Part III. Hazard Identification and Risk Assessment

SECTION 4. RISK ASSESSMENT

2023 SHMP Update Changes

- For the 2023 State Hazard Mitigation Plan (SHMP) update, all information on the risk assessment can be found in Section 4 and Section 5, particularly in the hazard profiles in Sections 5.1 through 5.16. For ease of review, the vulnerability assessment and consequence analysis follow each hazard profile so that all information about a specific hazard is in one continuous section. This section describes the identification of hazards, assets that were analyzed for vulnerability, and hazard-specific data and methodologies that were used in the risk assessment.
- A State-owned and -leased building dataset and a more robust critical facility inventory were available and utilized in the risk assessment update, though there remains an opportunity to further enhance the data maintained by the State of West Virginia (the State) regarding State facilities, critical facilities, and community lifelines.
- Updated hazard spatial data sets were used to assess vulnerability.

4.1 Overview

44 C.F.R. §201.4(c)(2): States are required to undertake a risk assessment that provides '…the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview.'

The risk assessment is a process by which the State determines which hazards are of concern and addresses the potential impacts of those hazards statewide. The risk assessment helps communicate vulnerabilities, develop priorities, and inform decision-making for both the SHMP and for other emergency management efforts.

Risk

For the purposes of the 2023 SHMP, risk is the potential for damage or loss created by the interaction of hazards with assets such as people, buildings, infrastructure, and/or natural and cultural resources.

The risk assessment for the 2023 SHMP Update provides the factual basis for developing a State mitigation strategy. It makes the connection between vulnerability and the proposed hazard mitigation actions.

The West Virginia Emergency Management Division (WVEMD) envisions the 2023 SHMP to serve as a reference for the local hazard mitigation plan (LHMP) updates in the State. With that in mind, the 2023 SHMP included a comprehensive update to the 2018 SHMP risk assessment process. The process used to analyze hazards for the SHMP is described in this section and the hazard profiles included in Sections 5.1 through 5.16. Regional/local planners can follow the same or similar processes to update the LHMPs. The risk assessment in the SHMP focuses on evaluating State-owned and -leased facilities and State-level critical resources.

For the 2023 SHMP, the risk assessment for each hazard is divided into three parts: (1) hazard profile, (2) vulnerability assessment, and (3) consequence analysis. The vulnerability assessment now follows the hazard profile, so that all information about a particular hazard is found in one continuous section. The following is the consistent outline for each hazard's risk assessment section (Sections 5.1 through 5.16):

- Hazard Profile
  - Identification and description of the hazard
  - Location of the hazard and areas vulnerable to damage
  - Extent (i.e., strength or magnitude of the hazard)
  - Previous occurrences of the hazard
  - Probability of future hazard events, including due to changes in weather patterns and conditions
- Vulnerability Assessment
  - Vulnerability of State-owned and -leased buildings
  - Vulnerability of critical facilities
  - Vulnerability of the population, including socially vulnerable populations
  - Future changes that may impact vulnerability
- Consequence Analysis
  - Impacts to the public
  - Impacts to responders
  - Impacts to continuity of operations
  - Impacts to property, facilities, and infrastructure
  - Impacts to the environment
  - Impacts to the economic condition of the State
  - Impacts to public confidence in the State's governance

4.2 Identification of Hazards

The first step of the risk assessment is to identify and profile all natural hazard occurrences. The goal of this first step is to identify and understand the characteristics of the state's most significant risks (FEMA State Mitigation Planning Key Topics Bulletin: Risk Assessment 2016).

WVEMD considered a full range of hazards that could affect the State for the 2023 SHMP. The process included a review of the State's disaster history, the 2018 SHMP, hazard events that have occurred in West Virginia in the last five years, and the Federal Emergency Management Agency's (FEMA) National Risk Index (NRI). Outreach was conducted to include subject-matter experts in the planning process and on the State Planning Team (SPT) to ensure the appropriate elements of each hazard were included and best-available data was used for the risk assessment.

4.2.1 Disaster History

The State's disaster history, in combination with an understanding of the location and type of State-owned and -leased buildings and natural assets, provides direction on the identification of hazards and their significance. Of the 77 federal disasters declared in the State from 1954 to December 2022, West Virginia received 66 major disaster declarations (DR), 9 emergency declarations (ER), and 2 fire suppression assistance/fire management assistance declarations (FM). In late 2001, the FSA Program transitioned to the FM Program (FEMA 2021), though the State has not received any declarations under the FM Program. Table 4-1 outlines each FEMA declaration that the State has received since 1954. It should be noted that declarations prior to 1964 do not contain county data as it is not available (FEMA 2023). Additional details regarding declarations during the performance period of the 2018 SHMP are discussed further in Sections 5.1 through 5.16.

Table 4-1. State of West Virginia FEMA Major Disaster, Emergency, and Fire Suppression Assistance/Fire Manc Declarations

Date Declared	Incident	Disaster Number	Counties Affected
August 4, 1954	Flood	DR-21-WV*	Statewide
January 31, 1957	Flood	DR-67-WV*	Statewide
July 23, 1961	Floods	DR-117-WV*	Statewide
March 9, 1962	Severe Storms, High Tides, Flooding	DR-125-WV*	Statewide
March 13, 1963	Severe Storms, Flooding	DR-147-WV*	Statewide
March 20, 1964	Severe Storms, Flooding	DR-165-WV*	Statewide
March 13, 1967	Flooding	DR-224-WV	Barbour, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, G Hardy, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Marion, Mason, Mc Monroe, Nicholas, Pocahontas, Putnam, Raleigh, Randolph, Summers, Tucker, Wood, Wyoming
September 3, 1969	Severe Storms, Flooding	DR-278-WV	Greenbrier, Nicholas, Pocahontas
September 24, 1969	Severe Storms, Flooding	DR-279-WV	Greenbrier
February 27, 1972	Heavy Rains, Flooding	DR-323-WV	Boone, Kanawha, Lincoln, Logan, Mingo, Raleigh, Wyomi
July 3, 1972	Tropical Storm Agnes	DR-344-WV	Barbour, Berkeley, Brooke, Greenbrier, Hampshire, Hancock, Hardy, Jefferson, Monroe, Morgan, Ohio, Preston, Wetzel
August 23, 1972	Heavy Rains, Flooding	DR-349-WV	Logan, McDowell, Mingo, Wyoming
January 29, 1974	Severe Storms, Flooding	DR-416-WV	Kanawha, Lincoln, Logan, Mingo, Wayne
April 11, 1974	Severe Storms, Flooding	DR-426-WV	Fayette, Greenbrier, Raleigh, Wyoming
September 12, 1975	Heavy Rains, Flooding	DR-481-WV	Marshall, Ohio
January 19, 1977	Drought	EM-3021-WV	Fayette, Grant, Greenbrier, Hampshire, Hardy, Mercer, Mineral, Monroe, Summers, Wyoming
April 7, 1977	Severe Storms, Flooding	DR-531-WV	Cabell, Greenbrier, Lincoln, Logan, McDowell, Mercer, Mingo, Raleigh, Summ
August 24, 1977	Drought	EM-3051-WV	Grant, Greenbrier, Hampshire, Hardy, Mineral, Monroe, Pendleton, Poca
August 24, 1977	Severe Storms, Landslides and Flooding	EM-3052-WV	Boone, Logan, Mingo

Date Declared	Incident	Disaster Number	Counties Affected
December 14, 1978	Severe Storms, Flooding	DR-569-WV	Cabell, Jackson, Lincoln, Mingo, Wayne
August 15, 1980	Severe Storms, Flooding	DR-628-WV	Fayette, Nicholas, Raleigh, Hancock, Harrison, Jackson, Kanawha, Marion, Mars Preston, Putnam, Taylor, Webster
May 15, 1984	Severe Storms, Flooding	DR-706-WV	Logan, McDowell, Wayne, Mingo
November 7, 1985	Severe Storms, Flooding (Hurricane Juan)	DR-753-WV	Barbour, Berkeley, Braxton, Calhoun, Doddridge, Gilmer, Grant, Greenbrier Harrison, Jefferson, Lewis, Marion, Mineral, Monongalia, Monroe, Morgan, Pocahontas, Preston, Randolph, Summers, Taylor, Tucker, Tyler, Ups
March 17, 1993	Severe Snowfall and Winter Storm	EM-3109-WV	Barbour, Berkeley, Boone, Braxton, Brooke, Cabell, Calhoun, Clay, Doddridge, Greenbrier, Hampshire, Hancock, Hardy, Harrison, Jackson, Jefferson, Kanawha McDowell, Marion, Marshall, Mason, Mercer, Mineral, Mingo, Monongalia, Mo Ohio, Pendleton, Pleasants, Pocahontas, Preston, Putnam, Raleigh, Randol Summers, Taylor, Tucker, Tyler, Upshur, Wayne, Webster, Wetzel, Wirt,
July 12, 1995	Severe Storm, Heavy Rains, Flooding, Mudslides	DR-1060-WV	Mercer, Mineral, Nicholas
January 13, 1996	Blizzard	DR-1084-WV	Barbour, Berkeley, Boone, Braxton, Brooke, Cabell, Calhoun, Clay, Doddridge, Greenbrier, Hampshire, Hancock, Hardy, Harrison, Jackson, Jefferson, Kanawha McDowell, Marion, Marshall, Mason, Mercer, Mineral, Mingo, Monongalia, Mo Ohio, Pendleton, Pleasants, Pocahontas, Preston, Putnam, Raleigh, Randol Summers, Taylor, Tucker, Tyler, Upshur, Wayne, Webster, Wetzel, Wirt,
January 25, 1996	Flooding	DR-1096-WV	Raleigh, Berkeley, Brooke, Grant, Greenbrier, Hampshire, Hancock, Hardy, Jeffe Mercer, Mineral, Monroe, Morgan, Nicholas, Ohio, Pendleton, Pleasants, P Randolph, Summers, Tucker, Tyler, Webster, Wetzel, Woo
May 23, 1996	Flooding	DR-1115-WV	Wayne, Barbour, Boone, Harrison, Lincoln, Logan, McDowell, Mercer, Mingo, F Raleigh, Randolph, Tucker, Upshur, Wetzel, Wyoming
August 14, 1996	Flooding	DR-1132-WV	Cabell, Upshur, Barbour, Braxton, Clay, Gilmer, Monongalia, Nicholas, Ra
September 11, 1996	Hurricane Fran	DR-1137-WV	Jefferson, Randolph, Berkeley, Grant, Hampshire, Hardy, Mineral, Morgan,
March 7, 1997	Severe Storms/Flooding	DR-1168-WV	Braxton, Cabell, Calhoun, Clay, Gilmer, Jackson, Kanawha, Lincoln, Mason, P Wayne, Wetzel, Wirt, Wood
July 1, 1998	Severe Storms, Flooding and Tornadoes	DR-1229-WV	Webster, Cabell, Braxton, Calhoun, Clay, Doddridge, Gilmer, Harrison, Jacks Marion, Marshall, Ohio, Pleasants, Ritchie, Roane, Tyler, Wetzel, V
February 28, 2000	West Virginia Winter Storm	DR-1319-WV	Pocahontas, Barbour, Braxton, Cabell, Calhoun, Doddridge, Gilmer, Harrison, Ja Lincoln, Marion, Mason, Monongalia, Preston, Putnam, Randolph, Ritchie, Roar Upshur, Wetzel, Wirt
June 3, 2001	Severe Storms & Flooding	DR-1378-WV	Cabell, Calhoun, Marion, Mason, Mingo, Preston, Putnam, Roane, Summers, Fayette, McDowell, Taylor, Boone, Clay, Greenbrier, Lincoln, Logan, Mercer, Ni Wyoming

Date Declared	Incident	Disaster Number	Counties Affected
November 16, 2001	Southwest Complex Fire	FSA-2391-WV	Boone, Cabell, Clay, Kanawha, Lincoln, Logan, McDowell, Mercer, Mingo, Rale
November 16, 2001	Trough and Smoke Hole Fire Complexes	FSA-2392-WV	Grant, Hardy
May 5, 2002	Severe Storms, Flooding, and Landslides	DR-1410-WV	Logan, Summers, Kanawha, Raleigh, McDowell, Mercer, Mingo,
March 14, 2003	Severe Winter Storms	DR-1455-WV	Brooke, Hancock, Hardy, Marion, Marshall, Monongalia, Ohio, Pendleton, Su Tyler, Wetzel, Berkeley, Clay, Gilmer, Grant, Hampshire, Jefferson, Mineral, Preston, Wirt, Fayette, Harrison, Braxton, Cabell, Calhoun, Greenbrier, Jacks Lincoln, Logan, McDowell, Mason, Mercer, Mingo, Monroe, Nicholas, Putnam, Wayne, Webster, Wyoming
June 21, 2003	Severe Storms, Flooding and Landslides	DR-1474-WV	Tucker, Marion, Berkeley, Harrison, Ritchie, Preston, Boone, Cabell, Doddrid Logan, McDowell, Mason, Mingo, Monongalia, Nicholas, Putnam, Wa
September 23, 2003	Hurricane Isabel	DR-1496-WV	Berkeley, Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan, Pendleto
November 21, 2003	Severe Storms, Flooding, and Landslides	DR-1500-WV	Barbour, Doddridge, Marshall, Pendleton, Pocahontas, Ritchie, Upshur, Cab Calhoun, Clay, Fayette, Gilmer, Greenbrier, Harrison, Kanawha, Lewis, Linco Marion, Mercer, Monongalia, Monroe, Nicholas, Putnam, Raleigh, Summers, T Wetzel, Wyoming
June 7, 2004	Severe Storms, Flooding and Landslides	DR-1522-WV	Boone, Cabell, Calhoun, Clay, Fayette, Kanawha, Lewis, Lincoln, McDowell, Ma Braxton, Gilmer, Jackson, Logan, Mercer, Mingo, Putnam, Raleigh, Roane, We
August 6, 2004	Severe Storms, Flooding, and Landslides	DR-1536-WV	Fayette, Lincoln, Logan, Mingo,
September 20, 2004	Severe Storms, Flooding and Landslides (Hurricane Ivan)	DR-1558-WV	Boone, Clay, Putnam, Berkeley, Brooke, Cabell, Hancock, Jackson, Kanawha, Li Mason, Mingo, Morgan, Ohio, Pleasants, Tyler, Wayne, Wetzel, W
February 1, 2005	Severe Storms, Flooding, and Landslides	DR-1574-WV	Brooke, Hancock, Marshall, Ohio, Tyler, Wetzel
September 5, 2005	Hurricane Katrina Evacuation	EM-3221-WV	Statewide
May 1, 2007	Severe Storms, Flooding, Landslides, and Mudslides	DR-1696-WV	Barbour, Boone, Cabell, Gilmer, Grant, Hardy, Lewis, Lincoln, Logan, McDowe Pocahontas, Putnam, Upshur, Wayne, Webster, Wyomin

Date Declared	Incident	Disaster Number	Counties Affected
June 19, 2008	Severe Storms, Tornadoes, Flooding, Mudslides, and Landslides	DR-1769-WV	Braxton, Calhoun, Lewis, Ritchie, Webster, Wirt, Jackson, Jefferson, Wetzel, Ba Gilmer, Harrison, Marion, Taylor, Tucker, Tyler
May 15, 2009	Severe Storms, Flooding, Mudslides, and Landslides	DR-1838-WV	Gilmer, Lewis, Roane, Upshur, Wirt, Mercer, Raleigh, Calhoun, McDowell,
March 2, 2010	Severe Winter Storm and Snowstorm	DR-1881-WV	Boone, Calhoun, Clay, Fayette, Greenbrier, Jefferson, Kanawha, McDowell, Me Pendleton, Pocahontas, Raleigh, Randolph, Ritchie, Roane, Wy
March 29, 2010	Severe Storms, Flooding, Mudslides, and Landslides	DR-1893-WV	Summers, Kanawha, Fayette, Greenbrier, Mercer, Raleig
April 23, 2010	Severe Winter Storms and Snowstorms	DR-1903-WV	Berkeley, Brooke, Doddridge, Grant, Hampshire, Hancock, Hardy, Jefferson, Ma Monongalia, Morgan, Ohio, Pocahontas, Preston, Ritchie, Tucker, T
June 24, 2010	Severe Storms, Flooding, Mudslides, and Landslides	DR-1918-WV	Lewis, Logan, McDowell, Mingo, Wyoming
March 16, 2012	Severe Storms, Tornadoes, Flooding, Mudslides, and Landslides	DR-4059-WV	Doddridge, Mingo, Monongalia, Ritchie, Roane, Harrison, Lincoln, Marion, Pr
March 22, 2012	Severe Storms, Flooding, Mudslides, and Landslides	DR-4061-WV	Lincoln, Logan, Mingo
June 30, 2012	Severe Storms	EM-3345-WV	Statewide
July 23, 2012	Severe Storms and Straight-Line Winds	DR-4071-WV	Barbour, Berkeley, Braxton, Calhoun, Doddridge, Gilmer, Grant, Hardy, Harri Logan, Marshall, Pendleton, Pleasants, Preston, Putnam, Randolph, Ritchie, Su Upshur, Wayne, Wetzel, Wirt, Wyoming, Boone, Cabell, Clay, Fayette, Greenbr Lincoln, McDowell, Mason, Mercer, Mingo, Monroe, Nicholas, Pocahontas, F Webster, Wood
October 29, 2012	Hurricane Sandy	EM-3358-WV	Statewide
November 27, 2012	Hurricane Sandy	DR-4093-WV	Barbour, Boone, Braxton, Clay, Fayette, Kanawha, Lewis, Nicholas, Pendleton, Raleigh, Randolph, Taylor, Tucker, Upshur, Webster, Wyom

Date Declared	Incident	Disaster Number	Counties Affected
July 26, 2013	Severe Storms and Flooding	DR-4132-WV	Mason, Roane
January 10, 2014	Chemical Spill	EM-3366-WV	Boone, Cabell, Clay, Jackson, Kanawha, Lincoln, Logan, Putnam
March 31, 2015	Severe Winter Storm, Flooding, Landslides, and Mudslides	DR-4210-WV	Barbour, Boone, Braxton, Cabell, Doddridge, Fayette, Gilmer, Harrison, Jacks Lincoln, Logan, McDowell, Marshall, Mercer, Mingo, Monongalia, Putnam, Ra Summers, Tucker, Tyler, Upshur, Wayne, Webster, Wetzel, Wirt, Wo
May 14, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4219-WV	Boone, Cabell, Lincoln, Logan, Mingo, Wayne
May 18, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4220-WV	Braxton, Brooke, Doddridge, Gilmer, Jackson, Lewis, Marshall, Ohio, Pleasants
May 21, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4221-WV	Cabell, Calhoun, Greenbrier, Jackson, Pleasants, Roane, Summe
August 7, 2015	Severe Storms, Straight-line Winds, Flooding, Landslides, and Mudslides	DR-4236-WV	Braxton, Clay, Jackson, Lincoln, Logan, Nicholas, Roane, Webste
June 25, 2016	Severe Storms, Flooding, Landslides, and Mudslides	DR-4273-WV	Braxton, Gilmer, Lewis, Randolph, Upshur, Wayne, Clay, Fayette, Greenbrier Lincoln, Monroe, Nicholas, Pocahontas, Roane, Summers, We
August 18, 2017	Severe Storms, Flooding, Landslides, and Mudslides	DR-4331-WV	Doddridge, Monongalia, Ohio, Preston, Randolph, Taylor, Tucker, Tyler, Harris Wetzel
April 17, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4359-WV	Brooke, Cabell, Calhoun, Doddridge, Hancock, Harrison, Lincoln, Logan, Marsha Ohio, Pleasants, Preston, Ritchie, Taylor, Tyler, Wayne, Wetzel, W
July 12, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4378-WV	Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan, Pendl

Date Declared	Incident	Disaster Number	Counties Affected
August 2, 2019	Severe Storms, Flooding, Landslides, and Mudslides	DR-4455-WV	Grant, Pendleton, Preston, Randolph, Tucker
March 13, 2020	Covid-19	EM-3450-WV	Statewide
April 3, 2020	Covid-19 Pandemic	DR-4517-WV	Statewide
May 13, 2021	Severe Winter Storms	DR-4603-WV	Cabell, Lincoln, Mason, Putnam
May 20, 2021	Severe Storms and Flooding	DR-4605-WV	Boone, Lincoln, Logan, Cabell, Kanawha, Mingo, Wayne
November 28, 2022	Severe Storms, Flooding, Landslides, and Mudslides	DR-4678-WV	McDowell
November 28, 2022	Severe Storms, Flooding, Landslides, and Mudslides	DR-4679-WV	Fayette

Source: FEMA 2023
** For this event, as per the FEMA website, no additional information was filed for this event*
DR Major Disaster Declaration
EM Emergency Declaration
FEMA Federal Emergency Management Agency
FSA Fire Suppression Assistance Declaration

4.2.2 2023 SHMP Update Hazards of Concern

44 C.F.R. §201.4(c)(2)(i): The State plan much include an overview and analysis of jurisdictions'' vulnerability to the identified hazards and the potential losses including jurisdictions most threatened and most vulnerable.

In accordance with the FEMA's State Mitigation Planning Policy Guide (FEMA 2022), the SHMP must provide an overview of all natural hazards that can affect the State. The Steering Committee and SPT evaluated the 2018 SHMP hazards of concern by examining the historic events that have taken place in the State since 2018, and reviewing the LHMPs, NRI information, and other data provided by FEMA. A review of natural hazards that can affect the State is provided in Table 4-2. Table 4-2 lists each natural hazard, identifies if the hazard was profiled in the 2018 SHMP, identifies if the hazard was profiled in the 2023 SHMP (i.e., if the hazard is a current hazard of concern to the State), and provides a reason if the hazard was omitted in the 2023 SHMP.

