harmful to human health and the environment and costs thousands, if not millions of dollars to clean up.

Spills into waterways and those that reach the groundwater are of particular concern due to the threat they impose to drinking water and subsequently public health, the environment, and fauna in the area.

Additionally, transportation-based hazard incidents have the potential to result in cascading impacts. For example, a rail-based incident could isolate a community in Jefferson County as well as several other communities in the region. Officials from such operators as CSX Transportation concur. In a past interview, the company's hazmat manager out of Pittsburgh noted that a significant problem associated with rail incidents, particularly those involving hazardous materials, is that a stopped train can block several roadway intersections, essentially cutting some areas off. These blocks not only hinder evacuation from those areas but also emergency services access to those areas.

Hazardous materials incidents can occur rapidly over a large area. The chemical, physical, and biological properties of hazardous materials pose a potential risk to life, health, the environment, and property when not properly contained.

Many factors determine the impact of a potential incident including quick and solid decision-making by emergency officials, location and type of release, evacuation and shelter-in-place needs, public health concerns, and relevant economic considerations. Additionally, while most incidents are generally brief, the resulting recovery and cleanup may take time to exact.

If evacuation is necessary due to a chemical emergency, road closures and traffic jams may result. If a large-scale evacuation is deemed necessary, it can pose serious long-term economic consequences to the involved population area. A delay in the resumption of industry commerce may cause economic losses for

both business owners and employees. In addition, an evacuation ordered on short notice could cause serious problems for businesses requiring time to shut down specialized equipment.

There is also the monetary impact borne by responding public or private emergency response organizations. These agencies may be challenged by the expenses dictated by a hazardous material release and may need to wait an uncomfortable length of time for the responsible party to reimburse any outstanding costs, further straining the economic resources of the region.

Several emergency preparedness and response plans have been developed with regards to hazardous materials incidents for Jefferson County, including the Jefferson County Emergency Operations Plan and Emergency Support Function (ESF 10) Hazmat Response, and the Jefferson County Commodity Flow Study, 2012 and 2016. Several Extremely Hazardous Substances (EHS) facilities have developed off-Site Emergency Response Plans as well. Upon reviewing the information from the commodity flow study, it was apparent that liquefied petroleum gas presented a risk to several areas in Jefferson County. The update of both the 2016 Hazardous Materials Commodity Flow Study and the Hazardous Materials Response Plan have been included as new mitigation actions in this plan update.

People

Hazardous material releases can contaminate air, water, and soils, possibly resulting in death and/or injuries. Dispersion can take place rapidly when transported by water and wind. While often accidental, releases can occur because of human carelessness, intentional acts, or natural hazards. When caused by natural hazards, these incidents are known as secondary events. Hazardous materials can include toxic chemicals, radioactive materials, infectious substances, and hazardous wastes. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas.

With a hazardous material release, whether accidental or intentional, there are several potentially exacerbating or mitigating circumstances that will affect its severity or impact. Mitigating conditions are precautionary measures taken in advance to reduce the impact of a release on the surrounding environment. Primary and secondary containment or shielding by sheltering-in-place protects people and property from the harmful effects of a hazardous material release. Exacerbating conditions, characteristics that can enhance or magnify the effects of a hazardous material release include:

- **Weather conditions**. Affects how the hazard occurs and develops.
- **Micro-meteorological effects of buildings and terrain**. Alters dispersion of hazardous materials
- **Non-compliance with applicable codes (e.g. building or fire codes) and maintenance failures (e.g. fire protection and containment features).** Can substantially increase the damage to the facility itself and to surrounding buildings.

The severity of the incident is dependent not only on the circumstances described above, but also with the type of material released and the distance and related response time for emergency response teams. The areas within closest proximity to the releases are generally at greatest risk, yet depending on the

agent, a release can travel great distances or remain present in the environment for a long period of time (i.e., centuries to millennia for radioactive materials), resulting in extensive impacts on people and the environment.

A worst-case scenario event of a hazardous material release would be if a release occurred in the most populous areas, such as dense Martinsburg neighborhoods. A hazardous material release would likely cause the evacuation of all nearby residents. Alternatively, a release on a major regional highway, such as I-81, could injure motorists and/or shut down traffic for hours.

The environmental impacts of hazardous material releases include:

- Hydrologic effects – surface and groundwater contamination
- Other effects on water quality such as changes in water temperature
- Damage to streams, lakes, ponds, estuaries, and wetland ecosystems
- Air quality effects – pollutants, smoke, and dust
- Loss of quality in landscape
- Reduced soil quality
- Damage to plant communities – loss of biodiversity; damage to vegetation
- Damage to animal species – animal fatalities; degradation of wildlife and aquatic habitat; pollution of drinking water for wildlife; loss of biodiversity; disease.

A major incident involving significant injuries may severely tax regional medical services, as medical facilities aren't generally designed to handle mass amounts of victims on short notice. Consequently, in the event of a major incident, hospitals and other medical facilities must still be able to provide their customary level of service to all patients, regardless of whether they were incident victims or not.

According to the NRC reports, no incidents were severe. Cost of cleanup for small spills is minimal and is the responsibility of the owner of the facility or transportation.

Structures

Areas that are home to one or more hazardous materials facilities should be considered vulnerable to hazardous materials releases from fixed facilities. Table 3.3.15-1 shows the most significant TRI facilities in Jefferson County. Within a 1.5-mile radius from each TRI facility shown in the table, there are 14,530 structures. This represents about 15 percent of all buildings in Jefferson County. Within a 1.5-mile radius from each TRI Facility listed, there are 221 critical facilities, representing about 26 percent of all critical facilities in Jefferson County. These findings are summarized in Table 33.15-3.

Table 3.3.15-3 Structures and Critical Facilities Vulnerable to Hazardous Materials Release

Jurisdiction	Total Structures	Structures in Hazardous Materials Area	% Structures in Hazardous Materials Area
Jefferson County Unincorporated	93,957	14,530	15%

Bolivar	1,552	0	0%
Charles Town	7,278	4,562	63%
Harpers Ferry	742	0	0%
Ranson	6,912	6,298	91%
Shepherdstown	1,312	0	0%
Jefferson County Total	111,753	25,390	23%

Jurisdiction	Total Critical Facilities	Critical Facilities in Hazardous Materials Area	% Critical Facilities in Hazardous Materials Area
Jefferson County Unincorporated	604	81	13%
Bolivar	6	0	0%
Charles Town	99	83	84%
Harpers Ferry	54	0	0%
Ranson	58	57	98%
Shepherdstown	31	0	0%
Jefferson County Total	852	221	26%

Source: 2021 National Analysis Dataset (updated May 2023, released May 2023), SP&D 1.5 Mile Buffers Zones, & Jefferson County Building Footprints and Address Points (2023)

Many areas of West Virginia are vulnerable to hazardous materials incidents connected directly with oil and gas wells, but according to the WV DEP's Office of Oil and Gas there are no permitted oil or gas operations in the Eastern Panhandle region (TAGIS WV DEP, 2021).