Table 4-2. Review of NRI Hazards for Inclusion in the 2023 SHMP

NRI Hazard	Profiled in the 2018 SHMP?	Profiled in the 2023 SHMP?	Review Notes
Avalanche	-	-	The State recognizes that this hazard may occur, but it was omitted; NRI indicates hazard does not apply to West Virginia.
Coastal Flooding	-	-	This hazard was omitted. West Virginia does not have any coastal areas.
Cold Wave	X	X	Included in the Extreme Temperature hazard profile
Drought	X	X	Included in the 2023 SHMP
Earthquake	X	X	Included in the 2023 SHMP
Hail	X	X	Included in the Severe Storms hazard profile
Heat Wave	X	X	Included in the Extreme Temperature hazard profile
Hurricane	X	X	Wind impacts are included in the Severe Storms hazard profile
Ice Storm	X	X	Included in the Winter Weather hazard profile
Landslide	X	X	Included in the 2023 SHMP
Lightning	X	X	Included in Severe Storms hazard profile
Riverine Flooding	X	X	Included in in the Flood hazard profile
Strong Wind	X	X	Included in the Severe Storms hazard profile
Tornado	X	X	Included in the Severe Storms hazard profile
Tsunami	-	-	This hazard was omitted. West Virginia does not have any coastal areas subject to tsunamis.
Volcanic Activity	-	-	The State recognizes that this hazard could theoretically occur, but it was omitted; NRI indicates hazard does not apply to West Virginia
Wildfire	X	X	Included in the 2023 SHMP
Winter Weather	X	X	Included in the 2023 SHMP

Notes: X = Yes; - = No

Based on the above reviews and the inclusion of additional non-natural hazards of concern, the hazards of concern evaluated for the 2023 SHMP are as follows:

- Dam Failure
- Drought
- Earthquake
- Extreme Temperatures
- Flood
- Hazardous Materials
- Landslide
- Levee Failure
- Pandemic
- Radiological Incidents
- Radon Exposure
- Severe Storms
- Subsidence
- Utility Failure
- Wildfire
- Winter Weather

4.2.3 LHMP Risk Assessment Roll-Up

44 C.F.R. §201.4(c)(2)(ii): The State plan much include an overview and analysis of jurisdictions'' vulnerability to the identified hazards and the potential losses including jurisdictions most threatened and most vulnerable.

The 11 regional hazard mitigation plan (HMP) and the Jefferson County HMP (i.e., the LHMPs) were reviewed during the 2023 SHMP update process. Rolling up the risk assessments of the LHMPs was challenging because the 12 plans differ in structure, hazards of concern, data used, and analysis methods, as noted in Table 4-3. The hazards profiled in each LHMP were reviewed to ensure that the 2023 SHMP incorporates information from local risk assessments; this information is integrated into the hazard profiles found in Sections 5.1 through 5.16. The hazard profiles identify the jurisdictions most vulnerable to and threatened by each hazard of concern. The 2023 SHMP risk assessment included a vulnerability assessment for the counties utilizing statewide population, building, and environmental resource spatial datasets.

Table 4-3 summarizes the vulnerability information presented in each of the LHMPs for the hazards of concern included in the 2023 SHMP. The table identifies for which hazards qualitative vulnerability information was presented and summarizes any quantitative vulnerability information presented in the respective hazard profiles. Loss estimates for most hazards were determined primarily based on past events. FEMA's Hazus software was used in some regions to model losses for earthquakes and flooding. Some LHMPs based loss estimates for flooding on the Total Exposure in Floodplain (TEIF) model, and some LHMPs based loss estimates for landslides on the Total Exposure in Areas of Landslides (TEAL) model.

Only losses for hazards profile in the 2023 SHMP are included, to provide a consistent analysis of the vulnerability described in the LHMPs. As shown in Table 4-4, the hazards profiled in the LHMPs may not exactly match the hazards profiled in the 2023 SHMP.

Table 4-4 lists the hazards identified in the LHMPs and the hazards of concern, and indicates the risk ranking of each hazard addressed in the respective LHMPs, to demonstrate which jurisdictions are most vulnerable to different hazards. Not all of the LHMPs specify the ranking by jurisdiction; some rank hazards only at the regional level. In those cases, the regional ranking values in Table 4-4 are reflected in each county's ranking values as well.

To make LHMPs across the State more consistent, the State has included a mitigation action to set statewide standards for LHMPs in Section 11 (Mitigation Actions) – Action EMD-1.

Table 4-3. Vulnerability Information in LHMPs

Hazard	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
Dam Failure	Q	Q	Q	Q	No details provided	Up to $101.3 million per failure	Q	Q	Q	Exposure analysis by county: $645.9 million - $2.7 billion
Drought	Q	Q	Q	Q	Q	$0	Q	$3 million in crop losses since 1977	$29.2 million in crops and livestock exposed	$7.8 million in exposed crops
Earthquake	Structural damages of $532 million if structures receive 5% damage	Hazus loss estimates by county: $79 million-$1.2 billion	Hazus loss estimates by county: $760K-$2.9 billion	Hazus annualized loss estimates by county: $62,390-$289,284	Q	Hazus annualized loss estimates by jurisdiction: $1-$43,796	Hazus loss estimates by county: $64.8-$234.8 million	Hazus loss estimates by county: $14.1-$127.0 million	Q	Numbers of exposed structures by county: 46,560 total
Extreme Temperature	-	Q	Q	Q	Q	-	$21,422 per year	XXXX	Q	-
Flood	TEIF analysis for each county: $46.9-$353 million in structure and contents losses	Hazus for building counts and % damage; no data on expected damage in dollars	TEIF analysis of exposed property value by jurisdiction: $292.1 million total	$5.9 million in expected annual losses; TEIF analysis of exposed critical facilities by jurisdiction	TEIF analysis of exposed property value by jurisdiction: $1.6 billion total	TEIF analysis of exposed property value by jurisdiction: $$871.6 million total	Hazus loss estimates by county: $52.4-$222.1 million	Hazus loss estimates by county: $36.2-$281.6 million	Hazus loss estimates by jurisdiction: $327.8 million total	TEIF analysis of exposed property value and losses by county: $86.5 million in estimated losses total
Hazardous Materials	-	Q	$867,302 in historic damages	-	-	-	$271,423 in historic damages	Estimated $814.5 million in historic damages	17,213 exposed structures and 45 exposed critical facilities in Berkeley County	Exposure analysis of structures and property value by county: 38,382 structures total

Hazard	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
Landslide	$10.5 billion in exposed property value	Q	TEAL analysis of exposed property by jurisdiction: $12.2 billion total	Q	TEAL analysis of exposed property by jurisdiction in high or medium susceptibility areas: $49.4 million total	Q	$770,250 in expected losses per year	$25K-$50K per event	TEAL analysis of exposed property by jurisdiction in high or medium susceptibility areas: $89.3 million total	TEAL analysis of exposed property by jurisdiction in high or medium susceptibility areas: $146.7 million total
Levee Failure	-	-	-	-	Up to $630 million in exposed property value	-	-	-	-	-
Pandemic	-	-	Projected $13.0 million in lost earnings	Q	$15.6 million in economic losses from pandemics	-	-	Up to $40.8 million in economic losses each year	Q	Q
Radiological Incidents	-	-	-	-	-	-	-	-	-	-
Radon Exposure	-	-	-	-	-	-	-	-	Q	-
Severe Storm	$10.5 billion in exposed property value	$20.3-$26.9 million in past damages	Thunderstorm: Q Tornado: $66,500 in losses per event	Q	Q	Up to $576.4 million, region-wide, per event Hazus annualized losses per jurisdiction: $82,419 total	$75,016 in losses per tornado; $18,512 per windstorm; $186,314 per hailstorm	$5.7 million in historic damages	$3.4 million in damage from lightning across the State from 2000-2020; no estimates of wind damage provided	Up to 46,560 structures and $4.6 billion in exposed property value

Hazard	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
Subsidence	-	Q	No details provided	-	-	Regional estimate not developed	-	-	-	Exposure analysis of structures and property value on abandoned mines by county: 14,162 structures and $1.8 billion total
Utility Failure	Q	-	Q	-	-	-	Q	-	Q	-
Wildfire	$10.5 billion in exposed property value	$13.1 million in firefighting cost in last 11 years	$10,000 in expected losses every four years	Q	$10,500-$200,000 in damages per event	Up to $23.8 billion, region-wide, per event	$10,628 loss per structure per fire	$1.0 million in historic damages	Historic damage of $10K-$50K in Berkeley County and $150K+ in Morgan County	19,133 structures and $1.8 billion in property value exposed
Winter Weather	$10.5 billion in exposed property value	$5-$11 million in past damages	$6.9 million in past damages since 2002	$46,898 in expected losses per event and $945,480 annually	$17,526 in expected losses per event	Up to $439.3 million, region-wide, per event	$520,260 in damages per year	$3.9 million in historic damages	Q	Up to 46,560 structures and $4.6 billion in exposed property value

Notes:
Q: Qualitative analysis *-: Not profiled in the LHMP*
TEAL: Total Exposure in Areas of Landslides model *TEIF: Total Exposure in Floodplain model*
Sources: West Virginia Region I Planning and Development Council 2022; Region 2 Planning and Development Council 2018; Regional Intergovernmental C Development Council 2022; Mid-Ohio Valley Regional Council 2023; Region VI Planning and Development Council 2018; Region VII Planning and De Planning and Development Council 2018; Region 9 Regional Planning and Development 2022; Belomar Regional Council 2022; Brooke Hancock Jefferson 2018; Jefferson County 2019

Table 4-4. Summary of Hazards of Concern Captured in State and Local Hazard Mitigation Pl

State/ Region/ County	Acts of Violence/ Civil Disturbance/ Violent Disturbance	Cyber Terrorism	Dam Failure	Drought	Earthquake	Extreme Temperature	Fire/Wildfire	Flood	Hailstorm	Hazardous Materials	Hurricane/Tropical Storm	Invasive Species	Landslide	Land Movements	Levee/Floodwall Failure	Lightning/Thunderstorm	Manufacturing Incidents	Opioid Crisis/ Substance Use Disorder	Pandemic/ Epidemic/ Public Health Crisis	Radiological Incidents	Radon Exposure	Source Water Contamination	Severe Storm/ Severe Summer Weather
State (2023)			X	X	X	X	X	X		X			X		X				X	X	X		X
Region 1 (2022)			9	8	10		7	1	2				3										5
McDowell County			9	8	10		7	1	2				3										5
Mercer County			9	8	10		7	1	2				3										5
Monroe County			9	8	10		7	1	2				3										5
Raleigh County			9	8	10		7	1	2				3										5
Summers County			9	8	10		7	1	2				3										5
Wyoming County			9	8	10		7	1	2				3										5
Region 2 (2018)	MH		L	L	L	MH	M	MH		MH				MH	L			H					MH
Cabell County	MH		L	L	L	MH	M	MH		MH				MH	L			H					MH
Lincoln County	MH		L	L	L	MH	M	MH		MH				MH	L			H					MH
Logan County	MH		L	L	L	MH	M	MH		MH				MH	L			H					MH
Mason County	MH		L	L	L	MH	M	MH		MH				MH	L			H					MH
Mingo County	MH		L	L	L	MH	M	MH		MH				MH	L			H					MH
Wayne County	MH		L	L	L	MH	M	MH		MH				MH	L			H					MH
Region 3 (2022)			L*	L*	L	M	M	H		L					L*				H				M
Boone County			L*	L*	L	M	M	H		L					L*				H				M
Clay County			L*	L*	L	M	M	H		L					L*				H				M
Kanawha County			L*	L*	L	M	M	H		L					L*				H				M

State/ Region/ County	Acts of Violence/ Civil Disturbance/ Violent Disturbance	Cyber Terrorism	Dam Failure	Drought	Earthquake	Extreme Temperature	Fire/Wildfire	Flood	Hailstorm	Hazardous Materials	Hurricane/Tropical Storm	Invasive Species	Landslide	Land Movements	Levee/Floodwall Failure	Lightning/Thunderstorm	Manufacturing Incidents	Opioid Crisis/ Substance Use Disorder	Pandemic/ Epidemic/ Public Health Crisis	Radiological Incidents	Radon Exposure	Source Water Contamination	Severe Storm/ Severe Summer Weather
Putnam County			L*	L*	L	M	M	H		L					L*				H				M
Region 4 (2022)			X	X	X	X	X	X					X						X				X
Fayette County			X	X	X	X	X	X					X						X				X
Greenbrier County			X	X	X	X	X	X					X						X				X
Nicholas County			X	X	X	X	X	X					X						X				X
Pocahontas County			X	X	X	X	X	X					X						X				X
Webster County			X	X	X	X	X	X					X						X				X
Region 5 (2023)			L	L	L	L	L	M					L				M		M				H
Calhoun County			L	L	L	L	L	M					L				M		M				H
Jackson County			L	L	L	L	L	M					L				M		M				H
Pleasants County			L	L	L	L	L	M					L				M		M				H
Ritchie County			L	L	L	L	L	M					L				M		M				H
Roane County			L	L	L	L	L	M					L				M		M				H
Tyler County			L	L	L	L	L	M					L				M		M				H
Wirt County			L	L	L	L	L	M					L				M		M				H
Wood County			L	L	L	L	L	M					L				M		M				H
Region 6 (2018)			L	L	L		L	M	L														L
Doddridge County			<	=	=		=	=	=														=
Harrison County			>	=	=		=	=	=														=
Marion County			=	=	=		=	>	=														=
Monongalia County			=	=	=		>	>	=														=

State/ Region/ County	Acts of Violence/ Civil Disturbance/ Violent Disturbance	Cyber Terrorism	Dam Failure	Drought	Earthquake	Extreme Temperature	Fire/Wildfire	Flood	Hailstorm	Hazardous Materials	Hurricane/Tropical Storm	Invasive Species	Landslide	Land Movements	Levee/Floodwall Failure	Lightning/Thunderstorm	Manufacturing Incidents	Opioid Crisis/ Substance Use Disorder	Pandemic/ Epidemic/ Public Health Crisis	Radiological Incidents	Radon Exposure	Source Water Contamination	Severe Storm/ Severe Summer Weather
Preston County			>	=	=		>	>	=														=
Taylor County			<	=	=		>	=	=														=
Region 7 (2018)	L		L	L	L	L	L	H		M			H										M
Barbour County	L		L	L	L	L	L	H		M			H										M
Braxton County	L		L	L	L	L	L	H		M			H										M
Gilmer County	L		L	L	L	L	L	H		M			H										M
Lewis County	L		L	L	L	L	L	H		M			H										M
Randolph County	L		L	L	L	L	L	H		M			H										M
Tucker County	L		L	L	L	L	L	H		M			H										M
Upshur County	L		L	L	L	L	L	H		M			H										M
Region 8 (2018)			ML	ML	ML		ML	H		ML									ML				M
Grant County			ML	ML	ML		ML	H		ML									ML				M
Hampshire County			ML	ML	ML		ML	H		ML									ML				M
Hardy County			ML	ML	ML		ML	H		ML									ML				M
Mineral County			ML	ML	ML		ML	H		ML									ML				M
Pendleton County			ML	ML	ML		ML	H		ML									ML				M
Region 9 (2022)	No region-level ranking was provided																						
Berkeley County	L	H	L	H	L	M	L	H	L	H	H	L				M		H	H		M	H	H
Morgan County	L	M	M	L	L	L	M	H	M	M	M	L				M		H	H		L	M	
Region 10 (2022)			M	L	L		L	H	L	L			L						L				M
Marshall County			=	=	=		=	>	>	=			=						=				>

State/ Region/ County	Acts of Violence/ Civil Disturbance/ Violent Disturbance	Cyber Terrorism	Dam Failure	Drought	Earthquake	Extreme Temperature	Fire/Wildfire	Flood	Hailstorm	Hazardous Materials	Hurricane/Tropical Storm	Invasive Species	Landslide	Land Movements	Levee/Floodwall Failure	Lightning/Thunderstorm	Manufacturing Incidents	Opioid Crisis/ Substance Use Disorder	Pandemic/ Epidemic/ Public Health Crisis	Radiological Incidents	Radon Exposure	Source Water Contamination	Severe Storm/ Severe Summer Weather
Ohio County			=	=	=		=	<	>	>			>						=				>
Wetzel County			=	=	=		=	<	<	<			<						=				<
Region 11 (2018)	M		M	L	L	M	L	H		H			M	M						M			M
Brooke County	M		M	L	L	M	L	H		H			M	M						M			M
Hancock County	M		M	L	L	M	L	H		H			M	M						M			M
Jefferson County (2019)	ML		L	L	ML	MH	MH	M		M		M	MH						H				M

Notes:
The 2018 SHMP evaluated extreme heat together with drought
H: High MH: Medium-High M: Medium/Moderate ML: Medium-Low L: Low L: Lowest X: Hazard was profiled but no rankin*
+: Overall ranking not provided in the LHMP
Region 1 ranked hazards from 1 to 10. 1-3 were assigned a High ranking; 4-7 were assigned a Medium ranking; 8-10 were assigned a Low ranking.
Region 6 and Region 10 identified whether each county's risk was greater than (>), less than (<), or equal to (=) the regions' as a whole, but n prioritization/ranking of each hazard for that county.
Sources: West Virginia Region I Planning and Development Council 2022; Region 2 Planning and Development Council 2018; Regional Intergovernmental C Development Council 2022; Mid-Ohio Valley Regional Council 2023; Region VI Planning and Development Council 2018; Region VII Planning and De Planning and Development Council 2018; Region 9 Regional Planning and Development 2022; Belomar Regional Council 2022; Brooke Hancock Jefferson 2018; Jefferson County 2019

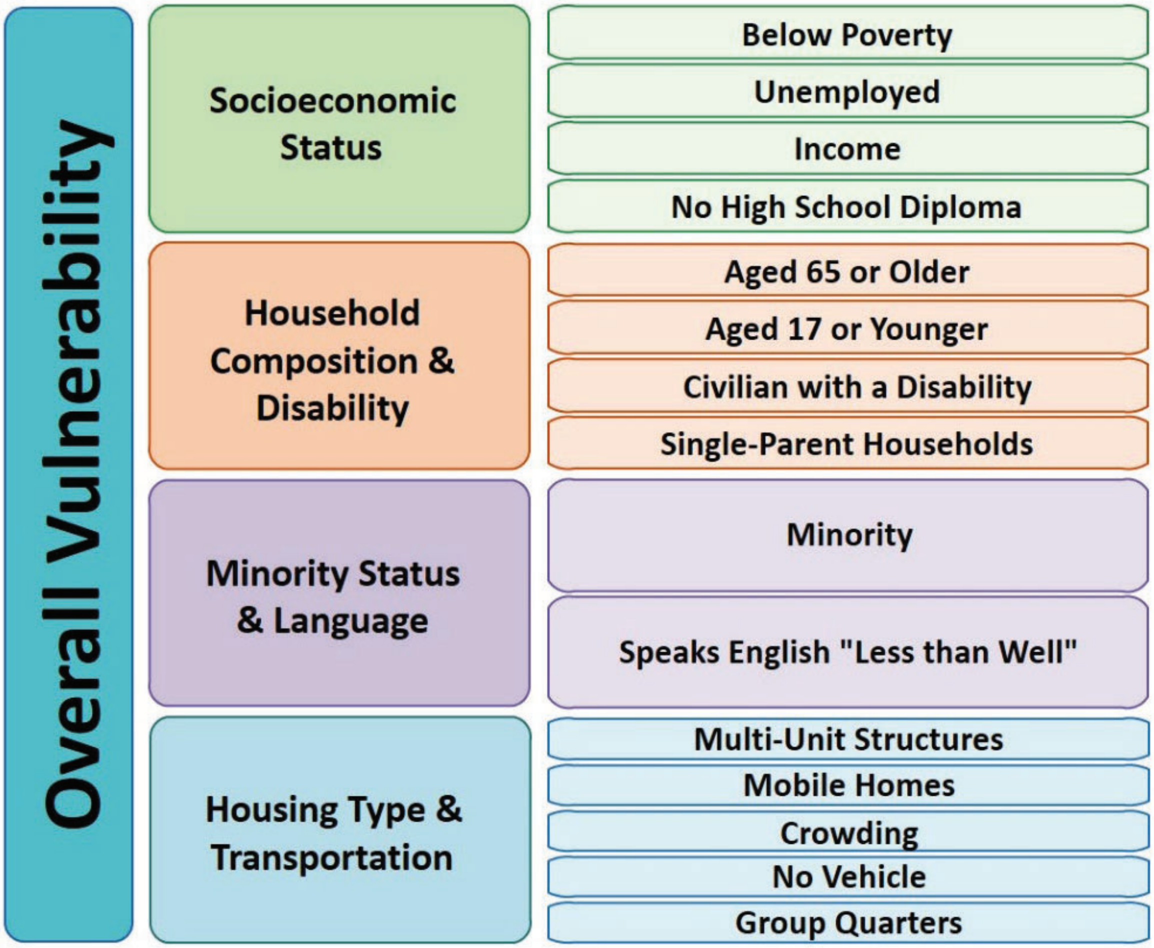
4.3 Population

Research has shown that some populations are at greater risk from hazard events because of decreased resources or physical abilities. As discussed in Section 2 (State Profile), these vulnerable populations include individuals experiencing economic hardships; older adults; children; Black, Indigenous, and People of Color; individuals experiencing homelessness; and visitors.

Social vulnerability is the likelihood of an individual, community, or group to be negatively affected by external stressors, creating barriers to the community's resilience and ability to recover from a disaster or emergency (FEMA n.d.). These external stressors may include access to transportation, access to broadband and reliable communications services, or socioeconomic factors (e.g., income, educational attainment, employment). Identifying concentrations of underserved and historically marginalized populations and geographic areas with high social vulnerability can assist communities in prioritizing support and resources to build resilience across the whole community.

Information collected through the U.S. Census Bureau, American Community Survey, and other sources is used to provide data on vulnerable populations and barriers contributing to social vulnerability. To identify areas in the State experiencing a higher rate of social vulnerability, the Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI) was utilized. The SVI is a combination of 15 different social factors that contribute to social vulnerability as shown in Figure 4-1.

Figure 4-1. CDC's Social Vulnerability Index U.S. Census Variables



Source: CDC 2022

The 2020 U.S. Census block data layers were used to estimate exposure and potential impacts to the general population. The 2020 U.S. Census demographic data available in FEMA's Hazus model was used to estimate potential impacts to older adults (over 65 years of age) and populations with income below the poverty threshold for the State. Populations vulnerable to each hazard are identified in the hazard profiles provided in Section 5.1 through 5.16.

4.4 Asset Inventories

National, State, and county resources were reviewed to identify best-available data to update the risk assessment. To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual properties.

4.4.1 State Assets

44 C.F.R. §201.4(c)(2)(ii): …. State owned or operated critical facilities located in the identified hazard areas shall also be addressed;

44 C.F.R. §201.4(c)(2)(iii): …. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

FEMA requires the State to identify its assets, which may include State-owned or operated buildings, infrastructure, and critical facilities. For the 2023 SHMP, the State assessed vulnerability of the following types of assets: State-owned and -leased buildings, state roads, and critical facilities identified by the State and others, including local and State-owned critical facilities and infrastructure.

State-Owned and State-Leased Buildings

WVEMD did not have access to a consolidated list of State buildings. In West Virginia, State facilities are managed by the Real Estate Office and insured by the Board of Risk and Insurance Management (BRIM). To incorporate the locations of the State facilities into the risk assessment, WVEMD obtained the list of all BRIM-insured buildings. Within this data, multiple structures were listed at the same physical address and were not able to be geolocated. For instance, all of West Virginia University's buildings were coded to a single address. Each facility with a unique address in the BRIM data was geocoded using an online geocoding system (geocodeo). For multiple structures listed at the same address, WVEMD's planning consultant identified a central location on the property to place a centroid point to represent the locations of all structures at that address. WVEMD is committed to working with BRIM and the Real Estate Office to geolocate each individual State-owned and -leased building and integrate facility data for the next update of the SHMP. Table 4-5 shows the number of individual State-owned and -leased facilities, by department, that were used for the SHMP risk assessment, along with the total insured value of structures and contents (used for building values) for those facilities.

Table 4-5. Summary of State-Owned or State-Leased Buildings by Department

	State-Owned or -Leased Buildings	
Agency	Count	Insured Structure and Contents Value
Adjutant General's Office State of West Virginia	6	$ 1,568,001.00
Administration, Secretary of Department of Administration	1	$ 112,001.00
Agriculture, Department of State of West Virginia	9	$ 5,219,758.00
Air And Environmental Quality Boards State of West Virginia	1	$ 60,001.00
Alcohol Beverage Control Administration State of West Virginia	1	$ 13,773,535.00
Architects, Board of State of West Virginia	1	$ 17,001.00
Armory Board State of West Virginia	60	$ 350,862,607.00
Arts, Culture, & History, Department of State of West Virginia	4	$ 7,287,556.00
Attorney General, Office of The State of West Virginia	1	$ 40,001.00
Aviation, Division of	1	$ 2,250,000.00
Bar, State of West Virginia	1	$ 1,480,000.00
Barbers & Cosmetologists, Board of State of West Virginia	1	$ 100,001.00
Blue Ridge Community & Technical College	4	$ 26,092,964.00

Agency	State-Owned or -Leased Buildings	
	Count	Insured Structure and Contents Value
Bluefield State College	1	$ 141,604,089.00
Board of Treasury Investments	1	$ 70,001.00
Bridgevalley Community & Tech College	2	$ 65,886,767.00
Cedar Lakes Conference Center State of West Virginia	1	$ 12,669,653.00
Chiropractic Examiners Board State of West Virginia	1	$ 100,001.00
Commission For National and Community Service, WV	1	$ 80,001.00
Concord University	1	$ 172,928,924.00
Conservation Agency, State of West Virginia	17	$ 1,139,570.00
Consolidated Public Retirement Board Department of Administration	1	$ 1,500,001.00
Consumer Advocate, Division of WV Public Service Commission	1	$ 150,001.00
Corrections, Division of State of West Virginia	28	$ 479,106,106.00
Courthouse Facilities Improvement Authority	1	$ 500,000.00
Dentistry, Board of State of West Virginia	1	$ 35,001.00
Department of Transportation	3	$ 6.00
Dietitians, Board of Licensed	1	$ 20,001.00
Eastern Panhandle Instructional Coop	16	$ 4,080,008.00
Eastern WV Community & Tech. College	5	$ 11,643,087.00
Economic Development Authority, State of West Virginia	1	$ 850,000.00
Economic Development, WV Dept of	1	$ 3,000,001.00
Education, Department of State of West Virginia	39	$ 31,558,461.00
Educational Broadcasting Authority, State of West Virginia	4	$ 12,268,085.00
Enterprise Resource Planning Board, WV	1	$ 2,000,001.00
Environmental Protection, Division of, State of West Virginia	26	$ 7,788,009.00
Ethics Commission, West Virginia Department of Administration	1	$ 130,000.00
Examiners In Counseling, Board of, State of West Virginia	1	$ 6,001.00
Fairmont State University	1	$ 225,296,551.00
Fire Commission State of West Virginia	1	$ 500,001.00
Fleet Management Office, Dept of Admin, State of West Virginia	1	$ 50,001.00
Forestry, Division of, State of West Virginia	22	$ 1,963,813.00
General Services Division, Department of Administration	14	$ 262,991,129.00
Geological And Economic Survey, State of West Virginia	1	$ 6,543,469.00
Glenville State College	1	$ 100,837,230.00
Governor, Office of, The State of West Virginia	1	$ 2,000,001.00
Health & Human Resources, Department of, State of West Virginia	118	$ 470,059,093.00
Higher Education Policy Commission, WV	10	$ 110,167,247.00
Highways, Division of, State of West Virginia	131	$ 174,229,588.00
Homeland Security & Emergency Management Division	1	$ 205,000.00
Insurance Commissioner, Office of, The State of West Virginia	4	$ 1,395,004.00
Investment Management Board, State of West Virginia	1	$ 2,500,001.00
Joint Committee on Government & Finance, State of West Virginia	1	$ 73,872.00
Justice & Community Services, Div. of	1	$ 750,001.00
Juvenile Services, Division of	23	$ 49,746,260.00
Labor, Division of, State of West Virginia	1	$ 975,001.00
Land Division/Dept of Agriculture, State of West Virginia	2	$ 149,407.00

Agency	State-Owned or -Leased Buildings	
	Count	Insured Structure and Contents Value
Landscape Architects, Board of, State of West Virginia	1	$ 2,501.00
Library Commission, State of West Virginia	2	$ 333,920.00
Lottery Commission, State of West Virginia	3	$ 61,700,001.00
Marshall University	1	$ 82,724,214.00
Military Affairs and Public Safety, Secretary of	1	$ 350,001.00
Miner’s Health Safety and Training, Division of, State of West Virginia	6	$ 24,025,004.00
Motor Vehicles, Division of, State of West Virginia	21	$ 8,175,730.00
Mountain State Esc	1	$ 1,250,000.00
Mountwest Community & Technical College	1	$ 3,013,114.00
National Coal Heritage Area Authority	3	$ 2,450,001.00
Natural Resources, Division of, State of West Virginia	19	$ 13,718,915.00
New River Community & Technical College	4	$ 17,223,666.00
Northern Community & Tech College, WV College Square	1	$ 10,900,000.00
Occupational Therapy Board, State of West Virginia	1	$ 10,001.00
Office of Technology/IS&C, Department of Administration	6	$ 24,832,005.00
Osteopathic Medicine, Board of, State of West Virginia	1	$ 25,001.00
Osteopathic Medicine, WV School of	13	$ 75,094,174.00
Parks, West Virginia State C\O Division of Natural Resources	73	$ 248,441,289.00
Pharmacy, Board of, State of West Virginia	1	$ 930,000.00
Physical Therapy, Board of, State of West Virginia	1	$ 80,001.00
Pierpont Community and Technical College	4	$ 13,816,298.00
Practical Nurses, Board of, State of West Virginia	1	$ 60,001.00
Prosecuting Attorneys Institute, WV	1	$ 121,001.00
Psychologists Examiners, Board of, State of West Virginia	1	$ 45,001.00
Public Service Commission, State of West Virginia	2	$ 18,209,069.00
Purchasing, Division of Department of Administration	2	$ 1,351,001.00
Rail Authority, State of West Virginia	1	$ 3,351,381.00
Real Estate Commission, State of West Virginia	1	$ 150,001.00
Regional Jail & Corr. Fac. Authority, State of West Virginia	5	$ 133,925,243.00
Registered Nurses, Board of, State of West Virginia	1	$ 250,001.00
Rehabilitation Services Division of Commerce	27	$ 12,297,773.00
Respiratory Care, WV Board of	1	$ 100,001.00
School Building Authority, West Virginia	1	$ 800,000.00
Schools For the Deaf and the Blind State of West Virginia	1	$ 55,747,270.00
Senior Services, Bureau of, State of West Virginia	2	$ 155,002.00
Shepherd University	1	$ 273,574,445.00
Southern Educational Services Coop	1	$ 1,000,000.00
Southern WV Community & Tech College	4	$ 64,142,169.00
Speech Pathology & Audiology Examiners West Virginia Board of	1	$ 20,001.00
State Police, West Virginia Dept of Military Affairs & Public Safety	90	$ 69,469,473.00
Supreme Court of Appeals, State of West Virginia	79	$ 7,052,070.00
Tax Appeals, WV Office of	1	$ 130,001.00
Tax Department, State of West Virginia	6	$ 5,400,006.00
Treasurer of State, State of West Virginia	4	$ 1,876,004.00

Agency	State-Owned or -Leased Buildings	
	Count	Insured Structure and Contents Value
University Physicians and Surgeons	12	$ 17,220,009.00
Veterans Assistance, Department of, State of West Virginia	16	$ 52,927,954.00
Veterinary Medicine, Board of, State of West Virginia	1	$ 25,001.00
Water Development Authority, State of West Virginia	1	$ 7,500,000.00
West Liberty University	3	$ 6,804,888.00
West Virginia Parkways Authority	17	$ 73,617,502.00
West Virginia State University - Institute	1	$ 140,023,150.00
West Virginia State University - Malden	1	$ 1,229,000.00
West Virginia University	1	$ 1,535,431,232.00
West Virginia University Arthurdale	1	$ 74,928.00
West Virginia University at Parkersburg	1	$ 61,770,204.00
West Virginia University Beckley	1	$ 520,502.00
West Virginia University Bruceton Mills	1	$ 3,435,337.00
West Virginia University Charleston	1	$ 791,798.00
West Virginia University Fort Ashby	1	$ 3,452,022.00
West Virginia University Granville	1	$ 19,775,502.00
West Virginia University Jacksons Mill	1	$ 14,600,207.00
West Virginia University Kearneysville	1	$ 4,127,255.00
West Virginia University Keyser	1	$ 126,627,242.00
West Virginia University Montgomery	1	$ 4,857,375.00
West Virginia University Reedsville	1	$ 8,769,528.00
West Virginia University Union	1	$ 506,330.00
West Virginia University Wardensville	1	$ 7,642,096.00
West Virginia University Weston	1	$ 2,240,145.00
Workforce West Virginia	11	$ 754,011.00
WV Public Employees Grievance Board	1	$ 285,001.00
WVsom Clinic Inc Dba Robert C Byrd Clinic	1	$ 2,250,001.00
Unknown	56	$ 112.00
TOTAL	**1,117**	**$6,103,990,952.00**

Source: WVBRIM 2022

State Roads

The State Department of Transportation's State route inventory was used to determine the State road exposure to spatially delineated hazards. For the analyzed hazards, the State roads were clipped to the hazard boundary, and mileage of roadway was calculated to estimate the exposed State road mileage per county within West Virginia. Economic impact of hazard events on road infrastructure has not been monetized, although exposure is identified and discussed. Section 2: State Profile includes a map of West Virginia that depicts the major highways located throughout the State.

Critical Facilities

WVEMD provided a list of 185 critical facilities to utilize for the risk assessment. Whereas the State focused on State-owned or State-leased facilities to assess vulnerability to its assets, the list of critical facilities included local and private facilities as well. The list included addresses with street numbers for the majority of the facilities. For the facilities that did not have spatial coordinates or the original coordinates were invalid, other location attributes were used to geocode the facilities.

Figure 4-2. Asset Inventory

The 2023 SHMP risk assessment included the collection and use of an expanded and enhanced asset inventory to estimate state vulnerability.

An estimated 144 critical facilities are State-owned and -leased buildings that appear in both inventories used for the risk assessment. The duplication of these assets is acknowledged and the datasets are reported separately.

Defaults were assigned to populate the required fields needed to estimate potential losses using Hazus. Structure values provided by West Virginia were left as-is in the dataset. Structures that did not have a pre-determined structure value in the provided data were assigned a default value of 1 for the structure and content costs as Hazus does not accept zero or NULL values for these fields. Assumptions were defined for the number of stories where a value did not exist and defaulted to a value of 1. Assumptions were also defined for Hazus defaults for year built, building types for the earthquake analysis, foundation type for the flood analysis, square footage, and first floor heights of structures where the values did not exist. The Hazus default attribute data for essential facilities (fire, police, medical care, and school facilities) was used to replace the default attribute values where the essential facilities could be matched to the critical facilities using the facility name.

Table 4-6 summarizes the total number of critical facilities by lifeline category and the insured value used to represent facility value in the risk assessment.

Table 4-6. Summary of Critical Facilities by Community Lifeline Category

Lifeline Category	Number	Total Insured Building and Contents Value
Communications	7	$10,240,007.00
Energy	0	$0
Food, Water, Shelter	8	$2,384,067.00
Hazardous Material	0	$0
Health & Medical	12	$200,276,228.00
Safety & Security	150	$946,402,599.00
Transportation	9	$44,654,481.00
Total	**186**	**$1,203,957,382.00**

Source: WVEMD 2022

4.4.2 Local Assets

44 C.F.R. §201.4(c)(2)(ii): The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events.

In addition to assessing the vulnerability of State assets, a key component to the risk assessment is to evaluate potential losses to jurisdictions in the State. As a first step, the 12 LHMPs were reviewed in an attempt to roll up the local risk assessment results in the 2023 SHMP to summarize losses in each county. However, the local plan risk assessment roll-up proved challenging because the LHMPs and specifically their risk assessments differ in structure, data used, and analysis methods. Therefore, the 2023 SHMP risk assessment included a vulnerability assessment for the counties utilizing statewide population, building, and environmental resource spatial datasets. Estimated exposure and potential impacts to these assets are reported in each hazard section. In addition, economic impacts are discussed qualitatively for each hazard.

General Building Stock

The 2023 SHMP focused on assessing vulnerability to State assets. As such, only property exposure and losses to State-owned and -leased facilities are included in the vulnerability assessments in the hazard profiles. The 2023 SHMP does not include estimates for exposure or losses to the general building stock throughout the State. The State relies on the regions/counties to assess exposure and losses to the general building stock as part of the development of the LHMPs.

Environmental Resources

WVEMD identified the following assets to include in the risk assessment based on the availability of spatial data: critical habitats (or habitats that are known to be essential for an endangered or threatened species), wetlands, parks and reserves, and watersheds. The spatial hazard layers were overlaid with these environmental resources in geographic information systems (GIS) to determine which environmental resources are located in the impact area of the hazard. Refer to Section 2 (State of WV Profile) for a more detailed description of these assets in the State.

Cultural Assets

Cultural asset information in the State of West Virginia is managed by the West Virginia Department of Arts, Culture & History. Facilities managed by that department were included in the set of State-owned and -leased facilities described above.

Changes That Impact Vulnerability

State hazard mitigation plans must be revised to reflect changes in development, including recent development, potential and projected land use and development, or conditions that may affect risk and vulnerability to the state and jurisdictions such as changes in population demographics. (FEMA State Mitigation Planning Key Topics Bulletin: Risk Assessment; 2016).

In addition to summarizing the current vulnerability, the State has identified three factors of change that can affect its vulnerability to hazards: (1) changes in population; (2) changes in development; and (3) other identified conditions as relevant and appropriate, including the impacts of future hazard conditions. Identifying these changes and integrating into the risk assessment ensures they are considered when developing the mitigation strategy to reduce these vulnerabilities in the future.

As summarized in Section 2 (State of WV Profile) the State of West Virginia has experienced little development over the performance period of the 2018 SHMP. There is no statewide system that tracks where this development has occurred or its location in hazard areas; however, members of the SPT report that development that has occurred has been concentrated in already-developed areas rather than in new areas. The State expects that trend to continue.

The 2018 SHMP did not include an analysis of State-owned and/or leased buildings and did not use the same critical facility inventory; therefore, changes in risk and vulnerability of these facilities over the performance period of the plan cannot be assessed. In addition, different general building inventories, hazard data, and methodologies were used in the 2018 SHMP than the 2023 SHMP making it impossible to conduct a side-by-side comparison analysis to determine changes in vulnerability. It is WVEMD and the Hazard Mitigation Officer's (HMO) vision that the 2023 SHMP set the new baseline for risk and will be used to assess changes of risk over time as future updates to the plan occur.

The impacts of changing future conditions on the hazards of concern are described in each hazard profile.

4.5 Hazard-Specific Data and Methodologies

44 C.F.R. §201.4(c)(2)(i): The risk assessment shall include the following: An overview of the type and location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future events, using maps where appropriate.

To assess vulnerability, three different levels of analysis were used depending upon the data available for each hazard as described below. Table 4-7 summarizes the types of analyses performed for each hazard followed by a discussion of each approach.

1. **Qualitative Analysis and Historic Occurrences** – This analysis includes an examination of historic impacts to understand potential impacts of future events of similar size. In addition, potential impacts and losses are discussed qualitatively using best-available data and professional judgment.

2. **Exposure Analysis** – This analysis involves overlaying available spatial hazard layers, or hazards with defined extent and locations, with assets in GIS to determine which assets are located in the impact area of the hazard. The analysis highlights which assets may be affected by the hazard. *If the center of each asset is located in the hazard area, it is deemed exposed and potentially vulnerable to the hazard.*

3. **Hazus Analysis (Loss estimation)** — The Hazus modeling software was used to estimate potential losses for the event-based earthquake and severe storms (wind) hazards. The State's Total Exposure in Floodplain (TEIF) and Total Exposure in Areas of Landslides (TEAL) models were used to estimate losses

for the flood and landslide hazards, respectively (see Sections 4.5.3 and 4.5.5). In addition, an examination of historic impacts and an exposure assessment was conducted for these spatially delineated hazards.

Table 4-7. Summary of Risk Assessment Analyses

Hazard	Data Analyzed					
	Population	State Buildings	State Roads	Critical Facilities	Environmental Resources	Cultural Assets
Dam Failure	E	E	E	E	-	E
Drought	Q	Q	Q	Q	Q	Q
Earthquake	-	H	-	H	-	-
Extreme Temperature	Q	Q	Q	Q	Q	Q
Flood	E	E, H	E	E, H	-	E
Hazardous Materials	E	E	E	E	-	E
Landslide	E	E	E	E	-	E
Levee Failure	E	E	E	E	-	E
Pandemic	Q	Q	Q	Q	Q	Q
Radiological Incidents	E	E	E	E	-	E
Radon Exposure	Q	-	-	-	-	-
Severe Storm	-	-	-	H	-	-
Subsidence	E	E	E	E	-	E
Utility Failure	Q	Q	Q	Q	Q	Q
Wildfire	E	E	E	E	-	E
Winter Weather	Q	Q	Q	Q	Q	Q

E – Exposure analysis; H – Hazus analysis; Q – Qualitative analysis
Note: The 12 LHMPs were also reviewed and potential losses summarized in hazard location and vulnerability assessment subsections when available.

Outreach was conducted at the early stages of the 2023 SHMP process to collaborate with hazard subject matter experts to obtain the best-available data and methodologies to assess risk (refer to Section 3). The following summarizes the data and analysis conducted to evaluate each hazard of concern. Sections 4.5.1 through 4.5.11 summarize the vulnerability assessment results.

4.5.1 Dam Failure

Statewide dam failure inundation area data was downloaded from the U.S. Army Corps of Engineers (USACE) National Inventory of Dams (NID). Point and polygonal data regarding mining-related impoundments regulated by the West Virginia Department of Environmental Protection's (WVDEP) Division of Mining and Reclamation (DMR) were provided by the West Virginia University GIS Technical Center (WVU GISTC). Between the USACE NID and the WVDEP DMR data, the risk assessment incorporated both coal and non-coal dams in the State.