Systems

A hazmat release while in transit is of great concern to the U. S. Department of Transportation. While most hazardous materials are stored and used at fixed sites, these materials are usually produced elsewhere and shipped to the fixed facility by rail car, truck, or onboard ships or barges. These vehicles are identified by signs or placards denoting the hazard. However, the possibility of release is present at any time. Hazardous materials are constantly being moved in West Virginia on interstate highways, the rail system and on shipping lanes in rivers and tributaries.

There are two major agencies that collect data as they relate to hazardous materials incidents the Pipeline and Hazardous Materials Safety Administration (PHMSA) governed by the U.S. Department of Transportation (DOT), and the National Response Center (NRC), governed by the U.S. Coast Guard (USCG).

The types of materials that can cause a hazmat release are wide-ranging and may include chlorine, sodium hydroxide, sulfuric acid, radioactive isotopes, anhydrous ammonia, gasoline and other hydrocarbons, as well as medical/biological waste from hospitals or clinics. Hazardous materials subject to reporting under the Emergency Planning and Community Right-to-Know Act (EPCRA) or Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) include these four groups:

- Extremely Hazardous Substances (EHS) – These are materials with acutely toxic properties that may do irreversible damage or cause death to people or harm the environment when released or used outside their intended use. Examples include ammonia, chlorine, and sulfuric acid.
- Hazardous Substances – These are any materials posing a threat to human health and/or the environment, or any substance designated by the Environmental Protection Agency (EPA) to be reported if a designated quantity of the substance is spilled into the waters of the United States or is otherwise released into the environment.
- Hazardous Chemicals – If present at a chemical facility in certain amounts, these substances require a Material Safety Data Sheet (MSDS) under the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard. Such substances are capable of producing fires and explosions or adverse health effects such as cancer, burns, or dermatitis.
- Toxic Chemicals – Chemicals or chemical categories that appear on the list because of their chronic or long-term toxicity.

In 2016, Jefferson County updated the county commodity flow study (CFS) and included information on highways, railways, and covered facilities. The following is a brief description of the findings of the CFS.

Highway

Approximately 49.2% of the total placarded vehicles recorded were carrying Class 3 (Flammable Liquids). Class 2 (Gases) were the second-most frequently carried materials (30%), followed by Class 8 (Corrosives, 8.3%).

Conclusions drawn from the CFS regarding highways included the following.

- National hazardous material incident trends generally predicted the hazardous materials that would be seen locally.
- Class 3 Flammables are involved in the most incidents nationally and were the most frequently recorded materials in Jefferson County, making up nearly half of all observed placards.
- Class 8 materials were involved in the second most number of highway incidents nationally, but these materials represented only 5% of observed placards in Jefferson County.
- Class 2 materials are involved in the third most highway incidents nationally and are the second most prevalent materials observed in Jefferson County.
- Gasoline (UN 1203) was the single-most recorded material in the study. Though a multitude of materials was observed during the study, the highway analysis alone suggests that local responders should primarily prepare for incidents involving flammable liquids, gases, and Class 9 materials.
- Commodity flow studies are significantly affected by the time of day, week, and even year in which they are conducted (i.e., monitoring the study area one week earlier or later could yield different results based on the shipping schedules and needs of covered facilities).

Table 3.3.15-4 Highway Risk Analysis Summary		
Roadway Name	**Miles in Jefferson County**	**Accidents with Placarded Loads per Year**
U.S. Route 340	32.38	0.425
State Route 9	15.8	0.147
State Route 45	2.58	0.009
State Route 115	4.13	0.011
State Route 51	8.81	0.012

Source: Jefferson County CFS (2016)

Railway

Due to the low probability of rail accidents involving hazardous materials and the past track record of very few hazmat rail accidents, Jefferson County is much more likely to experience a hazardous material event due to a roadway accident rather than to a rail accident. A significant number of materials transported by rail in Jefferson County are passing through the county, and not bound for a facility within the jurisdiction. Half of the materials listed are found only in the rail analysis.

Covered Facilities

Materials reported as part of the covered facilities analysis represent all hazard classes. Further, given the frequency of shipment information provided by covered facilities, it becomes clear that shipments of some materials could only be observed if field reconnaissance was completed for months or even up to a year. As such, it can be assumed that emergency responders should plan and prepare for hazardous material incidents from any hazard class.

Resources & Community Activities

It is more cost-effective to assess potential effects from a disaster and to implement preventative measures than to wait for a disaster to strike and then assess actual impacts. Determining which resources and community activities that are likely to be damaged in a disaster and applicable protection measures is advisable. This can be somewhat challenging with certain hazards that do not have a defined hazard area, as is the case with the transportation of hazardous materials. However, transporting hazardous materials means meeting strict safety standards and regulations set forth by the Federal Motor Carrier Safety Administration and OSHA. Minimizing exposure to populated areas during the transport of hazardous materials can mitigate impacts to people and property in the event of a spill. Natural, historic, and cultural resources along transportation corridors may be at-risk, chemical transported dependent, to a hazmat incident. Both evacuation procedures and shelter-in-place emergency messaging for potential hazmat incidents are in-place in Jefferson County.

National Register of Historic Places located within the 1.5-mile radius of the significant (5) TRI facilities.