For the 2023 SHMP, the total number of State buildings located in all spatially delineated dam failure inundation areas were examined. However, it is important to note that it is highly unlikely that all dams would fail at the same time. To assess local vulnerability, State buildings and critical facilities were analyzed for their proximity to the dam failure inundation areas along with their total replacement cost value. Socially vulnerable population counts, State highway mileage and acreage of land area were analyzed for their exposure to the dam inundation hazard area per county.

4.5.2 Earthquake

A Level 2 analysis was performed in Hazus v6.0 to estimate potential losses as a result of the 500-year probabilistic scenario (Section 4.6).

The State buildings and critical facilities were imported into Hazus as individual facilities to support this assessment (also known as a Hazus user-defined analysis). Default Hazus National Earthquake Hazards Reduction Program (NEHRP) D soils were identified as areas potentially more vulnerable to damage; these areas were used as the hazard extent for the exposure analysis. Damages are estimated at the census tract level, and for this assessment, results were summarized by the total for the State; as the results broken out by jurisdiction were too minimal for reporting. Results for critical facilities were reported by estimated damage per lifeline category. Damage estimates are calculated for losses to buildings (structural and non-structural) and contents; structural losses include load carrying components of the structure, and non-structural losses include those to architectural, mechanical, and electrical components of the structure, such as nonbearing walls, veneer and finishes, HVAC systems, boils, etc.

4.5.3 Flood

The 1- and 0.2-percent annual chance flood events were examined to evaluate the State's risk from the flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as NFIP.

The following data was used to evaluate exposure and determine potential future losses for this plan update:

- Statewide FEMA 2022 Effective DFIRM Flood Data
- Flood Depth Grid provided by WVU GISTC

The 2022 FEMA Effective DFIRM Flood data was used to create the 1- and 0.2-percent annual chance flood boundaries and was used to evaluate exposure and determine potential future losses. The depth grid that was provided by WVEMD for the 2023 SHMP was from the TEIF analysis and was integrated into the FAST (Hazus Flood Assessment Structure Tool) to estimate potential losses for the 1 percent annual chance flood event; FAST is a Hazus tool that assists in determining structure damages based upon inventory and default Hazus attributes. To estimate exposure to the 1 percent and 0.2 percent annual chance flood events, the FEMA Effective DFIRM flood boundaries were overlaid on the centroids of updated assets (State facilities and critical facilities). Centroids that intersected the flood boundaries were totaled to estimate the building replacement cost value. Socially vulnerable populations and land area were estimated by completing an area calculation against the flood hazard area. State roadways were estimated by clipping the State roads to the flood hazard areas and calculating mileage.

A flood analysis for the 1 percent annual chance flood event was run in FAST. Both the State facility and critical inventories were formatted to be compatible with FAST and its Comprehensive Data Management System (CDMS). Once CDMS was updated with the inventories, the original depth grid was divided into four segments, and the FAST assessment was run four times (once per depth grid segment). FAST calculated the estimated potential damages to State facility and critical facility inventories based on the depth grid generated and the default Hazus attributes.

4.5.4 Hazardous Materials

The hazardous materials release hazard area was defined as areas within ½ mile of a major roadway, railway, pipeline, or Superfund Amendment and Reauthorization Act (SARA)-defined “reporting facility,” or within 1 mile of a SARA-defined “planning facility.” The 1-mile buffer around planning facilities was used due to the absence of the specific vulnerability radii associated with each planning facility in the State’s data. To estimate exposure, the various hazardous materials areas were overlaid on the centroids of the State and critical facilities. Centroids that intersected the hazardous materials boundary were totaled to estimate the building replacement cost value. Socially vulnerable populations and land area were estimated by completing an area calculation against the hazardous materials hazard area. State roadways were estimated by clipping the State roads to the hazardous materials hazard areas and calculating mileage.

4.5.5 Landslide

Landslide susceptibility data for the State of West Virginia was downloaded by WVU. This is the same dataset that was utilized in the Total Exposure in Areas of Landslides (TEAL) analysis that the State developed.

For the landslide exposure analysis, we classified the landslide data into three landslide susceptibility areas described below, following the same classifications used in the TEAL analysis.

- Low: <0.3
- Medium: 0.3 – 0.7
- High: >0.7

The Medium Susceptibility hazard areas were analyzed during the exposure assessment to determine what population is located within the hazard area. The High Susceptibility hazard areas were analyzed during the exposure assessment to determine what population, State-owned and -leased facilities, critical facilities, mileage of State roadways, and acreage of land area are located within the hazard area. To estimate exposure, the landslide hazard data was overlaid on the centroids of the State and critical facilities. Centroids that intersected the landslide hazard area were totaled to estimate the building replacement cost value. Socially vulnerable populations and land area were estimated by completing an area calculation against the landslide hazard area. State roadways were estimated by clipping the State roads to the landslide hazard area and calculating mileage.

4.5.6 Levee Failure

The levee failure hazard area was determined using delineated flood hazard zones protected by a levee throughout the State. These areas were analyzed during the exposure assessment to determine what population, State-owned and -leased facilities, and critical facilities are located within the hazard area. To estimate exposure, the levee failure hazard data was overlaid on the centroids of the State and critical facilities. Centroids that intersected the levee failure area boundary were totaled to estimate the building replacement cost value. Socially vulnerable populations and land area were estimated by completing an area calculation against the levee failure hazard area. State roadways were estimated by clipping the State roads to the levee failure hazard area and calculating mileage.

4.5.7 Radiological Incidents

Radiological Incidents data was created by assigning both a 10-mile and 50-mile buffer around the Beaver Valley Atomic Power Station in Pennsylvania, to correspond to the plume exposure pathway emergency planning zone (EPZ) and the ingestion exposure pathway EPZ, respectively. During the exposure assessment, the State determined what population, State facilities, and critical facilities are located within the assigned EPZs. To estimate exposure, the radiological incidents buffers were overlaid on the centroids of the State and critical facilities. Centroids that intersected the radiological incidents buffer boundaries were totaled to estimate the building replacement cost value. Socially vulnerable populations and land area were estimated by completing an area calculation against the radiological incidents buffer hazard area. State roadways were estimated by clipping the State roads to the radiological incidents hazard area and calculating mileage.

4.5.8 Severe Storms

A Hazus probabilistic analysis was performed in Hazus v6.0 to analyze the possible wind hazard losses for West Virginia for the 1000-year Mean Return Period (MRP) event. The probabilistic Hazus hurricane model activates a database of thousands of potential storms that have tracks and intensities reflecting the full spectrum of Atlantic hurricanes observed since 1886 and identifies those with tracks associated with the State. Hazus contains data on historic hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. The critical facility inventory was used for the analysis. Results are displayed for essential facilities by the estimated loss of days, and percent-probability of sustaining damage per facility type.

4.5.9 Subsidence

Subsidence data, including karst and abandoned mine lands were analyzed during the exposure assessment. To estimate exposure, the subsidence hazard datasets (i.e., areas underlain by limestone bedrock or mines) were overlaid on the centroids of the State and critical facilities. Centroids that intersected the subsidence hazard area boundaries were totaled to estimate the building replacement cost value. Socially vulnerable populations and land area were estimated by completing an area calculation against the subsidence hazard area. State roadways were estimated by clipping the State roads to the subsidence hazard area and calculating mileage.

4.5.10 Wildfire

An exposure assessment was conducted and results generated for the intermix and interface wildfire risk areas. For the purposes of the 2023 SHMP risk assessment, assets located in these two risk areas are deemed exposed and vulnerable. Wildfire data was analyzed during our exposure assessment to determine what population, State facilities, and critical facilities are located within the hazard area. To estimate exposure, the wildfire hazard data was overlaid on the centroids of the State and critical facilities. Centroids that intersected the wildfire hazard area boundaries were totaled to estimate the building replacement cost value. Socially vulnerable populations and land area were estimated by completing an area calculation against the wildfire hazard area. State roadways were estimated by clipping the State roads to the wildfire hazard area and calculating mileage.

4.5.11 Other Hazards

To assess the vulnerability of the State to the other hazards of concern (listed below) and their associated impacts, a qualitative assessment was conducted.

- Drought
- Extreme Temperatures
- Pandemic
- Radon Exposure
- Utility Failure
- Winter Weather

4.6 Limitations

The spatial hazard data used in this plan was generated by multiple agencies and organizations. Due to differing processes of data generation between these entities, spatial layer boundaries may not accurately align with each other.

The worst-case scenarios used are for planning purposes only and may not represent the actual worst-case a geographic area may experience. Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best-available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning hazards and their effects on the built environment. The reader is urged to use caution when interpreting these results as each hazard event is unique, and projections regarding future conditions may change over time as technology and science advances. Uncertainties also result from the following:

- Approximations and simplifications necessary to conduct a study
- Incomplete or outdated inventory, demographic, or economic parameter data
- The unique nature, geographic extent, and severity of each hazard event
- Mitigation measures already employed
- The amount of advance notice residents have to prepare for a specific hazard event

These factors can affect loss estimates by a factor of two or more. Therefore, potential exposure and loss estimates are approximate and should be used only to understand relative risk. Over the long term, the State of West Virginia will continue to collect additional data, and update and refine existing inventories, to assist in estimating potential losses.

Potential economic loss is based on the present value of the State buildings and general building stock utilizing best-available data. The State acknowledges significant impacts may occur to critical facilities and infrastructure (such as roads, airports, utilities) as a result of these hazard events, causing great economic loss not only to one community, but potentially cascading impacts throughout the State. However, monetized damage estimates to critical facilities and infrastructure, and economic impacts were not quantified and require more detailed loss analyses. In addition, economic impacts to industry (e.g., mining, timber) and the real estate market were not analyzed.

SECTION 5. HAZARD OVERVIEW

Section 4: Risk Assessment describes the process the State of West Virginia (the State) undertook to identify the hazards of concern for the 2023 State Hazard Mitigation Plan (SHMP). Sections 5.1 through 5.16 profile and assess the vulnerability and consequences of the following hazards (listed in alphabetical order, not in order of priority, consequence, or likelihood):

5.1 Dam Failure

5.2 Drought

5.3 Earthquake

5.4 Extreme Temperatures

5.5 Flood

5.6 Hazardous Materials

5.7 Landslide

5.8 Levee Failure

5.9 Pandemic

5.10 Radiological Incidents

5.11 Radon Exposure

5.12 Severe Storms

5.13 Subsidence

5.14 Utility Failure

5.15 Wildfire

5.16 Winter Weather

For each hazard, the profile includes the hazard description, its location, the range of extent of impacts, previous occurrences and losses, and the probability of future hazard events. The vulnerability assessment for each hazard examines potential losses to State assets, critical facilities and community lifelines, and the State's population. It also examines future changes and conditions that may impact vulnerability to the hazard. The consequence analysis for each hazard, in accordance with the Emergency Management Accreditation Program's (EMAP) *Emergency Management Standard* (Emergency Management Accreditation Program 2020), describes the hazard's impact to the public; responders; continuity of operations; property, facilities, and infrastructure; the environment; the economic condition of the State; and the public's confidence in the State's ability to govern.

5.1 Dam Failure

2023 SHMP Update Changes

- The hazard profile was reorganized and significantly enhanced to include detailed descriptions of the following: hazard definition, location, extent, previous occurrences, and probability of future occurrences (including how future conditions may impact the hazard).
- Dam failure events that occurred in the State of West Virginia (the State) from January 1, 2017, through December 31, 2022, were researched for this 2023 State Hazard Mitigation Plan (SHMP) Update.
- New and updated figures from federal, state, and local agencies are incorporated.
- State asset exposure to statewide dam inundation areas was analyzed. Local vulnerability was assessed using dam inundation areas of state-regulated dams.

5.1.1 Hazard Profile

Hazard Description

A dam is an artificial barrier allowing storage of water, wastewater, or liquid-borne materials for many reasons (flood control, human water supply, irrigation, livestock water supply, energy generation, containment of mine tailings, recreation, or pollution control) (Association of State Dam Safety Officials 2022).

Dam failures occur when the dam is damaged or destroyed, releasing water or other liquid stored behind the dam. Throughout history, hundreds of dams failed in the United States, causing property and environmental damage, injuries, and fatalities. According to the Association of State Dam Safety Officials, dam failures are most likely to occur as a result of the following (Association of State Dam Safety Officials 2021):

- Overtopping caused by water spilling over the top of a dam;
- Foundation defects, including settlement and slope instability;
- Cracking caused by movement;
- Inadequate maintenance and upkeep; and
- Seepage through a dam that is not properly filtered so that soil particles form sink holes in the dam (Association of State Dam Safety Officials 2021).

To minimize the likelihood of a dam failure, the WVDEP requires that dams be inspected every one to two years. The West Virginia Dam Control and Safety Act (West Virginia State Code §22-14) defines state-regulated dams as:

- 25 feet or more in height and impound 15 or more acre-feet (4,917,420 gallons) of water volume; or
- 6 feet or more in height and impound 50 or more acre-feet (16,391,400 gallons) of water volume (West Virginia Department of Environmental Protection 2023).

Exemptions from state-regulated dams include the following:

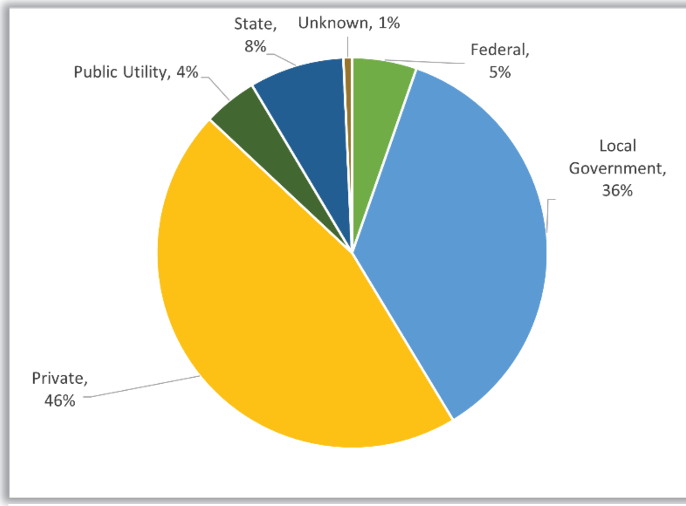
- Dams owned by the federal government;

- Dams that do not normally impound water, such as road fills with culverts sized to West Virginia Division of Highway (WVDOH) standards; or
- Dams built primarily for agricultural purposes and demonstrated to not cause loss of life if the dam fails (West Virginia Department of Environmental Protection 2023).

Location

The U.S. Army Corps of Engineers National Inventory of Dams (NID) identifies 561[1] dams in West Virginia (U.S. Army Corps of Engineers 2023). The NID lists 113 federally-regulated dams, meaning that the other 448 dams would be regulated by the State. Dams and reservoirs owned by the federal government are not subject to state jurisdiction except as otherwise provided by federal law. The state-regulated dams fall under the jurisdiction of West Virginia Department of Environmental Protection (WVDEP) Division of Dam Safety. The WVDEP Division of Dam Safety's participation in the 2023 SHMP update process is documented in Section 3 (Planning Process).

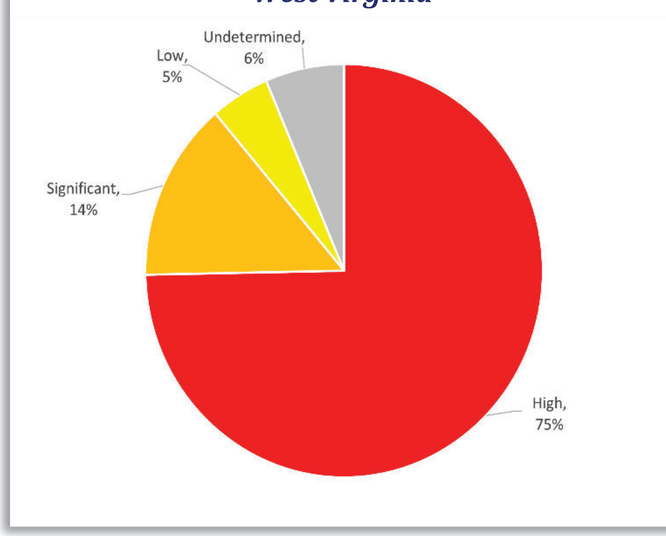
Figure 5.1-1. Dam Ownership in West Virginia



Source: USACE 2023

According to the WVDEP, there are 517 State-regulated dams in West Virginia. Therefore, there is uncertainty as to how many dams actually exist in the State. Section 11 (Mitigation Actions) includes Action DEP-5 for the State to determine how many dams exist in the State, and to ensure that data maintained by the NID, WVEMD, WVDEP, and the West Virginia University GIS Technical Center (WVU GISTC) are complete and consistent.

Figure 5.1-2. Hazard Classification of Dams in West Virginia



Source: USACE 2023

The analysis in this hazard profile reflects the dams listed in the NID. A full list of these dams is included in Appendix C. According to the U.S. Army Corps of Engineers, there are 30 dams in West Virginia owned by federal government agencies, such as the U.S. Army Corps of Engineers and the U.S. Forest Service, as shown in Figure 5.1-1 (U.S. Army Corps of Engineers 2023). As shown in Figure 5.1-2, of the 561 dams, 419 have been identified as having high

[1] The full list of dams in West Virginia includes 562 dams, but one is actually located in the Commonwealth of Virginia.

hazard downstream potential. Additional information can be accessed on the U.S. Army Corps of Engineers website (https://nid.sec.usace.army.mil/#/) and the WVDEP website (https://dep.wv.gov/WWE/ee/ds/Pages/default.aspx). The number of dams in each county is shown in Table 5.1-1.

Table 5.1-1. Dams in West Virginia, by County

County	Total Number of Dams in County	Number of High Hazard Dams	Number of Significant Hazard Dams	Number of Low Hazard Dams	Number of Undetermined Hazard Dams
Barbour	2	1	1	0	0
Berkeley	5	3	1	0	1
Boone	12	12	0	0	0
Braxton	7	7	0	0	0
Brooke	8	8	0	0	0
Cabell	6	4	0	2	0
Calhoun	1	1	0	0	0
Clay	2	1	0	0	1
Doddridge	2	1	1	0	0
Fayette	12	8	0	2	2
Gilmer	0	0	0	0	0
Grant	21	19	2	0	0
Greenbrier	5	5	0	0	0
Hampshire	5	0	4	0	1
Hancock	3	1	1	0	1
Hardy	9	8	0	1	0
Harrison	25	18	4	1	2
Jackson	14	8	4	0	2
Jefferson	5	1	2	2	0
Kanawha	18	12	5	1	0
Lewis	16	11	0	2	3
Lincoln	2	2	0	0	0
Logan	5	4	0	0	1
Marion	14	12	1	0	1
Marshall	19	16	2	1	0
Mason	14	7	6	0	1
McDowell	9	5	0	0	4
Mercer	20	19	1	0	0
Mineral	32	26	5	1	0
Mingo	10	9	1	0	0
Monongalia	16	8	3	4	1
Monroe	3	1	0	0	2
Morgan	15	11	2	1	1
Nicholas	8	7	1	0	0
Ohio	8	7	1	0	0
Pendleton	19	19	0	0	0
Pleasants	2	1	1	0	0
Pocahontas	8	2	4	1	1
Preston	20	11	7	2	0
Putnam	12	5	4	1	2
Raleigh	14	11	2	0	1
Randolph	6	3	0	2	1
Ritchie	7	3	2	1	1
Roane	8	5	1	0	2

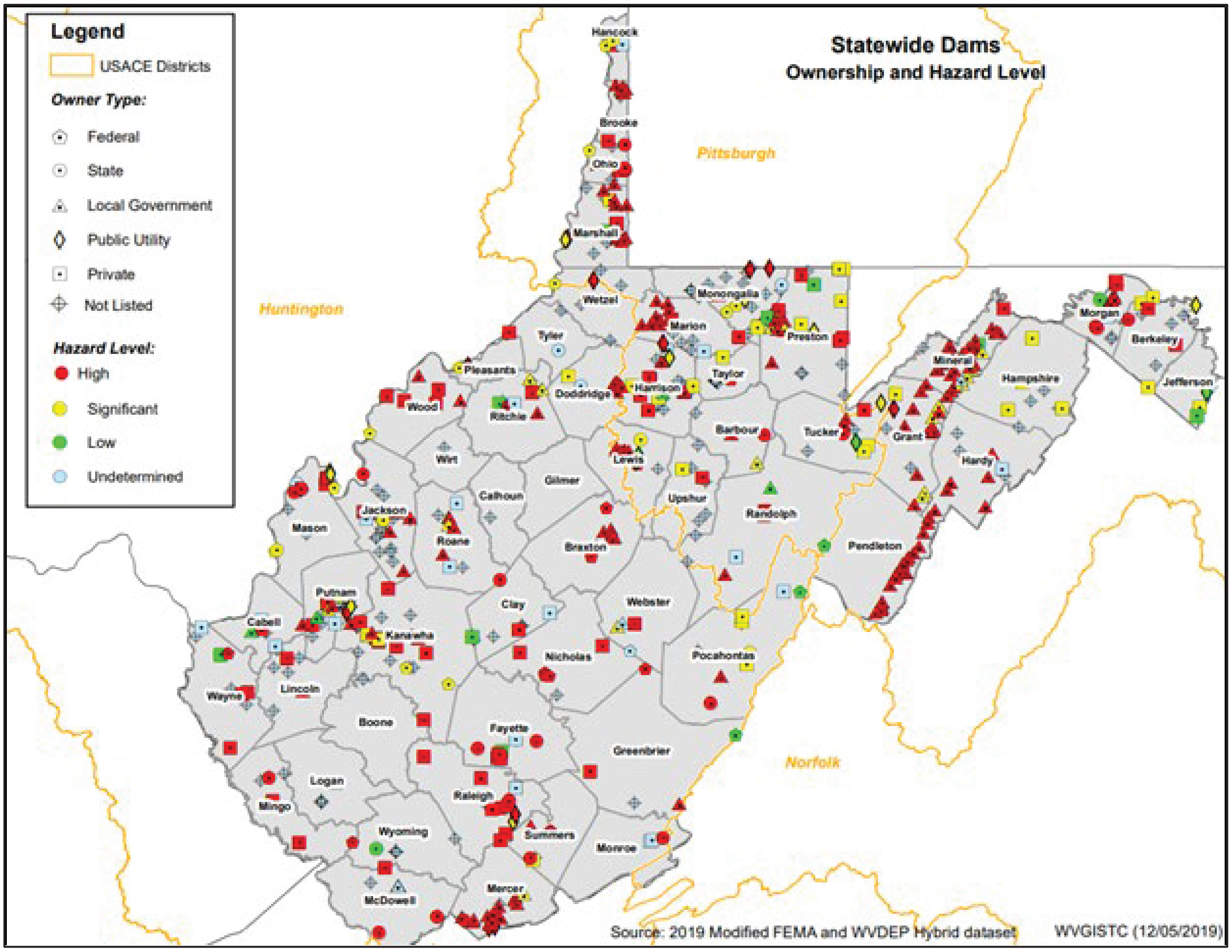
County	Total Number of Dams in County	Number of High Hazard Dams	Number of Significant Hazard Dams	Number of Low Hazard Dams	Number of Undetermined Hazard Dams
Summers	4	3	1	0	0
Taylor	2	2	0	0	0
Tucker	6	3	2	1	0
Tyler	2	2	0	0	0
Upshur	3	2	1	0	0
Wayne	7	6	0	0	1
Webster	4	1	1	0	2
Wetzel	2	1	1	0	0
Wirt	0	0	0	0	0
Wood	7	5	2	0	0
Wyoming	1	0	0	1	0
Unknown	74	71	2	0	1
Total (Statewide)	**561**	**419**	**79**	**27**	**36**

Source: USACE 2023

In the event of a failure or uncontrolled release of water, anything located within the inundation areas (downstream of the dam) would be flooded and impacts could be detrimental (Federal Emergency Management Agency 2013). Approximately 4.1 percent of the state's total square miles of land area is located within dam failure inundation areas. Mason County (48.2 percent), Putnam County (32.9 percent), and Cabell County (32.3 percent) have the greatest percentage of land in dam failure inundation areas (U.S. Army Corps of Engineers 2023) (WVU GISTC 2019).

Figure 5.1-3 illustrates the distribution of all dams (state- and non-state-regulated) throughout the state. Mineral County (32 dams), Harrison County (25 dams), Grant County (21 dams), and Mercer County (20 dams) have the largest number of dams in West Virginia. Regarding hazard classifications, Mineral County has the highest number of high hazard dams (26 dams), followed by Grant, Mercer, and Pendleton Counties with 19 high hazard dams each.

Figure 5.1-3. Dams Located in West Virginia



Source: WVU GISTC 2019

Extent

The West Virginia Division of Safety of Dams assigns hazard ratings to large dams in the state based on a classification system developed by the Federal Emergency Management Agency (FEMA) (WVDEP 2023). FEMA categorizes the downstream hazard potential into three categories in increasing severity: Low, Significant, and High (FEMA 2013).

WVDEP, in accordance with West Virginia State Code §47-34 (Dam Safety Rule), evaluates dams based on hazard potential downstream. Hazard potential is not related to the structural integrity of a dam but strictly to the potential for downstream flooding (West Virginia Department of Environmental Protection 2023). Table 5.1-3 provides the hazard potential definitions for each of the four hazard classes of dams in West Virginia and provides the number of dams associated with each classification, according to WVDEP.

Table 5.1-2. Downstream Hazard Potential Classification of Dams in West Virginia

Downstream Hazard Potential Classification	Dam Safety Regulations Definition	Number of Dams in West Virginia
Class 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.	412
Class 2 (Significant Hazard)	Dams located where failure may cause minor damage to dwellings, commercial or industrial buildings, important public utilities, main railroads, 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.	54
Class 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.	19
Class 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.	6

Sources: West Virginia Department of Environmental Protection 2023

Warning Time

High and significant hazard dam owners are required to prepare and maintain Monitoring & Emergency Action Plans (MEAP). The MEAP is to be used in the event of a potential dam failure or uncontrolled release of stored water. The monitoring portion of the plan sets forth a frequency of owner inspections that varies according to weather conditions. As heavy rainfall occurs, the frequency of inspections increases. If an imminent danger is identified, the emergency action portion of the plan is designed to notify the downstream communities to evacuate to the designated safe areas (WVDEP 2023).

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1954 and 2022, West Virginia was included in five major disaster (DR) or emergency (EM) declarations for dam failure-related events (FEMA 2023). These events were classified as flooding, heavy winds, slides, landslides, and mudslides. While dam failure was not identified in the declaration title or incident type, these events led to dam failures or incidents in West Virginia and are reflected in the table below.

Table 5.1-3. Dam Failure-Related Federal Declarations, 1954 to 2022

Date(s) of Event	Incident	Federal Designation	Counties Declared
January 19-February 2, 1996	Flooding	DR-1096-WV	Berkeley, Brooke, Grant, Greenbrier, Hampshire, Hancock, Hardy, Jefferson, Marshall, Mason, Mercer, Mineral, Monroe, Morgan, Nicholas, Ohio, Pendleton, Pleasants, Pocahontas, Preston, Raleigh, Randolph, Summers, Tucker, Tyler, Webster, Wetzel, Wood
May 15-June 10, 1996	Flooding	DR-1115-WV	Barbour, Boone, Harrison, Lincoln, Logan, McDowell, Mercer, Mingo, Pendleton, Pocahontas, Raleigh, Randolph, Tucker, Upshur, Wayne, Wetzel, Wyoming
February 28-March 15, 1997	Severe Storms/Flooding	DR-1168-WV	Braxton, Cabell, Calhoun, Clay, Gilmer, Jackson, Kanawha, Lincoln, Mason, Putnam, Roane, Tyler, Wayne, Wetzel, Wirt, Wood
April 14-18, 2007	Severe Storms, Flooding, Landslides, and Mudslides	DR-1696-WV	Barbour, Boone, Cabell, Gilmer, Grant, Hardy, Lewis, Lincoln, Logan, McDowell, Mingo, Pendleton, Pocahontas, Putnam, Upshur, Wayne, Webster, Wyoming
May 3-June 8, 2009	Severe Storms, Flooding, Mudslides, and Landslides	DR-1838-WV	Calhoun, Gilmer, Lewis, McDowell, Mercer, Mingo, Raleigh, Roane, Upshur, Wirt, Wyoming

Sources: Federal Emergency Management Agency 2023
FEMA Federal Emergency Management Agency
N/A Not Applicable
USDA U.S. Department of Agriculture

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was not included in any dam failure-related agricultural disaster declarations (USDA 2023).

Previous Events

In the past 100 years, there have been several dam failures or incidents in West Virginia. Table 5.1-5 lists dam failure events that impacted the State since 1890. This table includes events identified in the 2018 SHMP and events that occurred between January 1, 2018 through December 31, 2022.

Table 5.1-4. Dam Failure Events in the State of West Virginia (1890 to 2022)

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
March 31, 1890	Dam Incident at Little Kanawha River Dam	N/A	Putnam County	Details of this incident were not found during the 2023 SHM
January 1, 1914	Dam Incident at Stony River Dam	N/A	Grant County	There was an uncontrolled release of the reservoir at this da found regarding this incident.
1914 (exact date unknown)	Dam Failure	N/A	Lincoln County	Catastrophic failure of a coal mine tailings dam.
January 15, 1914	Dam Failure of Old Stony River Dam	N/A	Grant County	A reinforced concrete dam failed during a winter storm.
August 9, 1916	Dam Failure of Unnamed Dams	N/A	Kanawha and Boone Counties	Three dam failures were reported on August 9, 1916, as a re included one in Boone County and two in Kanawha County. and 75 deaths related to the flooding impacts. • Boone County – An inflow flood caused a dam failu • Kanawha County - An inflow flood caused an unna Valley to break, resulting in extensive damage in th $600,000 in damages. Rail lines, telephones, and c impacted. Another failure was reported between A
February 26, 1972	Dam Failure and Flooding – Buffalo Creek Dam	N/A	Logan County	Buffalo Creek flooding disaster was due to a catastrophic da consisted of three embankments. One embankment failed a the earthen dam, causing the subsequent failure of the othe wave barreling through Logan County that killed 139 people dollars worth of property. Since the Buffalo Creek Dam failu Virginia has not experienced deaths due to a dam failure.
January 1, 1973	Dam Incident at Gath Right Dam	N/A	Morgan County	Overtopping resulted in breaching at the left abutment. This incidents.
May 1, 1974	Dam Incident at Gath Right Dam	N/A	Morgan County	Overtopping resulted in breaching at the left abutment. Did this incident (third of three), though considerable downstrea
January 1, 1975	Dam Incident at R.D. Bailey Permanent Cofferdam	N/A	Mingo County	Overtopping and lateral and downward erosion were report additional details regarding this incident were found.
May 30, 1975	Dam Incident at Millville Dam	N/A	Hampshire County	Dam cap failed; no additional details regarding this incident
September 30, 1988	Dam Incident at Millville Dam	N/A	Hampshire County	A cavity was found in Block 13 of the dam foundation, near e from upstream to downstream, with dimensions of 23 feet w

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
January 19, 1996	Dam Incidents at Bruceton Mills Dam, Coolfont Dam, Terra Alta Lake Dam, and Thomas Dam	DR-1060-WV	Preston, Morgan, and Tucker Counties	• Bruceton Mills Dam - The dam was completely ove The masonry blocks at the left abutment were was that area. The West Virginia Division of Water and Section sent the owner a legal order requiring eme • Coolfont Dam – Adverse conditions were reported and emergency open channel spillways were repor • Terra Alta Lake Dam - The dam was overtopped in severe erosion and the loss of the majority of the d bridge was also damaged. The downstream face w Preston County Office of Emergency Services (OES accordance with the emergency action plan (EAP). Safety sent the owners a legal order requiring eme the spillway was closed to traffic, pending repairs. • Thomas Dam - Standby alert conditions were repo were notified of the situation by the Tucker County Maximum overtopping of the parapet wall was 8.5 placed to prevent erosion at the right abutment af February 1994 remained in good condition.
January 29, 1996	Dam Incident at Ranch Lake Estates Dam	DR-1060-WV	Putnam County	There was erosion visible along both sides of the outlet struc visible around the outlet end of both of the pipes. The owne drainpipe. The riser was subsequently demolished to effectiv ability to impound water. The current configuration classifie (non-jurisdictional within the scope of West Virginia Dam Co
May 16, 1996	Dam Incidents at Coolfont Dam and Lake Floyd Dam	DR-1115-WV	Morgan and Harrison Counties	• Coolfont Dam - Owners of the dam reported emer from Environmental Enforcement checked the con damage. • Lake Floyd Dam - Reservoir rose to within three inc embankment before subsiding during heavy rainfa monitors. No damage was reported.
May 31, 1996	Dam Incident at Chief Logan State Park Dam	N/A	Logan County	Erosion along the embankment of dam occurred during the f of this incident, the reservoir remained drained until repairs damages were reported.
June 19, 1996	Dam Incident at Indian Rocks Park Dam	N/A	Nicholas County	The Indian Rocks Park Dam overtopped during heavy thunde suffered considerable erosion but did not fail. Downstream l precaution.
February 21, 1997	Incident at Lake Chaweva Dam	N/A	Kanawha County	According to an inspection report, the concrete chute spillwa joints, leaning side walls, evidence of undermining, and wash

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
				along the left spillway wall. The slumping of embankment m proximity to the spillway channel. The drainpipe was rusted outlet. The integrity of the drainpipe through the interior of downstream valve maintained the interior pipe under consta the potential for interior embankment saturation and erosio a serious problem as defined in the Dam Safety Regulations drawdown began, a landslide developed within the reservoir agreed to a reduced rate of drawdown. An order was issued to drain the reservoir, submit an EAP, and submit plans to re
March 1, 1997	Dam Incident at Victor Ryan Embankment Pond	DR-1168-WV	Unknown	State Dam Safety personnel inspected the dam at Victor Rya reservoir overtopped, leaving the structure in a weakened co flowing down the hill at the left abutment and across the cre the downstream face of the embankment. A seepage zone w abutment with a flow of approximately 5 to 10 gallons per m
March 3, 1997	Dam Incident at Lake Washington Dam	DR-1168-WV	Putnam County	The wooden flashboards along the crest of the concrete amb out. No damage to the concrete ambursen structure was ob flashboards and associated pipe supports were removed afte in lower reservoir levels of approximately three feet. No dov
October 11, 2000	Dam Failure in Big Sandy River watershed's Tug Fork	N/A	Mingo County	A dam in Inez, Kentucky affected WV streams and caused $5 both states.
July 19, 2002	Dam Failure	N/A	Logan County	A coal waste valley fill slid into a pond, causing it to discharg emergency spillway and overtop, destroying three houses.
August 8, 2003	Dam Incident at Millville Dam	N/A	Jefferson County	A cavity with irregular shape was found on Block 12 of the da entrance is in rock approximately 12 feet underneath the bo the downstream face of the concrete apron. No damages or event.
April 15, 2007	Dam Failure - Lee's Fishing Lake Dam	DR-1696-WV	Lincoln County	A privately-owned pond, Lee's Fishing Lake, rose 22 inches a hours. Nearly 1,000 people were evacuated, but no damage was reported.
January 1, 2008	Dam Failure – Falls Run Dam	N/A	Marion County	The Falls Run Dam was breached by the West Virginia Depar Protection after a pipe clogged. No injuries, deaths or damag
May 4, 2009	Dam Incident at Lake Lynn Dam	DR-1838-WV	Monongalia County	Staff at the Allegheny Energy Supply Company, LLC observed the hillside located approximately 85 yards downstream fro abutment). This was most likely due to the excessive rainfall damages or injuries were reported for this event.

Sources: Association of State Dam Safety Officials 2023, FEMA 2023; National Performance of Dams Program 2018, West Virginia Emergency Manageme

DR	*Major Disaster Declaration (FEMA)*
FEMA	*Federal Emergency Management Agency*

PROBABILITY OF FUTURE HAZARD EVENTS

Overall Probability

Dam failures are infrequent and usually coincide with events that cause them, such as landslides, excessive rain, and flooding. Earthquakes can cause structural damage to a dam. Floods can result in dams being overtopped, leading to scour of the base of the dam, and the force of floodwaters reaching a dam can cause structural damage to the dam. Likewise, if a major landslide reaches a waterway, it could cause a wave of water to forcefully impact a dam downstream. Landslides can also directly affect the ground around a dam structure, causing structural damage or erosion around the base of a dam. Any of these events cascading impacts of other hazards could increase the probability of a dam failure.

Dam incidents, which are less severe than actual dam failures, occurred multiple times per year in 1996 and 1997. According to FEMA, the National Performance of Dams Program, and the 2018 SHMP, the State experienced 26 dam failures/incidents between 1890 and 2022, as summarized in Table 5.1-6. Overall, the state is expected to experience fewer than one event every five years, with the possibility of an increase in frequency due to future changing conditions and aging infrastructure.

Table 5.1-5. Probability of Future Landslide Events in West Virginia

Hazard Type	Number Of Occurrences Between 1890 And 2022	Percent Chance of Occurrence in Any Given Year
Dam Failure	26	19.5%

Sources: National Performance of Dams Program 2018, West Virginia Emergency Management Division 2018, Federal Emergency Management Agency 2023

Projected Future Conditions

Projected future conditions may impact storm patterns and increase the probability of more frequent, extreme precipitation events and flooding, leading to increased risk of dam failures and incidents (Leslie 2019). In West Virginia, heavy rainstorms are becoming more frequent. Since 1895, total annual precipitation has been highly variable with a slight increase. Winter and spring precipitation totals are projected to increase, as well as the number and intensity of extreme precipitation events, creating an increased flood risk (NOAA National Centers for Environmental Information 2022).

Between 2010 and 2019, flooding has been the largest driver for dam failures in the United States. With projections of increased flooding and precipitation events, dams located in West Virginia may be more at risk of overtopping and failures associated with flooding (Association of State Dam Safety Officials 2021). Extreme rainfall events can severely damage dams or cause them to fail. Many older dams are not designed to modern standards and may not be able to withstand extreme weather events. The spillway systems of these dams may not be able to safely store or pass the excessive rain. This increased dam failure risk from projected flooding and precipitation events can lead to loss of life and property; impacts to the economy, infrastructure, and community; loss of water resources; and loss of flood protection (Association of State Dam Safety Officials 2015). With these projections, more intense events, combined with the aging dam infrastructure, could result in more dam failure incidents (Leslie 2019).

5.1.2 Vulnerability Assessment

To assess the vulnerability of state assets to the dam failure hazard, GIS software was used to overlay dam failure inundation areas with state facilities.

State Assets

Table 5.1-7 and Table 5.1-8 summarize the number and replacement cost value of state facilities located within dam failure inundation hazard areas. Kanawha County has the most facilities (147) and the highest total replacement cost value ($799,334,417) of State facilities. The Department of Health and Human Resources has the most facilities (28), while the Department of Administration General Services Division has the highest replacement cost value ($244,270,397) in the hazard area.

Table 5.1-6. State Facilities Located Within Dam Failure Inundation Areas, by County

State Facilities Located Within Dam Failure Inundation Hazard Area		Replacement Cost Value for State Facilities Within the Dam Failure Inundation Hazard Area By County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure and Contents)
Barbour	0	$0	$0	$0
Berkeley	0	$0	$0	$0
Boone	0	$0	$0	$0
Braxton	6	$2,419,153	$398,600	$2,817,753
Brooke	2	$0	$60,000	$60,000
Cabell	10	$12,047,696	$1,499,100	$13,546,796
Calhoun	1	$0	$300,000	$300,000
Clay	2	$0	$243,100	$243,100
Doddridge	0	$0	$0	$0
Fayette	3	$34,004,142	$2,690,000	$36,694,142
Gilmer	1	$0	$0	$0
Grant	0	$0	$0	$0
Greenbrier	0	$0	$0	$0
Hampshire	0	$0	$0	$0
Hancock	0	$0	$0	$0
Hardy	0	$0	$0	$0
Harrison	0	$0	$0	$0
Jackson	0	$0	$0	$0
Jefferson	0	$0	$0	$0
Kanawha	147	$627,036,530	$172,297,887	$799,334,417
Lewis	0	$0	$0	$0
Lincoln	1	$25,000	$0	$25,000
Logan	15	$23,475,000	$4,301,100	$27,776,100
Marion	3	$0	$77,500	$77,500
Marshall	4	$7,088,934	$871,000	$7,959,934
Mason	7	$225,000	$406,050	$631,050
McDowell	0	$0	$0	$0
Mercer	0	$0	$0	$0
Mineral	5	$2,747,022	$783,000	$3,530,022
Mingo	0	$0	$0	$0
Monongalia	3	$2,092,192	$606,425	$2,698,617
Monroe	0	$0	$0	$0
Morgan	0	$0	$0	$0
Nicholas	0	$0	$0	$0

State Facilities Located Within Dam Failure Inundation Hazard Area		Replacement Cost Value for State Facilities Within the Dam Failure Inundation Hazard Area By County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure and Contents)
Ohio	4	$8,904,384	$2,062,000	$10,966,384
Pendleton	0	$0	$0	$0
Pleasants	0	$0	$0	$0
Pocahontas	0	$0	$0	$0
Preston	0	$0	$0	$0
Putnam	14	$48,723,773	$25,767,725	$74,491,498
Raleigh	0	$0	$0	$0
Randolph	0	$0	$0	$0
Ritchie	0	$0	$0	$0
Roane	0	$0	$0	$0
Summers	0	$0	$0	$0
Taylor	2	$0	$422,000	$422,000
Tucker	0	$0	$0	$0
Tyler	0	$0	$0	$0
Upshur	0	$0	$0	$0
Wayne	5	$727,769	$755,000	$1,482,769
Webster	0	$0	$0	$0
Wetzel	0	$0	$0	$0
Wirt	0	$0	$0	$0
Wood	0	$0	$0	$0
Wyoming	0	$0	$0	$0
Total	235	$769,516,595	$213,540,487	$983,057,082

Sources: U.S. Army Corps of Engineers 2023, WVU GISTC 2019

Table 5.1-7. State Facilities Located Within Dam Failure Inundation Areas, by Agency

State Facilities Located Within Dam Failure Inundation Hazard Area		Replacement Cost Value for State Facilities Within the Dam Failure Inundation Hazard Area By Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Adjutant General's Office State of West Virginia	0	$0	$0	$0
Administration, Secretary of Department of Administration	1	$0	$112,000	$112,000
Agriculture, Department of State of West Virginia	0	$0	$0	$0
Air And Environmental Quality Boards State of West Virginia	1	$0	$60,000	$60,000
Alcohol Beverage Control Administration State of West Virginia	1	$8,398,535	$5,375,000	$13,773,535
Architects, Board of State of West Virginia	1	$0	$17,000	$17,000
Armory Board State of West Virginia	10	$67,621,146	$20,394,500	$88,015,646
Arts, Culture & History, Department of State of West Virginia	2	$4,384	$2,000	$6,384
Attorney General, Office of The State of West Virginia	0	$0	$0	$0
Aviation, Division of	0	$0	$0	$0
Bar, State State of West Virginia	0	$0	$0	$0
Barbers & Cosmetologists, Board of State of West Virginia	1	$0	$100,000	$100,000
Blue Ridge Community & Technical College	0	$0	$0	$0
Bluefield State College	0	$0	$0	$0
Board of Treasury Investments	1	$0	$70,000	$70,000