Table 3.3.15-5 National Register of Historic Places Vulnerable to Hazardous Materials Release	
TRI Facility	**Historic Building Name**
US CBP Advanced Training Center	Allstadt House and Ordinary

440 Koonce Road Harpers Ferry, WV, 25425	Halltown Colored Free School
	Halltown Union Colored Sunday School
Rockwool USA 665 Northport Avenue Kearneysville, WV, 25430	Hazelfield
	Tackley Farm
Ox Paperboard LLC 164 Eyster Rd Harpers Ferry, WV, 25425	Beall-Air
	Halltown Colored Free School
	Halltown Union Colored Sunday School
	Rion Hall
Griffith Energy Services Inc. 110066 Middleway Pike Charles Town, WV, 25414	Charles Town Mining, Manufacturing, & Improvement Company Building
	Gibson--Todd House
	Jacks-Manning Farm
	Jefferson County Courthouse
	New Opera House
	Charles Washington House
	Robert Worthington House
UFP Ranson LLC 249 16th Avenue Ranson, WV, 25438	Aspen Hill
	Charles Town Mining, Manufacturing, & Improvement Company Building
	Jefferson County Courthouse
	New Opera House

Source: 2021 National Analysis Dataset (updated May 2023, released May 2023), SP&D 1.5 Mile Buffers Zones, & 2020 National Register of Historic Buildings (Note: most recent update of National Register of Historic Buildings was in 2020.)

3.3.16 Terrorism

Location and Extent

This profile is intentionally generalized. Jefferson County Homeland Security and Emergency Management (JCHSEM) have identified a number of potential terrorist-related targets throughout the county and maintain files of such information separately from this document.

Terrorist attacks can occur anywhere. The term "terrorism" refers to intentional, criminal, malicious acts, but the functional definition of terrorism can be interpreted in many ways. Officially, terrorism is defined in the Code of Federal Regulations as "the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives" (28 CFR §0.85).

Acts of terrorism include threats of terrorism; assassinations; kidnappings; hijackings; bomb scares and bombings; cyber-attacks (computer-based attacks); and the use of chemical, biological, nuclear, and radiological weapons (FEMA 2009). An important consideration in evaluating terrorism hazards is the existence of facilities, landmarks, or other buildings of international, national, or regional importance. Several federal government buildings and Harper's Ferry, a significant landmark in terms of national importance are located in Jefferson County. Threats against the agricultural community and major transportation corridors, however, could be potential terrorist targets. The Eastern Panhandle could also be impacted by terrorism due to its proximity to the National Capital Region, which is one of the most target-rich areas of the country. Should a terrorist strike the National Capital Region, the region could see a mass influx of residents evacuating the area and major highways such as I-81 could become impassable due to the volume of traffic. The region could also suffer the indirect economic effects of the incident as many residents work in or close to D.C.

Any acts of terrorism can occur anywhere at any time of day. The National Terrorism Advisory System (NTAS) communicates information about terrorist threats by providing detailed information to the public, government agencies, first responders, airports and other transportation hubs, and the private sector. When there is a threat, an NTAS Alert will be announced by the Secretary of Homeland Security and will be shared with the public. It may include specific information about the nature of the threat, including the geographic region, mode of transportation, or critical infrastructure potentially affected, as well as steps that individuals and communities can take to protect themselves and help prevent, mitigate or respond to the threat. The alert indicates whether the threat is elevated or imminent. Elevated threats are when there is no specific information about the timing or location. Imminent threats are when it is believed the threat is impending or very soon. The alerts will be posted online and released to the news media for distribution. The United States Department of Homeland Security (USDHS) will also distribute alerts through its social media channels (USDHS 2013).

Possible Causes

There is no single cause of acts of violence; it is typically a non-rational, complicated, intertwined, series of reasons that have the outcome of violence. In his article Causes of Terrorism, Nick Grothaus lays out

the most common causes cited by leaders in the field of counterterrorism. These categories may apply to other types of violence not related to terrorism.

- **Ethno-Nationalism:** The desire of a population to break away from a government or ruling power and create a state of their own.
- **Alienation/Discrimination:** Individuals or groups face discrimination leading to further feelings of isolation. These people may become jaded towards society and feel excluded.
- **Religion:** Religion as a part of terrorism has been mainly attributed to Islamic fundamentalism although other religions have also had involvement in terrorist activities. For example, Christian Fundamentalists target abortion clinics, the Aryan Nation and the Church of Christ, Christians target the Jews and minorities (Post, 2007, pp. 211-212).
- **Socio-Economic Status:** Individuals and groups may be driven by a sense of relative depravation and lack of upward mobility within society.
- **Political Grievances:** A lack of political inclusiveness or grievances against a certain political order may cause individuals to join or create terrorist groups.

Range of Magnitude

The term "terrorism" refers to intentional, criminal, and malicious acts, but the functional definition of terrorism can be interpreted in many ways. The Federal Bureau of Investigation (FBI) classifies terrorism into two categories (FBI, 2022a):

- **International terrorism:** Violent acts committed by individuals and/or groups inspired by or associated with designated foreign terrorist organizations or nations (statesponsored), and
- **Domestic terrorism:** Violent, criminal acts carried out by individuals and/or groups to further ideological goals stemming from domestic influences, such as those of a political, religious, social, racial, or environmental nature

FEMA defines the three main goals of terrorism as causing public fear, convincing citizens that the government cannot protect against terrorism, and making the motivating causes known to the public. Terrorist attacks can take many forms. FEMA identifies the following as some of the common tactics of terrorism (FEMA, n.d.a):

- Agriterrorism—food contamination or destruction of crops via pest introduction or disease agents
- Arson/incendiary attack
- Armed attack
- Assassination
- Biological agent
- Chemical agent
- Cyberterrorism

- Conventional bomb
- Hijackings
- Intentional hazardous material release
- Kidnapping
- Nuclear bomb
- Radiological agent

The West Virginia State Fusion Center defines eight signs of Terrorism (West Virginia Fusion Center, 2023):

- **Surveillance:** Someone recording or monitoring activities. This may include the use of cameras, note taking, drawing diagrams, annotating on maps, or using binoculars or other vision-enhancing devices.
- **Elicitation:** People or organizations attempting to gain information about operations, capabilities, or people. Elicitation attempts may be made by mail, email, telephone, or in person. This could also include eavesdropping or friendly conversation.
- **Tests of Security:** Any attempts to measure reaction times to security breaches, attempts to penetrate physical security barriers, or monitor procedures in order to assess strengths and weakness.
- **Funding:** Suspicious transactions involving large cash payments, deposits, or withdrawals. Collections for donations, the solicitation for money, and criminal activity are common signs of terrorist funding.
- **Supplies:** Purchasing or stealing explosives, weapons, ammunition, etc. This also includes acquiring military uniforms, decals, flight manuals, passes or badges (or the equipment to manufacture such items), and any other controlled items.
- **Impersonation:** People who do not seem to belong in the workplace, neighborhood, business establishment, or anywhere else.
- **Rehearsal:** Putting people in position and moving them around according to their plan without actually committing the terrorist act.
- **Deployment:** People and supplies getting into position to commit the act. This is the person's last chance to alert authorities before the terrorist act occur.