State Facilities Located Within Dam Failure Inundation Hazard Area		Replacement Cost Value for State Facilities Within the Dam Failure Inundation Hazard Area By Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Bridgevalley Community & Tech College	1	$29,146,767	$2,690,000	$31,836,767
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	1	$0	$100,000	$100,000
Commission For National And Community Service, WV	1	$0	$80,000	$80,000
Concord University	0	$0	$0	$0
Conservation Agency, West Virginia State of West Virginia	2	$0	$11,000	$11,000
Consolidated Public Retirement Board Department of Administration	1	$0	$1,500,000	$1,500,000
Consumer Advocate, Division of WV Public Service Commission	1	$0	$150,000	$150,000
Corrections, Division of State of West Virginia	4	$11,148,000	$1,253,000	$12,401,000
Courthouse Facilities Improvement Authority	1	$300,000	$200,000	$500,000
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	0	$0	$0	$0
Dietitians, Board of Licensed	0	$0	$0	$0
Eastern Panhandle Instructional Coop	1	$0	$50,000	$50,000
Eastern WV Community & Tech. College	0	$0	$0	$0
Economic Development Authority State of West Virginia	0	$0	$0	$0
Economic Development, WV Dept of	0	$0	$0	$0
Education, Department of State of West Virginia	5	$0	$570,000	$570,000
Educational Broadcasting Authority State of West Virginia	0	$0	$0	$0
Enterprise Resource Planning Board, WV	1	$0	$2,000,000	$2,000,000
Environmental Protection, Division of State of West Virginia	7	$11,500	$1,101,591	$1,113,091
Ethics Commission, West Virginia Department of Administration	1	$65,000	$65,000	$130,000
Examiners In Counseling, Board of State of West Virginia	1	$0	$6,000	$6,000
Fairmont State University	0	$0	$0	$0
Fire Commission State of West Virginia	1	$0	$500,000	$500,000
Fleet Management Office, Dept of Admin State of West Virginia	1	$0	$50,000	$50,000
Forestry, Division of State of West Virginia	0	$0	$0	$0
General Services Division Department of Administration	12	$223,442,223	$20,828,174	$244,270,397
Geological And Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	0	$0	$0	$0
Governor, Office of The State of West Virginia	1	$0	$2,000,000	$2,000,000
Health & Human Resources, Department of State of West Virginia	28	$113,490,000	$48,680,000	$162,170,000
Higher Education Policy Commission, WV	2	$17,580,000	$1,542,246	$19,122,246
Highways, Division of State of West Virginia	23	$33,542,098	$8,503,236	$42,045,334
Homeland Security & Emergency Management Division	1	$0	$205,000	$205,000
Insurance Commissioner, Office of The State of West Virginia	0	$0	$0	$0
Investment Management Board, WV State of West Virginia	1	$0	$2,500,000	$2,500,000
Joint Committee On Government & Finance State of West Virginia	0	$0	$0	$0
Justice & Community Services, Div. of	1	$0	$750,000	$750,000
Juvenile Services, Division of	5	$7,504,700	$1,399,800	$8,904,500

State Facilities Located Within Dam Failure Inundation Hazard Area		Replacement Cost Value for State Facilities Within the Dam Failure Inundation Hazard Area By Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Labor, Division of State of West Virginia	1	$0	$975,000	$975,000
Land Division/Dept of Agriculture State of West Virginia	0	$0	$0	$0
Landscape Architects, Board of State of West Virginia	1	$0	$2,500	$2,500
Library Commission State of West Virginia	0	$0	$0	$0
Lottery Commission State of West Virginia	1	$46,200,000	$8,500,000	$54,700,000
Marshall University	0	$0	$0	$0
Military Affairs, Secretary of And Public Safety	1	$0	$350,000	$350,000
Miner's Health Safety, Division of And Training, State of West Virginia	0	$0	$0	$0
Motor Vehicles, Division of State of West Virginia	6	$1,000,000	$5,203,000	$6,203,000
Mountain State Esc	1	$1,000,000	$250,000	$1,250,000
Mountwest Community & Technical College	0	$0	$0	$0
National Coal Heritage Area Authority	0	$0	$0	$0
Natural Resources, Division of State of West Virginia	3	$50,000	$1,003,000	$1,053,000
New River Community & Technical College	0	$0	$0	$0
Northern Community & Tech College, WV College Square	1	$8,900,000	$2,000,000	$10,900,000
Occupational Therapy Board State of West Virginia	0	$0	$0	$0
Office of Technology/IS&C Department of Administration	5	$0	$22,382,000	$22,382,000
Osteopathic Medicine, WV Board of State of West Virginia	1	$0	$25,000	$25,000
Osteopathic Medicine, WV School of	3	$0	$26,900	$26,900
Parks, West Virginia State C\O Division of Natural Resources	4	$7,061,496	$744,100	$7,805,596
Pharmacy, Board of State of West Virginia	1	$850,000	$80,000	$930,000
Physical Therapy, Board of State of West Virginia	0	$0	$0	$0
Pierpont Community And Technical College	0	$0	$0	$0
Practical Nurses, Board of State of West Virginia	0	$0	$0	$0
Prosecuting Attorneys Institute, WV	1	$0	$121,000	$121,000
Psychologists Examiners, Board of State of West Virginia	1	$0	$45,000	$45,000
Public Service Commission State of West Virginia	2	$14,844,069	$3,365,000	$18,209,069
Purchasing, Division of Department of Administration	2	$155,000	$1,196,000	$1,351,000
Rail Authority State of West Virginia	0	$0	$0	$0
Real Estate Commission State of West Virginia	1	$0	$150,000	$150,000
Regional Jail & Corr. Fac. Authority State of West Virginia	0	$0	$0	$0
Registered Nurses, Board of State of West Virginia	1	$0	$250,000	$250,000
Rehabilitation Services Division of Commerce	6	$0	$6,295,249	$6,295,249
Respiratory Care, WV Board of	0	$0	$0	$0
School Building Authority, West Virginia	1	$500,000	$300,000	$800,000
Schools For The Deaf And The Blind State of West Virginia	0	$0	$0	$0
Senior Services, Bureau of State of West Virginia	0	$0	$0	$0
Shepherd University	0	$0	$0	$0
Southern Educational Services Coop	0	$0	$0	$0
Southern WV Community & Tech College	0	$0	$0	$0
Speech Pathology & Audiology Examiners West Virginia Board of	0	$0	$0	$0
State Police, West Virginia Dept of Military Affairs & Public Safety	16	$25,761,623	$11,763,600	$37,525,223
Supreme Court of Appeals State of West Virginia	14	$0	$2,640,800	$2,640,800
Tax Appeals, WV Office of	1	$0	$130,000	$130,000
Tax Department State of West Virginia	3	$0	$5,110,000	$5,110,000

State Facilities Located Within Dam Failure Inundation Hazard Area		Replacement Cost Value for State Facilities Within the Dam Failure Inundation Hazard Area By Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Treasurer of State State of West Virginia	2	$0	$1,165,000	$1,165,000
University Physicians And Surgeons	6	$530,000	$665,000	$1,195,000
Unknown	16	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	0	$0	$0	$0
Veterinary Medicine, Board of State of West Virginia	0	$0	$0	$0
Water Development Authority State of West Virginia	1	$6,500,000	$1,000,000	$7,500,000
West Liberty University	0	$0	$0	$0
West Virginia Parkways Authority	3	$4,673,500	$3,485,000	$8,158,500
West Virginia State University - Institute	1	$130,503,950	$9,519,200	$140,023,150
West Virginia State University - Malden	1	$1,114,000	$115,000	$1,229,000
West Virginia University	0	$0	$0	$0
West Virginia University Arthurdale	0	$0	$0	$0
West Virginia University At Parkersburg	0	$0	$0	$0
West Virginia University Beckley	0	$0	$0	$0
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	1	$14,207	$777,591	$791,798
West Virginia University Fort Ashby	1	$2,747,022	$705,000	$3,452,022
West Virginia University Granville	0	$0	$0	$0
West Virginia University Jacksons Mill	0	$0	$0	$0
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	0	$0	$0	$0
West Virginia University Montgomery	1	$4,857,375	$0	$4,857,375
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	0	$0	$0	$0
West Virginia University Wardensville	0	$0	$0	$0
West Virginia University Weston	0	$0	$0	$0
Workforce West Virginia	1	$0	$50,000	$50,000
WV Public Employees Grievance Board	1	$0	$285,000	$285,000
WVsom Clinic Inc Dba Robert C Byrd Clinic	0	$0	$0	$0
Total (WV State)	235	$769,516,595	$213,540,487	$983,057,082

Sources: U.S. Army Corps of Engineers 2023, WVU GISTC 2019

Critical Facilities and Community Lifelines

Transportation routes, including bridges and highways, are vulnerable to inundation from dam failures and have the potential to be destroyed, creating isolation and supply chain issues. Those that are most vulnerable are those that are already in poor condition or older in age and would not be able to withstand large amounts of water. Table 5.1-9 summarizes the total number of critical facilities, by community lifeline, located in the dam inundation areas statewide.

Table 5.1-8. Critical Facilities and Community Lifelines Exposure to Dam Failure Inundation Areas

Lifeline Category	Total Number of Facilities	Number of Facilities in Hazard Area	% of Total Facilities
Communications	7	6	85.7%
Energy	0	0	0.0%
Food, Water, Shelter	8	2	25.0%
Hazardous Material	0	0	0.0%

Health & Medical	12	3	25.0%
Safety & Security	149	46	30.9%
Transportation	9	3	33.3%
Total	**185**	**60**	**32.4%**

Sources: U.S. Army Corps of Engineers 2023, WVU GISTC 2019

Population

A minor dam failure may wash out into small streams or open fields, with little to impacts of populated areas. A major dam failure can greatly increase flooding and subsequent damages, buildings, infrastructure, and lifelines within inundation hazard areas. This could also lead to loss of life and injury, displacement, and increased distress of residents. Those that rely on water supply protected by dams, in the event the dam fails, they may lose access to drinking water (Federal Emergency Management Agency 2016). The risk analysis for dam failure found that 5.5 percent (100,100 people) of the state's total population lives within dam failure inundation hazard areas. Details regarding the population located in dam failure inundation hazard areas are shown in Table 5.1-10.

Impacts on Socially Vulnerable Populations

The risk analysis for dam failure found that 21.3 percent of people exposed to the dam failure inundation hazard areas are identified as socially vulnerable (21,344 people) (see Table 5.1-10). Studies have shown that socially vulnerable populations are more likely to be adversely affected by hazard events, like dam failures, and are less likely to recover such events (Flanagan, et al. 2011).

Table 5.1-9. Population Located Within the Dam Failure Inundation Hazard Area

County	Highly Vulnerable Population	Total Population	% Population Highly Vulnerable
Barbour	0	12	0.0%
Berkeley	0	2,470	0.0%
Boone	6	7	77.9%
Braxton	118	401	29.4%
Brooke	0	677	0.0%
Cabell	2,508	11,667	21.5%
Calhoun	0	141	0.0%
Clay	76	143	52.8%
Doddridge	0	0	0.0%
Fayette	116	1,910	6.1%
Gilmer	294	537	54.7%
Grant	0	0	0.0%
Greenbrier	0	4	0.0%
Hampshire	112	147	75.7%
Hancock	21	54	39.5%
Hardy	0	0	0.0%
Harrison	0	975	0.0%
Jackson	0	351	0.0%
Jefferson	0	306	0.0%
Kanawha	12,222	46,457	26.3%
Lewis	0	4	0.0%
Lincoln	0	821	0.0%
Logan	2,578	4,457	57.9%
Marion	156	2,167	7.2%
Marshall	711	1,735	41.0%
Mason	0	3,076	0.0%

County	Highly Vulnerable Population	Total Population	% Population Highly Vulnerable
McDowell	0	0	0.0%
Mercer	0	8	0.0%
Mineral	35	1,316	2.7%
Mingo	0	162	0.0%
Monongalia	73	2,216	3.3%
Monroe	0	24	0.0%
Morgan	0	216	0.0%
Nicholas	0	256	0.0%
Ohio	1,561	4,891	31.9%
Pendleton	0	0	0.0%
Pleasants	0	0	0.0%
Pocahontas	0	0	0.0%
Preston	0	0	0.0%
Putnam	0	4,805	0.0%
Raleigh	14	153	8.9%
Randolph	0	0	0.0%
Ritchie	0	0	0.0%
Roane	0	28	0.0%
Summers	50	1,145	4.4%
Taylor	694	1,399	49.6%
Tucker	0	0	0.0%
Tyler	0	0	0.0%
Upshur	0	0	0.0%
Wayne	0	4,281	0.0%
Webster	0	2	0.0%
Wetzel	0	0	0.0%
Wirt	0	126	0.0%
Wood	1	460	0.2%
Wyoming	0	91	0.0%
Total	21,344	100,098	21.3%

Sources: U.S. Army Corps of Engineers 2023, WVU GISTC 2019

Future Changes That May Impact State Vulnerability

Understanding future changes that may impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors in examining potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including impacts of future conditions

Potential or Projected Development

Any sections of growth located within the dam inundation areas and near the dam inundation areas could potentially be impacted by a dam failure. While existing floodplain development regulations in place at the county level may offer some protection for new development located in these areas, such protections would likely not be sufficient in many instances in the event of a catastrophic dam failure. This results from a number of factors, such as the extent of the dam inundation areas may be larger than the regulated floodplain and water depths and velocities may be stronger and higher than the 1 percent annual chance flood event.

Projected Changes in Population

While statewide population has declined over the past 10 years, population has increased in several areas throughout the state (e.g., Berkeley, Jefferson, and Monongalia Counties). From 2010 to 2019, the state's overall population decreased by 3.3 percent, and it is projected to decrease 7.8 percent by 2040 (West Virginia Department of Transportation 2020). As the overall population decreases, fewer people will be exposed to dam inundation hazard areas. However, counties with projected population increases, especially those with larger percentages living in dam inundation hazard areas, will have an increased risk of damages from dam failures.

Other Factors of Change

As discussed above, projected future conditions in West Virginia show an increased probability of more frequent, extreme precipitation and flooding events. Increased precipitation may stress dams, and the dams may not be able to retain and manage increases in water flow. With these projections, more intense events, combined with the aging dam infrastructure, could result in more dam failure incidents (Leslie 2019).

5.1.3 Consequence Analysis

Impacts to the Public

Impacts to the public are described in the Population section of Section 5.1.2, above.

Impacts to Responders

Dam failures can cause downstream flooding and can transport large volumes of sediment and debris, closing roadways and restricting access for residents and first responders. Other than the population in the dam failure inundation zone, the safety of the first responders on-scene is also at risk. First responders would be responsible for traffic control and responding to transportation accidents. They will also be responding to populations affected by flooding from the dam failure, risking their lives and safety while responding. All of these impacts can lead to burnout and secondary traumatic stress, even well after the response is over (Centers for Disease Control and Prevention 2018).

Impacts to Continuity of Operations

Dam failure events create flooding and downed trees, electrical wires, communication towers, and telephone poles and lines. Communication and power can be disrupted for days while utility companies work to repair the extensive damage. Continuity of operations, including continued delivery of services, may be impeded, and additional personnel would potentially be needed due to the lack of fire and police personnel in the state.

Impacts to Property, Facilities, and Infrastructure

Properties, facilities, and infrastructure located within dam inundation hazard areas can experience significant impacts and damages in the event of a dam failure. For State facilities and infrastructure impacts, refer to Table 5.1-7, Table 5.1-8, and Table 5.1-9. In addition, impacts to infrastructure (e.g., potable water intakes) from dam failure will mirror impacts due to flooding, as described in Section 5.5.

Table 5.1-10. State Roads Located Within Dam Failure Inundation Hazard Areas, by County

State Roads Located Within the Dam Failure Inundation Hazard Area			
County	Mileage of Roadway	County	Mileage of Roadway
Barbour	0.0	Mineral	10.7
Berkeley	0.1	Mingo	6.3
Boone	0.0	Monongalia	6.3
Braxton	34.1	Monroe	0.1
Brooke	1.2	Morgan	1.4
Cabell	14.4	Nicholas	15.2
Calhoun	4.3	Ohio	1.3
Clay	33.2	Pendleton	0.0
Doddridge	0.0	Pleasants	0.0
Fayette	15.5	Pocahontas	0.0
Gilmer	13.2	Preston	0.0
Grant	0.0	Putnam	49.5
Greenbrier	0.0	Raleigh	4.1
Hampshire	0.0	Randolph	0.0
Hancock	1.3	Ritchie	0.0
Hardy	0.0	Roane	0.0
Harrison	1.5	Summers	15.1
Jackson	1.4	Taylor	2.7
Jefferson	0.0	Tucker	0.0
Kanawha	75.7	Tyler	0.0
Lewis	0.0	Upshur	0.0
Lincoln	30.7	Wayne	36.4
Logan	62.1	Webster	0.1
Marion	1.2	Wetzel	0.0
Marshall	3.1	Wirt	0.8
Mason	52.3	Wood	0.9
McDowell	0.0	Wyoming	0.3
Mercer	0.0	**Total**	**496.5**

Sources: U.S. Army Corps of Engineers 2023, WVDOT 2021

IMPACTS TO THE ENVIRONMENT

Dam failures can cause downstream flooding and can transport large volumes of sediment and debris. Other examples of environmental impacts include pollution from septic system failures; pollution of potable water supplies; changes in configurations of streams; loss of wildlife habitats; and degradation of wetlands (Federal Emergency Management Agency 2012). The mining industry uses dams to contain mining waste (e.g., tailings containing crushed rock and processing fluids) and can cause significant impacts to the environment if they fail (Chambers 2023). A failure could release toxic materials into rivers and other bodies of water, affecting water and sediment quality and aquatic and human life (Kossoff 2014).

IMPACTS TO THE ECONOMIC CONDITION OF THE STATE

Depending on the severity of the dam failure event, damage to state assets can include structural damage from flooding, power outages, and debris. This can lead to road closures, limiting access to emergency personnel. Loss estimations for the dam failure hazard profiled in this assessment are based on complete damage of state facilities located within dam failure inundation hazard areas (refer to Table 5.1-7).

Another economic impact is mining. Impoundments and dams are an integral part of mining and are used to impound waste, store water for mine use, control runoff, and prevent flooding. Faulty design, construction, or operation can lead to a failure of the dam embankment or the containment system, resulting in the release of water or liquid-borne solid waste (Mine Safety and Health Administration 2023). A failure could significantly impact mining production, lead to fatalities and injuries, destroy homes and buildings, and cause environmental hazards depending on what is behind the dam. This was experienced in 1972 when three coal waste dams at the Buffalo Creek Mine failed, killing 125 people and injuring 1,100 more in communities downstream of the dams. Approximately 550 homes were destroyed, and more than 900 homes were damaged. Total property damage was estimated at $50 million (about $340 million in 2022 dollars) (Mine Safety and Health Administration 2022).

Impacts to Public Confidence in State Governance

One of the fundamental functions of government is to protect residents from threats to their health, safety, and welfare. Land use planning, public awareness, and emergency planning are all actions the government (state and local) can implement to help protect residents, buildings, critical facilities, and infrastructure. However, any type of dam failure can have negative impacts on how residents feel the government is responding to and protecting them from damages (TCEQ 2021).

5.2 Drought

2023 SHMP Update Changes

- Drought events that occurred in the State of West Virginia (the State) from January 1, 2015, through December 31, 2022, were researched for this 2023 State Hazard Mitigation Plan (SHMP) update.
- New and updated figures from federal and state agencies were incorporated.
- A qualitative vulnerability assessment was conducted at the state level to discuss drought impacts to state assets, critical facilities and lifelines, population, socially vulnerable populations, and future changes.

5.2.1 Hazard Profile

Hazard Description

Drought is a gradual phenomenon and is defined as a deficiency of precipitation over an extended period resulting in a water shortage (National Integrated Drought Information System 2022). This can lead to serious problems, including crop damages/losses and water supply shortages (National Weather Service 2022).

Types of Drought Defined

- Agricultural drought refers to the impacts on agriculture by factors such as rainfall deficits, soil water deficits, reduced ground water, or reservoir levels needed for irrigation.
- Meteorological drought is based on the degree of dryness or rainfall deficit and the length of the dry period.
- Hydrological drought is based on the impact of rainfall deficits on the water supply such as stream flow, reservoir and lake levels, and ground water table decline.
- Socioeconomic drought considers the impact of drought conditions (meteorological, agricultural, or hydrological drought) on supply and demand of some economic goods such as fruits, vegetables, grains, and meat. Socioeconomic drought occurs when the demand for an economic good exceeds supply because of a weather-related deficit in water supply (National Weather Service 2022).
- Ecological drought is a prolonged and widespread deficit in naturally available water supplies — including changes in natural and managed hydrology — that create multiple stresses across ecosystems (National Drought Mitigation Center 2022).

Location

All areas of the state are susceptible to drought, although the extent and severity of the drought will depend on the variance of rainfall throughout the state based on location. The identification of areas that are vulnerable to drought impacts is difficult due to the differences in microclimate and impact sectors.

West Virginia receives an annual average of 44.2 inches of precipitation, which replenishes ground water and reservoirs. Extended droughts can severely diminish the amount of water in streams, reservoirs, and aquifers. The population of West Virginia is equally dependent on public ground water systems, private wells or cisterns, and surface water for their water supply. Longer periods of drought can impact drinking water for those people (West Virginia Emergency Management Division 2016).

EXTENT

The State monitors precipitation, ground water levels, stream flows, snowpack, and water quality. The State uses a combination of five indices for information regarding drought conditions. This includes the Palmer Drought Severity Index (PDSI), Palmer Z Index, Crop Moisture Index (CMI), Standardized Precipitation Index (SPI), and the National Fire Danger Rating System (West Virginia Emergency Management Division 2016).

Drought Indices

Palmer Drought Severity Index

The PDSI allows for a categorization of various levels of wetness and dryness that are prominent over an area. The PDSI is calculated based on precipitation and temperature data as well as the local Available Water Content (AWC) of the soil (National Drought Mitigation Center 2023).

Figure 5.2-1. Palmer Drought Severity Index

Extremely Moist	Very Moist	Moderately Moist	Mid-Range	Moderate Drought	Severe Drought	Extreme Drought
+4.00 and above	+3.00 to +3.99	+2.00 to +2.99	-1.99 to +1.99	-2.00 to -2.99	-3.00 to -3.99	-4.0 and above

Source: National Drought Mitigation Center 2023

Palmer Z Index

The Palmer Z Index measures short-term drought on a monthly scale (National Centers for Environmental Information 2023).

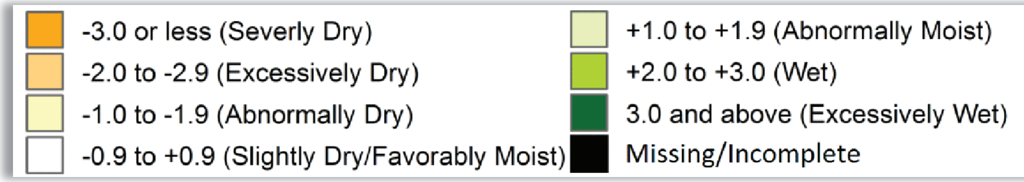
Figure 5.2-2. Palmer Z Index

Extremely Moist	Very Moist	Moderately Moist	Mid-Range	Moderate Drought	Severe Drought	Extreme Drought
+3.50 and above	+2.50 to +3.49	+1.00 to +2.49	-1.24 to +0.99	-1.25 to -1.99	-2.00 to -2.74	-2.75 and above

Source: National Centers for Environmental Information 2023

Crop Moisture Index

Figure 5.2-3. Crop Moisture Index



Source: National Weather Service (NWS) Climate Prediction Center (CPC) 2023

The CMI gives the short-term or current status of purely agricultural drought or moisture surplus and can change rapidly from week to week. The CMI indicate general conditions and not local variations caused by isolated rain. Input to the calculations include the weekly precipitation total and average temperature, division constants (water capacity of the soil, etc.), and previous history of the indices. The CMI can be used to measure the status of dryness or wetness affecting warm season crops and field activities (National Weather Service (NWS) Climate Prediction Center (CPC) 2023).

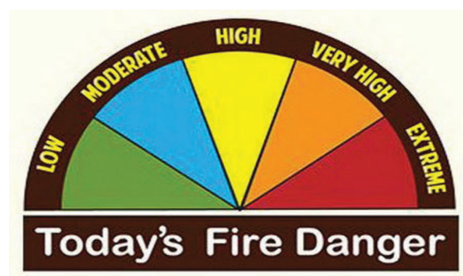
Standardized Precipitation Index

The SPI measures water supply, specifically precipitation. The SPI is computed over several time scales, typically from 1 month to 24 months, to evaluate both short-term drought and long-term drought. It can also measure precipitation excess (National Centers for Environmental Information 2023). A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive (National Drought Mitigation Center 2023).

National Fire Danger Rating System

The National Fire Danger Rating System (NFDRS) is a system that allows fire managers to estimate today's or tomorrow's fire danger for a given area. The key inputs into the NFDRS model are fuels, weather, topography, and risks. The ratings describe conditions that reflect the potential, over a large area, for a fire to ignite, spread, and require suppression action (U.S. Forest Service 2023). During longer periods of drought, fire danger levels are more likely to be high and the risk of wildfires occurring in areas experiencing drought are higher as well.

Figure 5.2-4. NFDRS



Source: U.S. Forest Service 2018

Warning Time

The State has a drought monitoring and assessment system in place that helps provide warning time for drought. There are four stages used to guide implementation of the State's drought response (refer to Table 5.2-1). Each stage is determined by referring to the five indices and assistance from National Oceanic and Atmospheric Administration (NOAA) to determine drought severity. The criteria is reassessed each month (West Virginia Emergency Management Division 2016). These outlooks can provide guidance for residents, farmers, business owners, and other industries in preparation of drought conditions, taking proactive measures to lessen drought impacts (U.S. Climate Resilience Toolkit 2021).

Table 5.2-1. West Virginia Drought Stages

Stage	Details
Normal	Refers to conditions that do not negatively impact water supplies, vegetation, or water quality in the state. No action needed.
Alert	1) When the PDSI reads -2.00 to -2.99 and stream flow, reservoir levels, and ground water levels are below normal over a several month period and/or the WVDHSEM Director, in coordination with appropriate state officials, determines Stage II activities are required, the Governor is to be requested to make a Drought Alert Declaration. 2) The alert can be rescinded once rainfall, stream flows, reservoir levels, and ground water levels return to normal or near normal levels for that time of year. The PDSI would be above - 1.0 for normal or near normal levels.
Conservation	1) Activated when the PDSI is between -3.00 to -3.99 and/or when the Director of WVDHSEM, in coordination with appropriate state officials, determines that Stage III activities are required. Stream flow, reservoir levels, and ground water levels continue to decline and forecasts indicate an extended period of below normal precipitation. 2) A return to Alert level happens when precipitation increases; stream flows, reservoir levels, and ground water levels stop their decline; and the PDSI begins to rise to -2.99 or higher or when the Director of WVDHSEM, in coordination with appropriate state officials, determines that Stage II activities are required. Extended forecasts should indicate a return to normal conditions.
Emergency	1) Activated when the PDSI is lower than -4.00 and/or the Director of WVDHSEM, in coordination with appropriate state officials, determines that Stage IV activities are required. The Governor may issue a Drought Emergency Declaration when water supplies are inadequate to meet projected demands and extreme measures must be taken. Forecasts are to indicate that precipitation levels, stream flows, reservoir levels, and ground water levels will continue to decline. 2) The Governor's declaration empowers state agencies to review allocation of supplies in communities not adequately responding to their water shortage and to implement emergency programs and actions as provided in the West Virginia Code.

Source: West Virginia Emergency Management Division 2016

PREVIOUS OCCURRENCES AND LOSSES

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1954 and 2022, West Virginia was included in two major disaster (DR) or emergency (EM) declarations for drought-related events (FEMA 2023). Table 5.2-2 summarizes these declarations.

Table 5.2-2. Drought-Related Federal Declarations, 1953 to 2022

Date(s) of Event	Incident	Federal Designation	Counties Declared
January 19, 1977	Drought	EM-3021-WV	Fayette, Grant, Greenbrier, Hampshire, Hardy, Mercer, Mineral, Monroe, Pendleton, Raleigh, Summers, Wyoming
August 24, 1977	Drought	EM-3051-WV	Grant, Greenbrier, Hampshire, Hardy, Mineral, Monroe, Pendleton, Pocahontas, Summers

Sources: USDA 2023, FEMA 2023
FEMA Federal Emergency Management Agency
N/A Not Applicable

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was included in five drought-related agricultural disaster declarations. Table 5.2-3 provides the USDA Secretarial disaster declarations in all West Virginia counties from January 1, 2012 through December 31, 2022 (USDA 2022).

Table 5.2-3. Drought-Related USDA Declarations, 2012 to 2022

Date(s) of Event	Designation Number	Description of Disaster	Counties Declared
November 4, 2019	USDA-S4565	Drought	Mingo
February 5, 2020	USDA-S4605	Drought and Excessive Heat	McDowell, Mercer, Mingo, Monroe, Summers
February 5, 2020	USDA-S4589	Drought and High Temperatures	Wayne
February 5, 2020	USDA-S4606	Drought	Jefferson
January 18, 2022	USDA-S5122	Drought and Excessive Heat	Berkeley, Jefferson, Morgan

Sources: USDA 2023
N/A Not Applicable
USDA U.S. Department of Agriculture

Previous Events

Table 5.2-4 lists periods of drought or drought events that have impacted the State since 1930. This table includes events identified in the 2018 SHMP and events that occurred between January 1, 2015, through December 31, 2022.

Table 5.2-4. Drought Events in the State of West Virginia (1929 to 2022)

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
1929-1930	Dust Bowl	N/A	Statewide	Drought was greater in length and intensity than any ev recorded since. Public water supplies suffered, resulting water and lack of flow for sewage.
January 19, 1977	Drought	EM-3021-WV	Fayette, Grant, Greenbrier, Hampshire, Hardy, Mercer, Mineral, Monroe, Pendleton, Raleigh, Summers, and Wyoming	No additional details regarding this event were found d
August 24, 1977	Drought	EM-3051-WV	Grant, Greenbrier, Hampshire, Hardy, Mineral, Monroe, Pendleton, Pocahontas, and Summers	No additional details regarding this event were found d
July 1997	Drought	N/A	Statewide	A very dry month, containing one seven-day heat wave, conditions across much of the fertile farmland of easter July proved to be the death knell for much of the crop y pasture. The West Virginia Farm Service Agency reporte statistics: Corn, hay, and pasture yields were 40- to 50 p damage to the corn crop included 2,500 to 3,000 acres Highlands (WVZ048>051, 055) but as much as 10,000 ac (WVZ052>053). Hay damage was estimated to be 40,00 an additional 80,000 acres per county. No significant da May 1999, Governor Underwood declared a statewide state as a result of extreme heat, lack of rainfall, and dr extensive damage and severe losses to farmers through
1999-2000	Drought	N/A	Statewide	This was the worst drought in state history since the Gr rural water wells and cisterns dried up; the water flow Potomac River, a major waterway through the Eastern below the record set in the Dust Bowl drought of 1929- due to the drought; and an estimated 2,000 farmers fac conditions . The West Virginia Department of Agriculture reported t West Virginia suffered a loss of more than $200 million, 1999 drought are still being witnessed.
October 2014	Drought	N/A	Greenbrier, Pocahontas, and Pendleton Counties	A Secretarial disaster designation was declared for Gree Pendleton Counties.

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
March 2015	Drought	N/A	McDowell, Mercer, Raleigh, and Wyoming Counties	An unusually dry spring resulted in a drought designatio counties bordering Ohio in Region 5.
October 1-22, 2019	Drought	USDA-S4565 (Mingo)	Greenbrier, Mingo, Monroe, Summers, and Mercer	Four counties (Monroe, Greenbrier, Summers, and Mer severe drought conditions starting October 1 and rema weeks through October 22. Mingo County was included to the drought conditions. Agricultural damages were s the USDA Farm Service Agency at $920,000 from pastu losses.
2019 - 2020	Drought and Excessive Heat	USDA-S4605 USDA-S4589 USDA-S4606	Jefferson, McDowell, Mercer, Mingo, Monroe, Summers, and Wayne	Much of West Virginia was in a drought by the fall of 20 conditions extended into the southern part of the state It was the last widespread drought there, and althoug dry conditions plaguing parts of Pennsylvania extended 2021). Throughout 2019 and 2020, West Virginia experienced moderate drought conditions. Two of these periods occ March-April 2020. The largest and longest dry period, d percent of the state, and similarly, late 2020 also had a
December 2021 – January 2022	Drought and Excessive Heat	USDA-S5122	Berkeley, Fayette, Jefferson, Morgan, Raleigh, and Summers	Dry conditions in December 2021 contributed to severa and Summers Counties. Due to these dry conditions, th Jefferson, and Morgan Counties in a declaration relate

Sources: National Centers for Environmental Information 2023, National Drought Mitigation Center, University of Nebraska 2023, FEMA 2023, USDA 2 Environmental Protection 2020, West Virginia Emergency Management Division 2018, NPR 1999, Tuckwiller 1999, West Virginia Archives & History 19

FEMA Federal Emergency Management Agency

USDA U.S. Department of Agriculture

Probability of Future Hazard Events

Overall Probability

Extended periods of dry weather with significant negative impacts on crops, livestock, and people have occurred in the past and will likely be decreasing in the future as rainfalls are projected to increase. Because drought is highly unpredictable and may vary locally, assessing probability of its occurrence is difficult. Quantifying drought in terms of historical frequency also proves to be a difficult task because of the variations in drought definition and the very limited and somewhat spotty nature of past drought reporting (West Virginia Emergency Management Division 2018).

According to USDA, FEMA, National Drought Mitigation Center, National Centers for Environmental Information, and the 2018 SHMP, the State experienced over 500 drought events between 1930 and 2022, as summarized in Table 5.2-5. Overall, the state is likely to experience at least five drought events of any magnitude or severity each year, with the possibility of an increase in frequency due to future changing conditions.

Table 5.2-5. Probability of Future Landslide Events in West Virginia

Hazard Type	Number Of Occurrences Between 1930 and 2022	Percent Chance of Occurrence in Any Given Year
Drought	505	100%

Sources: USDA 2023; FEMA 2023; National Drought Mitigation Center, University of Nebraska 2023; National Centers for Environmental Information 2023
Note: Drought events listed in the NOAA-NCEI database are those events classified as severe, extreme, or exceptional.

Projected Future Conditions

Droughts are projected to be more intense in the future due to rising temperatures increasing the rate of soil moisture loss during dry periods (National Centers for Environmental Information 2022).

Drought is a serious environmental threat to West Virginia. Projected future conditions can exacerbate droughts by making them occur more frequent, more severe, and for longer periods of time (USGS 2023). Temperatures in West Virginia have risen approximately 1°F over the last century. Rising temperatures and changing rainfall patterns will likely increase the intensity of both floods and droughts. During the next century, average annual precipitation and the frequency of heavy downpours are likely to keep rising. Average precipitation is likely to increase during winter and spring but not change significantly during summer and fall. Rising temperatures will melt snow earlier in spring and increase evaporation, and thereby dry the soil during summer and fall. As a result, the projected change in future conditions is likely to intensify flooding during winter and spring and droughts during summer and fall (U.S. Environmental Protection Agency 2016).

5.2.2 Vulnerability Assessment

State Assets

The entire State 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 (Borunda 2020).

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 (discussed below) in and adjacent to the WUI zone and located in high wildfire risk areas are considered vulnerable to wildfire. Section 4.15 (Wildfire) describes the state's vulnerability to the wildfire hazard.

Critical Facilities and Community Lifelines

As stated previously, drought does not directly impact structures. However, water-dependent community lifelines and critical facilities may be impacted. Under extreme drought conditions, where local water supplies are depleted and water utilities are unable to supply adequate water pressure, fire departments and healthcare facilities could be impacted. Additionally, similar to state-owned buildings, critical facilities, and community lifelines have an increased risk of wildfires, especially those located in the WUI.

Population

The entire population of the State 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 (Moreland 2016).

Impacts on Socially Vulnerable Populations

Overall, the entire population of the State is exposed and vulnerable to drought. Therefore, the exposed socially vulnerable population to drought is equal to the statewide percentage: 60.4 percent of the total population.

Future Changes That May Impact State Vulnerability

Understanding future changes that may impact vulnerability in the State can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors in examining potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including impacts of future conditions

Potential or Projected Development

Any sections of growth and development, especially in areas that rely on surface water, could be impacted by drought. As water levels are lowered due to increase rates of use, drought can occur more readily than from lack of precipitation alone.

Projected Changes in Population

While statewide population has declined over the past 10 years, the population has increased in several areas throughout the state (e.g., Berkely, Jefferson, and Monongalia Counties). From 2010 to 2019, the state's overall population decreased by 3.3 percent, and it is projected to decrease 7.8 percent by 2040 (West Virginia Department of Transportation 2020). As the overall population decreases, fewer people will be exposed to drought impacts. However, counties with projected population increases, especially those with larger percentages that use surface water for potable water, will have an increased risk of drought impacts.

Other Factors of Change

As discussed above, projected future conditions for West Virginia indicate more intense droughts due to rising temperatures and changing rainfall patterns. Refer to Projected Future Conditions for details on how future conditions can impact droughts.

5.2.3 Consequence Analysis

Impacts to the Public

The entire population of the State is either directly or indirectly impacted and vulnerable to drought events, with the greatest impacts on water supply. The population of West Virginia is equally dependent on public ground water systems, private wells or cisterns, and surface water for their water supply (West Virginia Emergency Management Division 2016). For those who rely on surface water (e.g., reservoirs and lakes) for potable water, lower surface water levels can be detrimental to the water supply, diminishing the amount of water in reservoirs, lakes, and streams (Moreland 2016). Overall, the entire population of the State is exposed and vulnerable to drought. Therefore, the exposed socially vulnerable population to drought is equal to the statewide percentage: 60.4 percent of the total population.

Impacts to Responders

Limited impacts to first responders related to drought are anticipated in West Virginia. However, drought may limit water supplies available for firefighting activities.

Impacts to Continuity of Operations

While droughts can impact the entire State, it is not anticipated that drought conditions will impact the State's ability to continue operations during and after a drought.

Impacts to Property, Facilities, and Infrastructure

The entire State is exposed and vulnerable to drought, as described in the State Assets section of Section 5.2.2.

Impacts to the Environment

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.

Impacts to the Economic Condition of the State

Drought can impact the economy in many ways because water is an important part of so many businesses and activities. Farms rely on water to grow food, and animals need water to survive. The economic impacts of drought can lead to losses to those businesses that rely on water, including losses from agriculture businesses and losses associated with recreation (e.g., boating, finishing) (National Drought Mitigation Center 2023).

A prolonged drought event could have significant impacts in counties that have large amounts of agricultural lands. West Virginia has extensive agricultural operations throughout the state, many of which are vulnerable to shortages in rainfall. Short-term droughts can impact agricultural productivity, while longer-term droughts are more likely to impact agriculture and water supply. Jurisdictions that have invested in water supply and distribution infrastructure are generally less vulnerable to drought. Short- and long-term drought may lead to an increase in the incidence of wildfires, which might, in turn, lead to increased potential for landslides or mudflows once rain occurs (West Virginia Emergency Management Division 2018).

According to the current Census of Agriculture 2017 State Profile, there are 23,622 farms across West Virginia covering more than 3.6 million acres. The Counties of Preston (4.8 percent), Jackson (4.2 percent), and Berkeley (4.0 percent) have the greatest percentage of farms in the state. The market value of products sold is estimated at $754.2 million (USDA 2017). Table 5.2-6 provides a summary of the market value for crops and livestock in the state.

Table 5.2-6. State of West Virginia Agriculture Market Value (2017)

Agricultural Products Sold	Market Value
Value of crops, including nursery and greenhouse	$153,117,000.00
Value of livestock, poultry, and their products	$601,162,000.00
Total value of agricultural products sold	**$754,279,000.00**

Impacts to Public Confidence in State Governance

Public confidence would largely depend upon how effectively the State and county and local governments prepare for and respond to a drought event.

5.3 Earthquake

2023 SHMP Update Changes

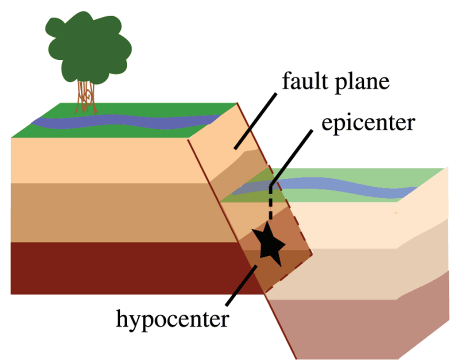
- Earthquake events that occurred in West Virginia from January 1, 2017, through December 31, 2022, were researched for this 2023 State Hazard Mitigation Plan (SHMP) update.
- New and updated figures from federal and state agencies are incorporated.
- This section now includes a discussion of how earthquakes impact socially vulnerable populations and community lifelines.

5.3.1 Hazard Profile

Hazard Description

Earthquakes occur when two blocks of the Earth suddenly slip past each other. The surface where they slip is called the fault, illustrated in Figure 5.3-1. The location below the Earth's surface where the earthquake starts is called the hypocenter, and the location directly above it on the surface is called the epicenter (USGS 2023). Earthquakes result in three basic phenomena: ground motion, surface faulting, and related ground failures. While most earthquakes tend to occur at the boundaries where tectonic plates meet, some earthquakes do occur in the middle of the plates (West Virginia Emergency Management Division 2018).