The severity of terrorist incidents depends upon the method of attack, the proximity of the attack to people, animals, or other assets and the duration of exposure to the incident or attack device. For example, chemical agents are poisonous gases, liquids or solids that have toxic effects on people,

animals, or plants. Many chemical agents can cause serious injuries or death. In this case, severity of injuries depends on the type and amount of the chemical agent used and the duration of exposure.

Biological terrorist incidents have a somewhat low probability of occurring in Jefferson County. These incidents include the release of diseases such as smallpox into the general population for destructive purposes. Biological events have an extremely high risk associated with them, as the effects of such an event can exceed the capabilities of the healthcare facilities located in Jefferson County and the loss of human life can be disastrous. While preparedness is improving, Jefferson County is not equipped on the local level to cope with a large-scale terrorist incident.

Chemical terrorist incidents are comparable to biological incidents in that they have a relatively low probability of occurring, yet are associated with an extremely high risk. Chemical incidents include the use of weapons that subject the general population to toxic chemicals similar to those that could be released during a hazardous materials incident. Chemical incidents are capable of subsequent losses to large percentages of the population. Jefferson County does contain public water systems, which makes the threat of small-scale biological and chemical attacks plausible.

Events involving explosive Weapons of Mass Destruction (WMDs) also have a relatively low probability of occurring in Jefferson County. However, in the event that a nuclear or other large explosive device was to discharge in or near the county, the inherent loss of life could be catastrophic. A WMD threat is ever present and the reduction of such threat is dependent upon the actions of other countries, which are unpredictable. As long as there are weapons, and the capability to deliver those weapons, the threat will remain. The Department of Defense estimates that as many as 26 nations may possess chemical agents and/or weapons and an additional 12 may be seeking to develop them.

Railroad facilities are another example of potential terrorist targets. Dams and water and sewage treatment facilities are likewise potential targets. Facilities in neighboring counties may also be susceptible to WMD-type attacks and may affect Jefferson County indirectly.

There are also several SARA Title III facilities and a few major transportation routes that traverse the region; making intentional hazardous material releases a potential threat to citizens and the environment. This hazard is addressed in Section 3.3.18. Critical facilities including police stations, hospitals, fire stations, schools, wastewater treatment plants, and water supply facilities, may be potential terrorist targets.

A terrorism event can cause public fear regarding the use of mass transportation or leaving their homes in the event of a biological or nuclear attack. Communication systems, both public and private, can fail because of an overwhelming amount of usage or damage to its infrastructure. Healthcare facilities can become quickly inundated and must be prepared to triage injured patients, handle mass casualties, and conduct decontamination operations.

The secondary hazards resulting from a terrorist attack depend on the size and scope of the incident. Some possible secondary hazards include widespread utility failure, health effects such as epidemics or pandemics, flooding (if a dam was destroyed), and environmental contamination. Also of concern is the disruption an attack may cause to the State's government facilities.

Past Occurrence

Nathan Clark, 25, was arrested in Charles Town, West Virginia, on August 12, 2019, after someone alerted authorities to posts Clark allegedly made online threatening to kill people. Authorities were alerted after someone allegedly found threatening comments Clark made online saying he was going to kill people. After a thorough investigation, Clark was charged with making terroristic threats. During the investigation, several PVC pipes and pistols were also confiscated at Clark's home. (https://www.dcnewsnow.com/news/local-news/west-virginia/charles-town-man-arrested-for-alleged-terror-threats/).

Future Occurrence

The probability of terrorism occurring cannot be quantified with as great a level of accuracy as that of many natural hazards. Furthermore, these incidents generally occur at a specific location, such as a government building, rather than encompassing an area such as a floodplain. Thus, planning should be asset-specific, identifying potentially at-risk critical facilities and systems in the community. Once a comprehensive list of critical assets has been developed, it should be prioritized so that efforts can be directed to protect the most important assets first. Then, beginning with the highest-priority assets, the vulnerabilities of each facility or system to each type of hazard should be assessed.

For the purpose of developing a realistic prioritization of terrorism hazard mitigation projects, three elements should be considered in concert:

- Relative importance of the various facilities and systems in the asset inventory
- Vulnerabilities of those facilities
- Threats that are known to exist

Critical assets and infrastructures are systems whose incapacity or destruction would have a debilitating effect on the county:

- Emergency services
- Government services
- Water supply systems
- Transportation networks
- Telecommunications infrastructure
- Electrical power systems
- Gas and oil facilities

Vulnerability Assessment

Since the probability of terrorism occurring cannot be quantified in the same way as that of many natural hazards, it is not possible to assess vulnerability in terms of likelihood of occurrence. Instead, vulnerability is assessed in terms of specific assets. By identifying potentially at-risk terrorist targets in a community, planning efforts can be put in place to reduce the risk of attack. All communities in Jefferson County are vulnerable on some level, directly or indirectly, to a terrorist attack. However, communities where specific potential targets are located should be considered more vulnerable. FEMA's Integrating

Manmade Hazards into Mitigation Planning (2003) encourages site-specific assessments that should be based on the relative importance of a particular site to the surrounding community or population, threats that are known to exist and vulnerabilities including:

Inherent Vulnerability

- Visibility – How aware is the public of the existence of the facility?
- Utility – How valuable might the place be in meeting the objectives of a potential terrorist?
- Accessibility – How accessible is the place to the public?
- Asset mobility – is the asset's location fixed or mobile?
- Presence of hazardous materials – Are flammable, explosive, biological, chemical and/or radiological materials present on site? If so, are they well secured?
- Potential for collateral damage – What are the potential consequences for the surrounding area if the asset is attacked or damaged?
- Occupancy – What is the potential for mass casualties based on the maximum number of individuals on site at a given time?

Tactical Vulnerability

Site Perimeter

- Site planning and Landscape Design – Is the facility designed with security in mind – both site-specific and with regard to adjacent land uses?
- Parking Security – Are vehicle access and parking managed in a way that separates vehicles and structures?

Building Envelope

- Structural Engineering – Is the building's envelope designed to be blast-resistant? Does it provide collective protection against chemical, biological, and radiological contaminants?

Facility Interior

- Architectural and Interior Space Planning – Does security screening cover all public and private areas?
- Mechanical Engineering – Are utilities and HVAC systems protected and/or backed up with redundant systems?
- Electrical Engineering – Are emergency power and telecommunications available? Are alarm systems operational? Is lightning sufficient?
- Fire Protection Engineering – Are the building's water supply and fire suppression systems adequate, code-compliant, and protected? Are on-site personnel trained appropriately? Are local first responders aware of the nature of the operations at the facility?
- Electronic and Organized Security – Are systems and personnel in place to monitor and protect the facility?

Sites that may potentially be vulnerable to terrorist attacks include the following:

The West Virginia Fusion Center also exists to provide resources, expertise, and information to the center with the goal of maximizing the ability to detect, prevent, investigate, and respond to criminal and terrorist activity. Intelligence processes through which information is collected, integrated, evaluated, analyzed, and disseminated are a primary focus. Data fusion involves the exchange of information from different sources including law enforcement, public safety, and the private sector. Relevant and actionable intelligence results from analysis and data fusion. The fusion process helps agencies be proactive and protect communities.

3.3.18 Cyber Terrorism

Cyber terrorism is a broad term that refers to acts associated with the convergence of terrorism and cyberspace. Generally, cyber terrorism involves unlawful attacks or threats against computers, networks, and the information stored therein to intimidate or coerce a government or its people to achieve political or social objectives (Denning, 2000). These acts can range from taking control of a host website, to using networked resources to directly cause destruction and harm.

The Cyber Security and Infrastructure Security Agency web page maintains that cyber-attacks can come in many forms. Malware, Phishing, and Ransomware are becoming increasingly common forms of attack and can affect individuals and large organizations. Malware is any software used to gain unauthorized access to IT systems in order to steal data, disrupt system services or damage IT networks in any way. Ransomware is a type of malware identified by specified data or systems being held captive by attackers until a form of payment or ransom is provided. Phishing is online scam enticing users to share private information using deceitful or misleading tactics. CISA offers a variety of tools and resources that individuals and organizations can use to protect themselves from all types of cyber-attacks.

CISA is constantly monitoring cyberspace for new forms of malware, phishing, and ransomware. Offer numerous tools, resources, and services to help identify and protect against cyber-attacks. CISA also collaborates with governments at all levels as well as internationally and private sector entities to share information and collaborate in securing our networks on national and global scales. Defending against cyber-attacks requires coordination across many facets of our nation, and it is CISA's mission to ensure we are armed against and prepared to respond to ever-evolving threats.

Location and Extent

Cyber-attacks may not always constitute acts of cyber terrorism because some acts may have relatively small impacts and only produce annoyances. A cyber-attack is generally considered an act of cyber terrorism when the following motivations are present:

- **Effects-based:** When computer attacks result in effects that are disruptive enough to generate fear comparable to a traditional act of terrorism.
- **Intent-based:** When unlawful or politically motivated computer attacks are done to intimidate or coerce a government or people to further a political objective, or to cause grave harm or severe economic damage (Rollins and Wilson, 2007).

Cyber-attacks can be further divided into the following categories based on the complexity of the attack:

- **Simple-Unstructured:** Simple-unstructured attacks are the most common. These are amateurish attacks with relatively minimal consequences.

- **Advanced-Structured:** Advanced-structured attacks are more sophisticated and consequential and have a greater emphasis on targeting victims prior to an attack, resulting in a more debilitating effect.

- **Complex-Coordinated**: Complex-coordinated attacks are the most advanced and most troublesome type of attacks where success could mean a network shutdown (Denning, 2000).

Cyber terrorism can cause severe disruptions to transportation, public safety, and utility services, all of which are critical infrastructure that are highly dependent on information technology. Cyber terrorism can take many forms, including attacks through physical means, electronic means, and use of malicious code. Cyber terrorists can also have a wide range of personal, political, or cultural agendas. All state agencies, as well as individuals, businesses, and other institutions in the region, are potential targets for cyber terrorism. Potential threats include identity theft, loss of sensitive information, disruption of services, and other malicious activity.

Cyber terrorists can be difficult to identify because the internet provides a meeting place for individuals from various parts of the world. Individuals or groups planning a cyber-attack are not organized in a traditional manner, as they are able to effectively communicate over long distances without delay. Cyber-attacks are also unpredictable and typically occur without warning.

Past Occurrences

During the COVID-19 Pandemic of 2020-2021, more than 50,000 West Virginians received attempted unemployment scam in their mail or email. Scott Adkins, acting commissioner with Workforce West Virginia, said they received more than 50,000 fraudulent claims based around the Pandemic Unemployment Assistance (PUA) program (WSAZ 3, 2020). Many attacks seemed to stem from credit bureau data breaches that exposed personally identifying details, and public officials sought to shore up government defenses to avoid agencies falling to such a breach themselves. This led to the creation and signing by Governor Jim Justice of the Creating WV Cyber Incident Reporting Bill. The legislation is designed to lay the groundwork for tightening up cyber defenses and enable faster response to threats by helping state officials better understand the scope of problems impacting various agencies, learn about attacks soon after they happen, and regularly review defense strategies (Patterson-Gordon, 2021).

On May 7, 2021, the Colonial Pipeline suffered a ransomware attack that impacted equipment managing the pipeline. In response, the Colonial Pipeline Company halted all the pipeline's operations. This caused gas shortages across the east coast, with some (limited) effects in West Virginia. This was the largest cyberattack on an oil infrastructure target in the history of the United States.

Another large-scale attack was the Equifax data breach in 2017, which was estimated to potentially impact over 700,000 residents of West Virginia and over 145.5 million nationally. The information accessed included names, Social Security numbers, birthdates, addresses, and driver's license numbers (WHSV,

2019). Additionally, in 2014 the largest data breach in history impacted over 3 billion Yahoo user accounts, including the names, email address, date of birth, and telephone numbers of over 500 million users (CSO, 2018). In terms of a data breach cyber-attack, this could be considered a worst-case scenario event. Large-scale data breach events are becoming more common.

Locally, the Jefferson County Commission experienced a cybersecurity event in December 2022. The Jefferson County Department of Information Technology took immediate action to isolate the impacted system, execute the department's cybersecurity protection protocols, and restrict any further unauthorized activity.

Per West Virginia State Code, this incident was reported to the WVOT in addition to the relevant federal and state law enforcement authorities for further investigation. No personal information was compromised, and Jefferson County residents experienced no disruption of County services.

In addition to large-scale acts of cyber terrorism, smaller cyber-attacks occur daily. Billions of emails are sent each day, and spam and phishing emails account for a significant share of all email traffic. Additionally, brute force attacks, which are trial and error attempts to obtain user passwords and pins, are frequently used by criminals attempting to crack encrypted data or gain access to private accounts. Firewalls can be effective at keeping security threats such as these out, but once a cybercriminal gains access to a system, they can attack from within. For example, gaining access to a state employees email account would allow a hacker to send additional phishing emails from within a network, which may not be as monitored as closely as attacks from outside the system. This is known as spear phishing.

Future Occurrences

Cyber terrorism is an emerging hazard that has the potential to impact the region's computer infrastructure and the systems and services that are provided to the public. Concerns about cyber terrorism throughout the United States are growing as its impacts could have potentially crippling effects. Security experts describe the threat of cyber terrorism as imminent.

West Virginia Office of Technology website details mitigation tactics that individuals and business owners can take to prevent breaches in cybersecurity, including daily cybersecurity tips and presentations (WV Office of Technology, 2021).

Range of Magnitude

In recent years, cyber terrorism has become a significant threat and can impact people, businesses, institutions, local governments, and state agencies to varying degrees. Impacts from a large-scale cyber terrorism event could disrupt the state's economy and potentially threaten its economic stability. The magnitude of a cyber terrorism attack will vary greatly based on the extent of systems affected and duration of the impact. Additionally, the magnitude will vary based upon which specific system is affected by an attack, the ability to preempt an attack, and an attack's effect on continuity of operations. The largest threat to institutions from cyber terrorism comes from any processes that are networked and

controlled via computer. The county and individual municipalities should address and take measures to reduce any vulnerabilities that could allow access to sensitive data or processes.

The West Virginia Office of Technology (WVOT) developed Executive Branch security standards, policies, and procedures for use by Executive Branch agencies, as well as to provide best practices guidelines for all other State and local organizations. With these policies in hand, agencies, with the assistance of the WVOT, develop their own procedures as needed. In addition, supplemental documents covering topics that are not included in the umbrella documents, or those that treat the same matters more stringently, are acceptable.

Under WVOT the West Virginia Cyber Security Office is charged with enhancing the overall information security posture of the Executive Branch of West Virginia State Government. The mission of the CSO is to support the goals of the State by assuring the availability, integrity, and appropriate confidentiality of information. Primary objectives include the development and implementation of proactive measures to prevent security problems, as well as an effective response to security incidents when those prevention methods are defeated. The CSO encompasses three main categories: information security management, risk management, and incident handling.

Goals

- Maintain compliance with legal regulatory requirements
- Implement practical measures to protect the State's data and systems from compromise
- Adopt best practices in order to safeguard all forms of information

WVOT And the Cyber Security Office is charged with a series of activities:

Technology Audits

Audit efforts are focused on areas presenting the highest degree of risk, and where risk mitigation will provide the greatest potential benefit to the Executive Branch. The Audit Program also reviews internal controls within the WVOT operations and will conduct audits of selected 3rd party providers at their off-site locations.

Technology Policies

The WVOT has created a general security policy, and other security-related policies and procedures, for the Executive Branch of West Virginia government. Agencies may establish more stringent policy supplements, but duplication of content should be avoided. Each agency developing a security policy supplement must submit it to the WVOT for review/approval.

Information Security Training

The State of West Virginia utilizes a learning management system to deploy required, security and privacy training to all employees of the Executive Branch. Electronic security tips and awareness videos are released on a regular basis.

Security Operations Center (SOC)

- Traffic analysis, event correlation
- Threat analysis and alerts
- Vulnerability scanning of state network
- Web activity monitoring and site blocking
- Network violation management
- Support OISC Audit program

Computer Security Incident Response Team (CSIRT)

Maintains policies and procedures for incidents, maintain central point of contact for reporting incidents, and complete professional digital forensic investigations.

Vulnerability Assessment

People

All communities in Jefferson County are vulnerable on some level, directly or indirectly, to a cyber terrorism attack. However, in general, areas with higher concentrations of government or industry facilities may have higher risk.

Structures

All county and municipal facilities are vulnerable to cyber terrorism. While the physical structures of these buildings are generally not at risk, information systems and data stored within them are vulnerable. Government computer networks contain sensitive information that is integral to the security of the State and could be the target of a cyber-attack.

Systems

County and municipal governments possess and maintain resident personal and financial information, including tax filings, birth and death records, Social Security numbers, medical information, and more. Additionally, many critical facilities that are essential to Jefferson County's operations are reliant upon computer networks to monitor and control critical functions. For example, an attack on internet access or the power grid could have detrimental impacts on county services and functions. Additionally, a large-scale computer breach could lead to economic costs in lost productivity to the impacted agency/organization and potentially related businesses and industries. However, lost revenues and productivity would depend on the type of magnitude of the cyber terrorism event.

Resources and Community Activities

Generally, cyber terrorism has no direct effect on the environment; however, the environment may be affected if a hazardous materials release occurred because of critical infrastructure failure as a result of cyber terrorism. Similarly, an act of cyber terrorism on a nuclear facility could have devastating environmental consequences if the plant suffered an intentional catastrophic failure.

West Virginia is among the top 10 states nationwide to offer foundational computer science courses to public school students. West Virginia is a pioneer in creating a computer science K-12 pathway for all students. Governor Jim Justice signed Senate Bill 267 in 2019, which charged the WVDE with reaching all public-school students with computer science. This law makes the Mountain State one of the first to require all students to start their computer science education in elementary school and be exposed to a variety of computer science experiences throughout their K-12 career.

Local events:

https://www.dcnewsnow.com/news/local-news/west-virginia/jefferson-county-contracts-for-cyber-security-monitoring/

3.3.19 Utility Interruption

Location and Extent

Utility interruptions include any impairment of the functioning of telecommunication, gas, electricity, water, or waste networks. Interruptions or outages occur because of geomagnetic storms, fuel or resources shortage, electromagnetic pulses, information technology failures, transmission facility or linear utility accident, and major energy, power, or utility failure. The focus of utility interruptions as a hazard lies in fuel, energy, or utility failure. These kinds of interruptions rarely spontaneously occur on their own; this hazard is often secondary to other natural hazard events, particularly transportation crashes and incidents, lightning strikes, extreme heat or cold events, and coastal and winter storms. The causes for outages are usually downed power wires or utility poles as a result of inclement weather or vehicle incidents. Additionally, outages can be caused by blown transformers or tripped circuit breakers. Most often, there is no cause reported and power is restored within the hour.

Utility interruptions in Jefferson County occur regularly but are usually small-scale, localized incidents. Utility interruptions are possible anywhere there is utility service. Table 3.3.19-1 lists the major utility companies in the region. Utility interruptions and power failures can take place throughout the region.

Table 3.3.19 -1 Major Utility Companies in Jefferson County

Company Name	Type of Utility
First Energy, Potomac Edison	Electricity
Mountaineer Gas Company	Natural Gas
AmeriGas Propane	Propane Gas
Roach Energy	
ThompsonGas – Bel Air& Huntfield	
Blossman Gas	
Shawley's LP Gas	
Suburban Propane	
Verizon	Telecom
Frontier Communications	
Xfinity - Comcast Cable	

Source: JCHSEM, 2023

According to the 2021 5-year American Community Survey, in Jefferson County, 72.0 percent of housing units use electricity as their heat source, followed by 11.1 percent of homes using propane gas for heat. (ACS S2504). As a result, an interruption in any of those utilities could affect a significant number of residents. In addition, an increasing reliance on internet access and telecommunications could also impact many residents at any given time.

Past Occurrence

According to the State of West Virginia 2023 Hazard Mitigation Plan, Section 5.14 Utility Failure, between 2010 and 2022, a total of 12 utility failure events occurred across the state. These failures were due to various hazard events including thunderstorm wind, blizzards, high wind, extreme cold, flash flood, flood, and winter storm.

Jefferson County has a hazard history of utility interruptions as shown on Table 3.3.19-2. The table shows a sample of power outage events in the area reported in the National Centers for Environmental Information. It is not a comprehensive list, but it does represent the impact of recent utility interruptions.

Table 3.3.19-2 Recent Utility Interruptions in Jefferson County (2015-July 2023)

Date	Cause	Location	Narrative
7/5/2017	Tornado	Charles Town	The National Weather Service in Baltimore MD/Washington DC confirmed a weak tornado near Charles Town in Jefferson County WV on July 05 2017. Debris from the roof of one barn was thrown into power lines, snapping a telephone pole. Projectile impacts were also noted in nearby barn roofs from two- by-four pieces of wood that were lofted by the tornado
6/29/2019	Thunderstorm Wind	Charles Town	A tree was blown down near the intersection of Oak Lee Drive and Jack Rabbit Lane. Power lines were also blown down in the 1500 block of Flowing Springs Road.
7/6/2020	Thunderstorm Wind	Charles Town	Numerous trees and power lines were blown down in Shenandoah Junction, mainly along Daniels Road and Shenandoah Junction Road. Some trees were snapped.
7/6/2020	Thunderstorm Wind	Bolivar/Harpers Ferry	Multiple trees and power lines blew down in the Harpers Ferry area.
9/3/2020	Thunderstorm Wind	Kearneysville	A tree blew down onto power lines near the intersection of WV-480 Kearneysville Pike/Duke Street and WV-48/1 Persimmon Lane.
5/3/2021	Tornado	Charles Town	
5/26/2021	Thunderstorm Wind	Charles Town	A dozen power poles blew down on Middleway Pike just west of Charles Town. A tree and wires blew down on 4th Street in Charles Town. Two trees blew down on East Washington Street in Charles Town.
8/13/2021	Thunderstorm Wind	Bar Dane	A power pole snapped as the result of a falling tree near the intersection of Charles Town Road and East Burr Boulevard.
7/15/2023	Thunderstorm Wind	Ranson	An isolated line of thunderstorms Friday evening in Jefferson County caused widespread damage and a host of problems for residents and emergency responders. The calls were for downed trees, live powerlines, and five separate structure fires. Calls came for a transformer fire in Ranson.

Source: National Centers for Environmental Information, July 2023; MetroNews

Future Occurrence

Utility interruptions will continue to occur annually with minimal impact. Widespread utility interruption events usually occur approximately once every five years, usually as a secondary effect of an extreme

weather event. These interruptions should be anticipated, and first responders should be prepared during severe weather events. Research by the National Oceanic and Atmospheric Administration (NOAA) suggests that climate change may cause more extreme storms in West Virginia (Climate.gov, 2021).

Power outages can be expected at any time of year, on a nearly monthly basis. Iced power lines; falling tree limbs due to ice, wind, or lightning strikes; and vehicle incidents damaging power lines, or their support poles can all be reasons for power outages.

The region around Jefferson County is expected to see large increases in precipitation and numbers of very hot and very cold days (Climate Central, 2022). These factors can increase the occurrence of hazards such as flooding, hurricanes and tropical storms, landslides, tornados and windstorms, wildfires, and winter storms. Impacts from any of these hazards can lead to utility interruption on a range of scales. Overall, the probability of future utility outages impacting the region can be considered *highly likely* according to the Risk Factor Methodology (see Table 4.4.1-1).

Aging infrastructure also brings risk in the form of potential utility interruptions, particularly for places like Jefferson County with aging infrastructure. In many utility systems, significant portions of the equipment and facilities date from the growth periods of the 1950s and 1960s that followed World War II. As this equipment ages, it deteriorates from the constant wear and tear of service. Eventually the equipment reaches a point at which it will either fail on its own or because of outside forces (storms, loads it was designed to handle but no longer can, etc.). These failures cause service interruptions and can require expensive emergency repairs. In addition, as repairs have taken place along transmission routes, there is often a mix of new and old equipment along the line, as repair and not replacement is generally the choice made to resolve an issue.

The wholesale replacement of a system is not a feasible solution for utility companies. This would require the interruption of services while the replacement occurs, as well as accessing the existing system (which may lie under roads, private property, or other inconvenient places). Utility companies face the challenge of managing the issue of the aging infrastructure. They are tasked with reducing the effects of aging equipment while also controlling the deterioration of the existing system as much as possible. This balance will be tenuous as transmission equipment continues to age and break down. These breakdowns will likely lead to more frequent utility disruptions as time goes by.

Range of Magnitude

The most severe utility interruptions will be regional or widespread power and telecommunications outages. With the loss of power, electrically powered equipment and systems will not be operational. Examples may include lighting; HVAC and ancillary support equipment; communication (i.e., public address systems, telephone, computer servers, and peripherals); ventilation systems; fire and security systems; refrigerators, sterilizers, trash compactors, office equipment; and medical equipment. This can cause food spoilage, loss of heat or air conditions, basement flooding (sump pump failure), lack of light, loss of water (well pump failure), lack of phone service, or lack of internet service. However, this is most often a short-term nuisance rather than a catastrophic hazard.

The severity of a utility interruption can be compounded with extreme weather events, especially winter weather events. Interruptions can also be more severe for special needs populations that are dependent on electronic medical equipment. Utility interruptions can significantly hamper first responders in their efforts to provide aid in a compound disaster situation, especially with losses of telecommunications and wireless capabilities. Telecommunications interruptions will also hinder first responders' efforts. Additionally, an internet outage could be crippling to the economy, as many companies and government entities process payments and invoices electronically rather than with cash or physical checks.

In a possible worst-case scenario for Jefferson County, a winter storm event could cause widespread power outages, leaving citizens without heat in the midst of subzero temperatures for several days. The power outage would also put elderly populations or others at risk of health problems due to the lack of heat and the inability to call for assistance or leave their homes. Power lines could also be difficult to repair depending on the magnitude of the storm. A power outage during the summer could also have serious consequences for much the same reason. During the summer the temperatures in Jefferson County can occasionally exceed 100°F, and with no air conditioning this can put elderly and other vulnerable populations in danger of dehydration, heat exhaustion, or heat stroke.

Vulnerability Assessment

All jurisdictions are vulnerable on some level to utility interruptions, but because this hazard often occurs in conjunction with other hazards, jurisdictions that have been identified as more vulnerable to winter storms, windstorms, tornado, flooding, and other natural hazard events may be more vulnerable to a utility interruption.

People

All of Jefferson County and its municipalities are exposed to utility failure. Residents might be displaced or require temporary to long-term sheltering due to interruptions to their daily lives as a result of utility failure. Loss of utilities to support access to heating, cooling, and potable water can result in increased health impacts. The population adversely affected by utility failure may also include those beyond the disaster area that rely on communication lines or water lines that run through the state.

According to the State of West Virginia 2023 Hazard Mitigation Plan, socially vulnerable populations may be impacted at a disproportionately higher rate than the rest of the population. Individuals that are socially vulnerable may have increased medical needs, which can be exacerbated due to overheating, heatstroke, or hyperthermia. Power failure leading to loss of heating and cooling in homes could exacerbate these health risks. Additionally, socially vulnerable individuals dependent upon electric-powered medical equipment could face severe impacts, including loss of life. Economically disadvantaged residents are at high risk for bracing intense cold and hot conditions because of the potential inability to afford backup generators, which may pose health issues, such as hypothermia or heat stroke (WV State HMP, 2023).

Structures

Emergency medical facilities, including retirement homes and senior centers are particularly vulnerable to power outages. While back-up power generators are often used at these facilities, loss of electricity may result in hot or cold temperatures for which elderly populations are particularly vulnerable. Conservation and improved technology have resulted in more efficient use of energy sources. The increasing use of alternative fuel supplies, such as kerosene heaters, wood burning stoves, coal burners, etc., has also decreased our vulnerability to future shortages. However, severe weather extremes, accidents, labor strikes, terrorism, or nationwide shortages could cause significant energy shortage problems. Emergency management officials can reduce vulnerability to utility interruption through training and exercises, such as the "Dark Grid" exercise, which prepares emergency responders and community leaders for a coordinated response to widespread utility interruptions.

In addition, all critical facilities are vulnerable to utility interruptions, especially the loss of power. The establishment of reliable backup power at these facilities is extremely important to continue to provide for the health, safety, and well-being of Jefferson County and its citizens.

Systems

Figure 3.3.19-1 Transformer Fire in Jefferson County 7/15/23 (MetroNews, 2023)

The region is also well known to have many areas with limited cellular and broadband access. Areas of concern are the rural portions of Jefferson County. The West Virginia Broadband Council provides Broadband Mapping Data and Resources (https://broadband.wv.gov/broadband-development-hub/). The West Virginia Broadband Enhancement Council was established in code during the 2017 Regular Legislative Session with the passage of House Bill 3093 and signed into law by Governor Jim Justice. The Code sets the many directives for the Council with the primary emphasis being on the development of broadband infrastructure in unserved and underserved areas of the State (WV Broadband Enhancement Council, 2021). Stakeholders and community members have noted concern about broadband and cellular interruption in receiving and sending emergency communications.

Since implementing an enhanced vegetation management program in 2014, Potomac Edison infrastructure has experienced significantly fewer tree-related outages in areas where tree trimming has been conducted to the new standards. The company services 1,550 miles of lines in its territory in the Eastern Panhandle. In 2020, the company saw a 45 percent reduction in tree-related outages compared to 2019, and the amount of time customers experienced service interruptions due to trees dropped by 75 percent. According to a PR Newswire article, to help minimize the impact of tree-related damages during

severe weather, Mon Power, and Potomac Edison's tree contractors plan to clear vegetation along approximately 6,800 miles of power lines in 2023 to help enhance electric service reliability for West Virginia customers. They have already completed that work along more than 2,400 miles of power lines this spring (PRNewsWire, 2023). Actions like this can be taken by utility providers to reduce an area's utility interruption vulnerability.

Historic Resources & Community Activities

All of the building stock, including historic structures, are exposed to utility interruptions. Impacts sustained from these interruptions are likely to be secondary impacts. Should water distribution be reduced or not available, then structures could be at increased risk for structural fire since current fire suppression is dependent on accessing water supply from hydrants. Interruption of utility gas or water distribution could also reduce the effectiveness of facilities to operate at full capacity.

As previously mentioned, utility interruptions are secondary impacts. Therefore, community activities impacted by natural hazard events, there is a high possibility of utility interruption. While a slight disruption to events may occur as a result of utility interruptions in the region, long term disruptions or event cancelations are not anticipated from this hazard, based on past occurrences.