Figure 5.3-1. Earthquake Fault



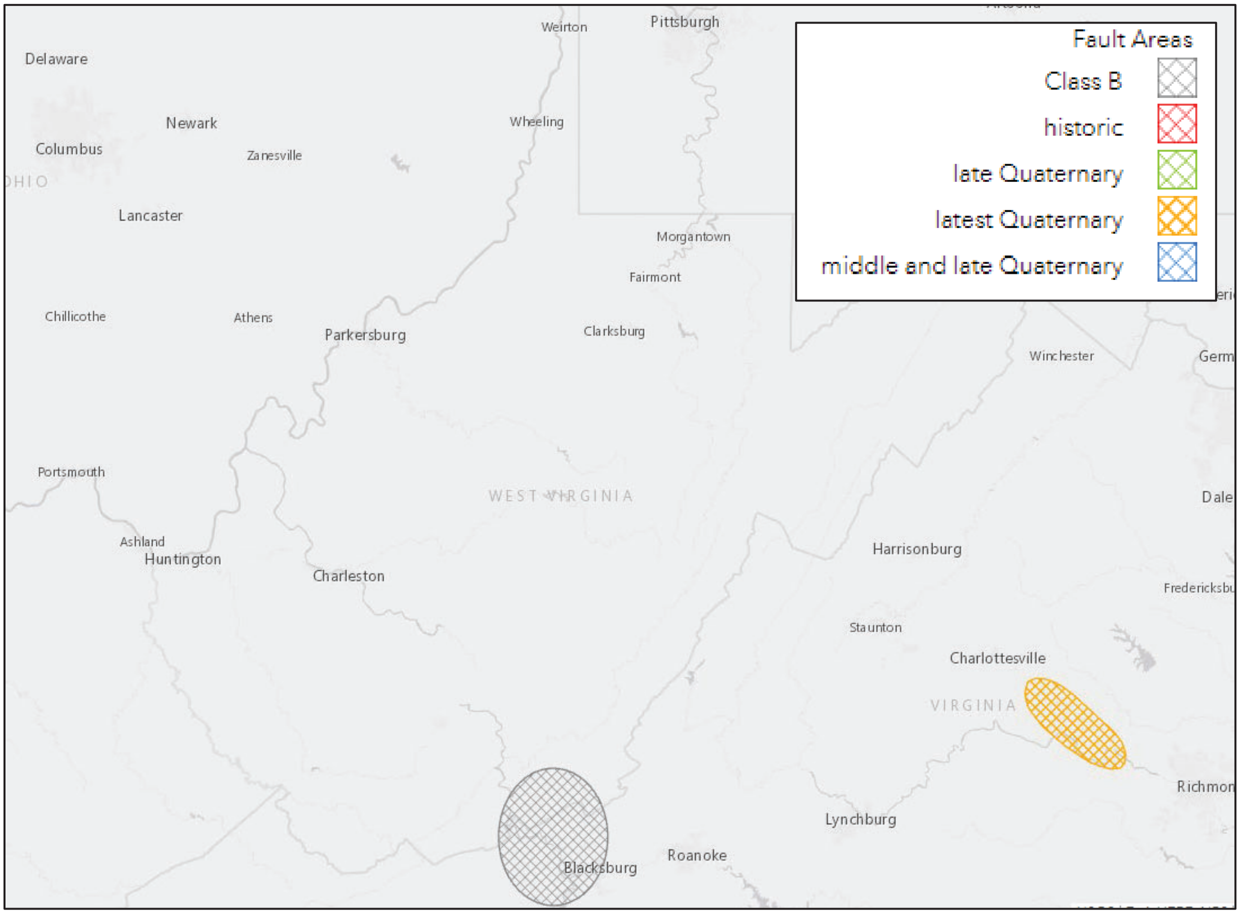
Source: USGS 2023

Location

Earthquakes occur along fault lines; however, they can impact anywhere in West Virginia. A majority of the earthquakes have occurred in the southern portion of the state where there is a higher seismic hazard.

Earthquakes occur along several fault lines crossing into West Virginia, but larger earthquakes develop in surrounding states and felt by many in West Virginia (West Virginia Emergency Management Division 2018). The Glee County Seismic Zone is located in southern West Virginia near the border of Virginia. This portion of the state has experienced the most earthquakes. Faults in this area trend toward Tennessee, and earthquakes in this zone can be associated with the Narrows Fault, the Saltville Fault, and/or the Holston Valley Fault (William & Mary University 2023) (see Figure 5.3-2).

Figure 5.3-2. Fault Lines and Areas in West Virginia



Source: U.S. Geological Survey 2023

EXTENT

The severity of an earthquake is classified by magnitude and intensity.

Measuring Earthquakes

Magnitude

Magnitude is the size of the earthquake. An earthquake has a single magnitude. The shaking that it causes has many values that vary from place to place based on distance, type of surface material, and other factors. Magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude 5.3 is a moderate earthquake, and a 6.3 is a strong earthquake (U.S. Geological Survey 2023).

Magnitude is commonly expressed by ratings on the moment magnitude scale (Mw). It is based on the total moment release of the earthquake. Moment is a product of the distance a fault moved and the force required to move it (Michigan Tech 2023); (U.S. Geological Survey n.d.).

The scale is as follows:

- Great—Mw > 8

- Major—Mw = 7.0 – 7.9
- Strong—Mw = 6.0 – 6.9
- Moderate—Mw = 5.0 – 5.9
- Light—Mw = 4.0 – 4.9
- Minor—Mw = 3.0 – 3.9
- Micro—Mw < 3

Intensity

The intensity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features and varies with location. Figure 5.3-3 and Table 5.3-1 show the ratings of the scale as well as the perceived shaking and damage potential for structures. The range of ground shaking depends on the distance from the earthquake, the rock and soil conditions at sites, and complexities in the structure of the Earth's crust that affect how the seismic waves radiate from the earthquake source.

The modified Mercalli intensity scale is generally represented visually using ShakeMaps, which show the expected ground shaking at any given location produced by an earthquake with a specified magnitude and epicenter. A ShakeMap shows the variation of ground shaking in a region immediately following significant earthquakes.

Figure 5.3-3. Modified Mercalli Scale

CIIM Intensity	People's Reaction	Furnishings	Built Environment	Natural Environment
I	Not felt			Changes in level and clarity of well water are occasionally associated with great earthquakes at distances beyond which the earthquakes felt by people.
II	Felt by a few.	Delicately suspended objects may swing.		
III	Felt by several; vibration like passing of truck.	Hanging objects may swing appreciably.		
IV	Felt by many; sensation like heavy body striking building.	Dishes rattle.	Walls creak; window rattle.	
V	Felt by nearly all; frightens a few.	Pictures swing out of place; small objects move; a few objects fall from shelves within the community.	A few instances of cracked plaster and cracked windows with the community.	Trees and bushes shaken noticeably.
VI	Frightens many; people move unsteadily.	Many objects fall from shelves.	A few instances of fallen plaster, broken windows, and damaged chimneys within the community.	Some fall of tree limbs and tops, isolated rockfalls and landslides, and isolated liquefaction.
VII	Frightens most; some lose balance.	Heavy furniture overturned.	Damage negligible in buildings of good design and construction, but considerable in some poorly built or badly designed structures; weak chimneys broken at roof line, fall of unbraced parapets.	Tree damage, rockfalls, landslides, and liquefaction are more severe and widespread wiht increasing intensity.
VIII	Many find it difficult to stand.	Very heavy furniture moves conspicuously.	Damage slight in buildings designed to be earthquake resistant, but severe in some poorly built structures. Widespread fall of chimneys and monuments.	
IX	Some forcibly thrown to the ground.		Damage considerable in some buildings designed to be earthquake resistant; buildings shift off foundations if not bolted to them.	
X			Most ordinary masonry structures collapse; damage moderate to severe in many buildings designed to be earthquake resistant.	

Source: U.S. Geological Survey 2022

Table 5.3-1. Modified Mercalli Intensity and PGA Equivalents

Modified Mercalli Scale	Perceived Shaking	Potential Structure Damage		Estimated PGA (%g)
		Resistant Buildings	Vulnerable Buildings	
I	Not Felt	None	None	Less than 0.17%
II-III	Weak	None	None	0.17% – 1.4%
IV	Light	None	None	1.4% – 3.9%
V	Moderate	Very Light	Light	3.9% – 9.2%
VI	Strong	Light	Moderate	9.2% – 18%
VII	Very Strong	Moderate	Moderate/Heavy	18% – 34%
VIII	Severe	Moderate/Heavy	Heavy	34% – 65%
IX	Violent	Heavy	Very Heavy	65% – 124%
X – XII	Extreme	Very Heavy	Very Heavy	More than124%

Source: U.S. Geological Survey n.d.

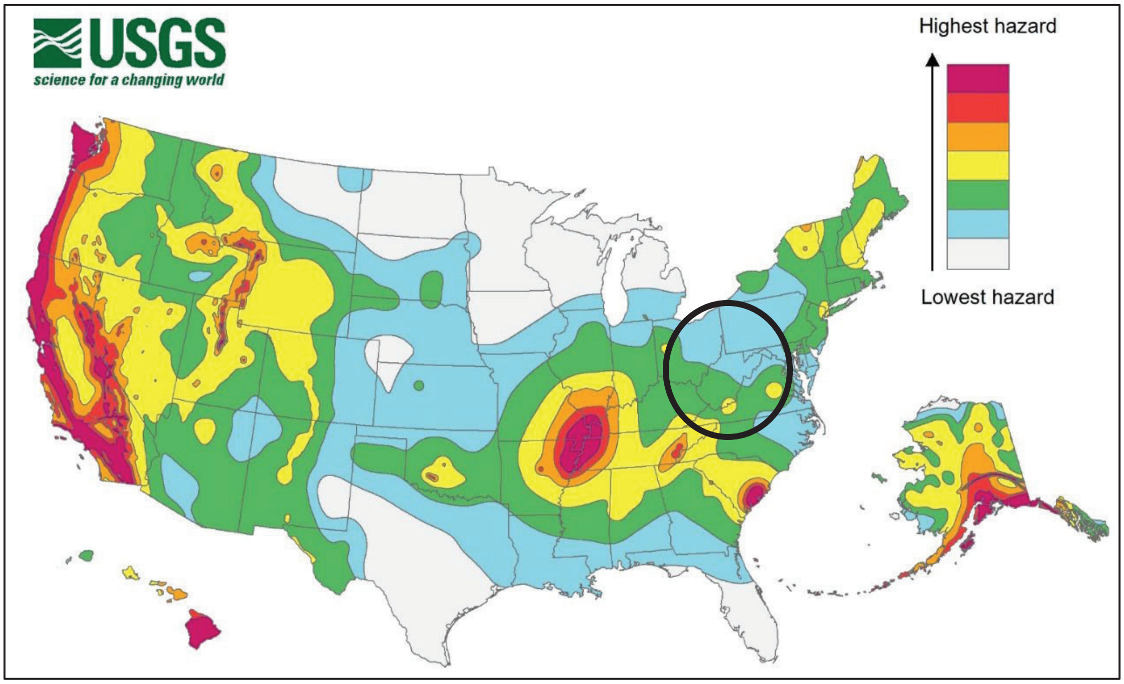
Ground Acceleration

One way to express an earthquake's severity is to compare its acceleration to the normal acceleration due to gravity. Peak ground acceleration (PGA) is what is experienced by a particle on the ground. It measures the maximum force experienced by a small mass located at the surface of the ground during an earthquake (U.S. Geological Survey 2019). Figure 5.3-4 shows peak ground accelerations having a 2 percent probability of being exceeded in 50 years for a firm rock site. The highest hazard areas are shown in red, and the lowest hazard areas are shown in gray. West Virginia is shown predominantly as having a low hazard (light to moderate shaking), with a small portion of the state having a medium hazard (strong shaking).

Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures (U.S. Geological Survey 2021). The following generalized observations provide qualitative statements about the likely extent of damages for earthquakes with various levels of ground shaking (PGA) at a given site:

- Ground motions of 1 to 2%g are widely felt by people; hanging plants and lamps swing strongly, but damage levels, if any, are usually very low.
- Ground motions below 10%g usually cause only slight damage, except in unusually vulnerable facilities.
- Ground motions of 20 to 50%g may cause significant damage in some modern buildings and very high levels of damage (including collapse) in poorly designed buildings.
- Ground motions greater than 50%g may cause higher levels of damage in many buildings, even those designed to resist seismic forces (U.S. Geological Survey 2021).

Figure 5.3-4. 2018 Long-Term National Seismic Hazard Map



Source: U.S. Geological Survey 2018
Note: The models are based on seismicity and fault-slip rates, and take into account the frequency of earthquakes of various magnitudes. Locally, the hazard may be greater than shown, because site geology may amplify ground motions.

Warning Time

Under the Disaster Relief Act of 1974, the USGS has the federal responsibility to issue alerts for earthquakes, enhance public safety, and reduce losses through effective forecasts and warnings. The USGS currently issues rapid, automatic earthquake information via the internet, email messages, text messages, and social media (U.S. Geological Survey n.d.). Currently, there is no reliable way to predict the day or month that an earthquake will occur at any given location. The ShakeAlert® earthquake early warning system has been developed to monitor for significant earthquakes and issue alerts to warn that strong shaking is expected imminently. The ShakeAlert® system is being developed to cover California, Oregon, and Washington. Depending on how far a person is from the earthquake, these potential warning systems could give from a few seconds to a minute's notice that major shaking is about to occur (U.S. Geological Survey 2022). The warning time is very short, but it could allow for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system. Currently, no such earthquake early warning system has been developed for West Virginia.

PREVIOUS OCCURRENCES AND LOSSES

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, the State was not included in any disaster (DR) or emergency (EM) declarations for earthquakes (FEMA 2023).

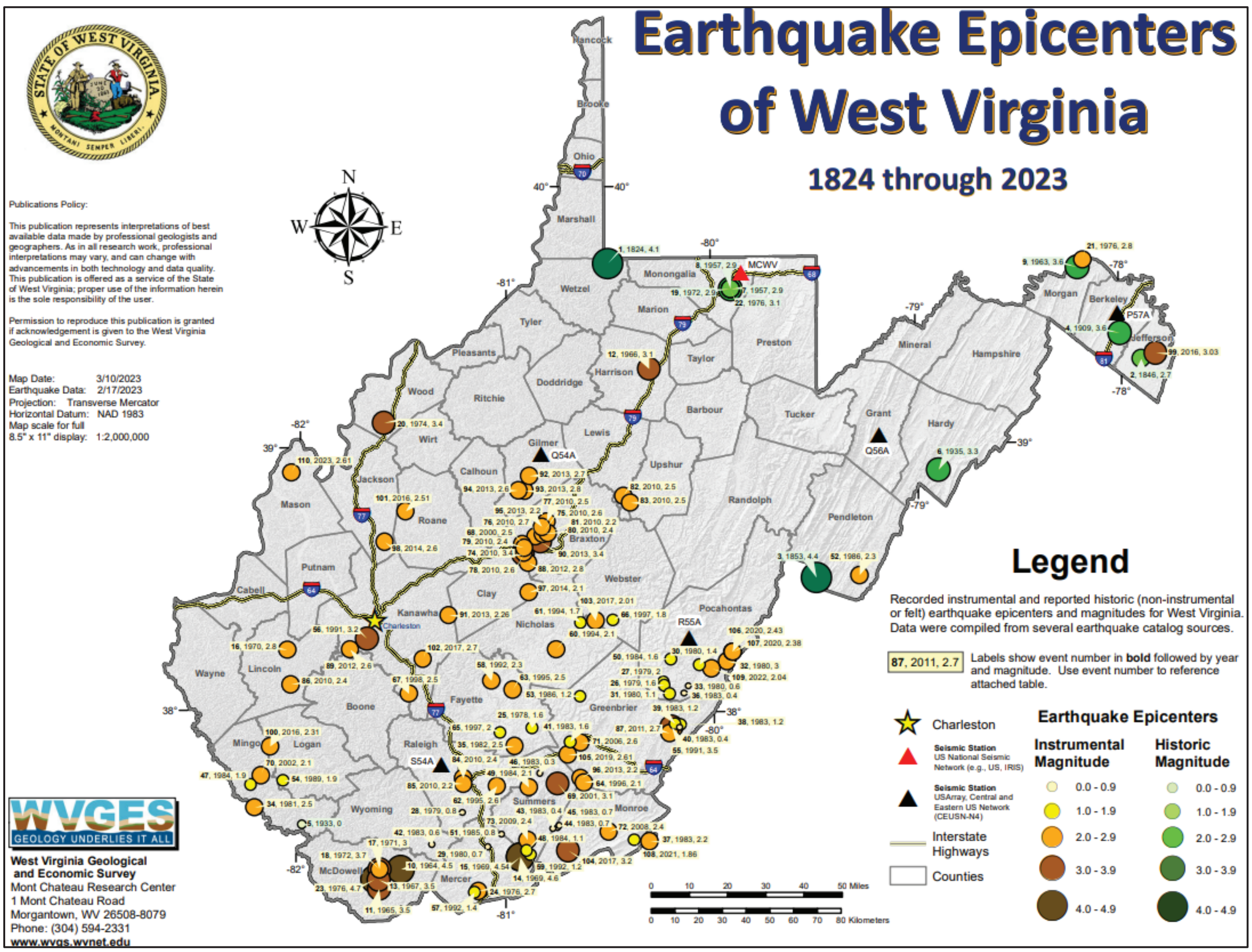
U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was not included in any agricultural disaster declarations pertaining to earthquakes (USDA 2023).

Previous Events

Figure 5.3-5 illustrates earthquakes with epicenters in West Virginia. Table 5.3-2 lists earthquake events that impacted the State since 1824. This table includes events identified in the 2018 SHMP events that occurred from January 1, 2017, through December 31, 2022. Due to the number of events, the table includes only those events with recorded damages or reports of people having felt the earthquake. For a full list of earthquakes, refer to the State's Geological and Economic Survey website (https://www.wvgs.wvnet.edu/).

Figure 5.3-5. Earthquake Epicenters in West Virginia, 1824 to 2023



Source: West Virginia Geological and Economic Survey 2023

Table 5.3-2. Earthquake Events in the State of West Virginia (1824 to 2022)

Date(s) of Event	Magnitude	Federal Disaster Declaration (if applicable)	Location (recorded epicenter)	Counties Affected	Description
1897	N/A	N/A	Not reported	Giles	Earthquake located in Giles County, Virginia w Virginia.
April 2, 1909	3.6	N/A	Not reported	Berkeley	Earthquake centered near Charles Town, WV from walls and residents were awakened by th
1935	N/A	N/A	Quebec, Canada	Not reported	Earthquake located in Timiskaming, Quebec, C
1937	N/A	N/A	Anna, OH	Not reported	Earthquake in Anna, Ohio felt in Region 2 alon
1944	N/A	N/A	Not reported	Canada	Strong earthquake tremors in Canada reached
1969	4.3	N/A	Not reported	Unknown	Earthquake with a 4.3 magnitude was the mos Virginia's history. Epicenter location is not kno
1972	N/A	N/A	Not reported	Monongalia	Morgantown, WV experienced a minor tremo
1974	N/A	N/A	Not reported	Giles	Giles County, Virginia was the center of a mod earthquake in Ohio was felt in Parkersburg an
April 29, 2010	2.6	N/A	3 km WNW of Gassaway, West Virginia	Braxton	According to USGS, seven people in West Virg earthquake.
April 29, 2010	2.7	N/A	7 km W of Gassaway, West Virginia	Braxton	According to USGS, eight people in West Virgi earthquake.
May 7, 2010	2.6	N/A	14 km WSW of Gassaway, West Virginia	Braxton	According to USGS, four people in West Virgin earthquake.
August 21, 2010	2.5	N/A	19 km WNW of Helvetia, West Virginia	Upshur	According to USGS, four people in West Virgin earthquake.
August 25, 2011	2.7	N/A	14 km SE of Falling Spring, West Virginia	Greenbrier	West Virginians felt a 5.8 Md earthquake that quake caused buildings in Charleston to sway, Charlotte, NC. According to USGS, 68 people in felt the earthquake.
January 10, 2012	2.8	N/A	14 km WNW of Birch River, West Virginia	Braxton	According to USGS, 28 people in West Virginia earthquake.
March 31, 2013	3.4	N/A	West Virginia	Braxton	According to USGS, 36 people in West Virginia earthquake.

Date(s) of Event	Magnitude	Federal Disaster Declaration (if applicable)	Location (recorded epicenter)	Counties Affected	Description
July 20, 2013	2.7	N/A	6 km SW of Glenville, West Virginia	Gilmer	Three low-magnitude earthquakes occurred. T and were not reported, but rather showed up
July 30, 2013	2.8	N/A	12 km SSW of Glenville, West Virginia	Gilmer	Three low magnitude earthquakes occurred. T and were not reported, but rather showed up
August 16, 2013	2.6	N/A	13 km SW of Glenville, West Virginia	Gilmer	Three low-magnitude earthquakes occurred. T and were observed on sensing equipment. Ac people in West Virginia reported having felt th
October 13, 2013	2.2	N/A	5 km NW of Gassaway, West Virginia	Braxton	A similar, small-scale earthquake was picked u
October 19, 2013	2.2	N/A	2 km N of Alderson, West Virginia	Greenbrier	A similar, small-scale earthquake picked up by
June 6, 2014	2.6	N/A	13 km NNE of Sissonville, West Virginia	Jackson	A small, 2.6 Md earthquake was picked up by
January 17, 2016	3.0	N/A	3 km NE of Ranson, West Virginia	Jefferson	A 3.0 Md earthquake was reported by one per
August 6, 2016	2.3	N/A	6 km WNW of Verdunville, West Virginia	Mingo	A 2.3 Md earthquake picked up in Shamrock, V
September 13, 2017	3.2	N/A	11 km NE of Peterstown, West Virginia	Monroe	According to USGS, 81 people in West Virginia earthquake.
July 30, 2020	2.4	N/A	10 km ENE of Huntersville, West Virginia	Pocahontas	According to USGS, seven people in West Virg earthquake.
December 7, 2021	1.9	N/A	16 km ESE of Union, West Virginia	Monroe	According to USGS, one person in West Virgin earthquake.
August 10, 2022	2.0	N/A	3 km S of Huntersville, West Virginia	Pocahontas	According to USGS, one person in West Virgin earthquake.

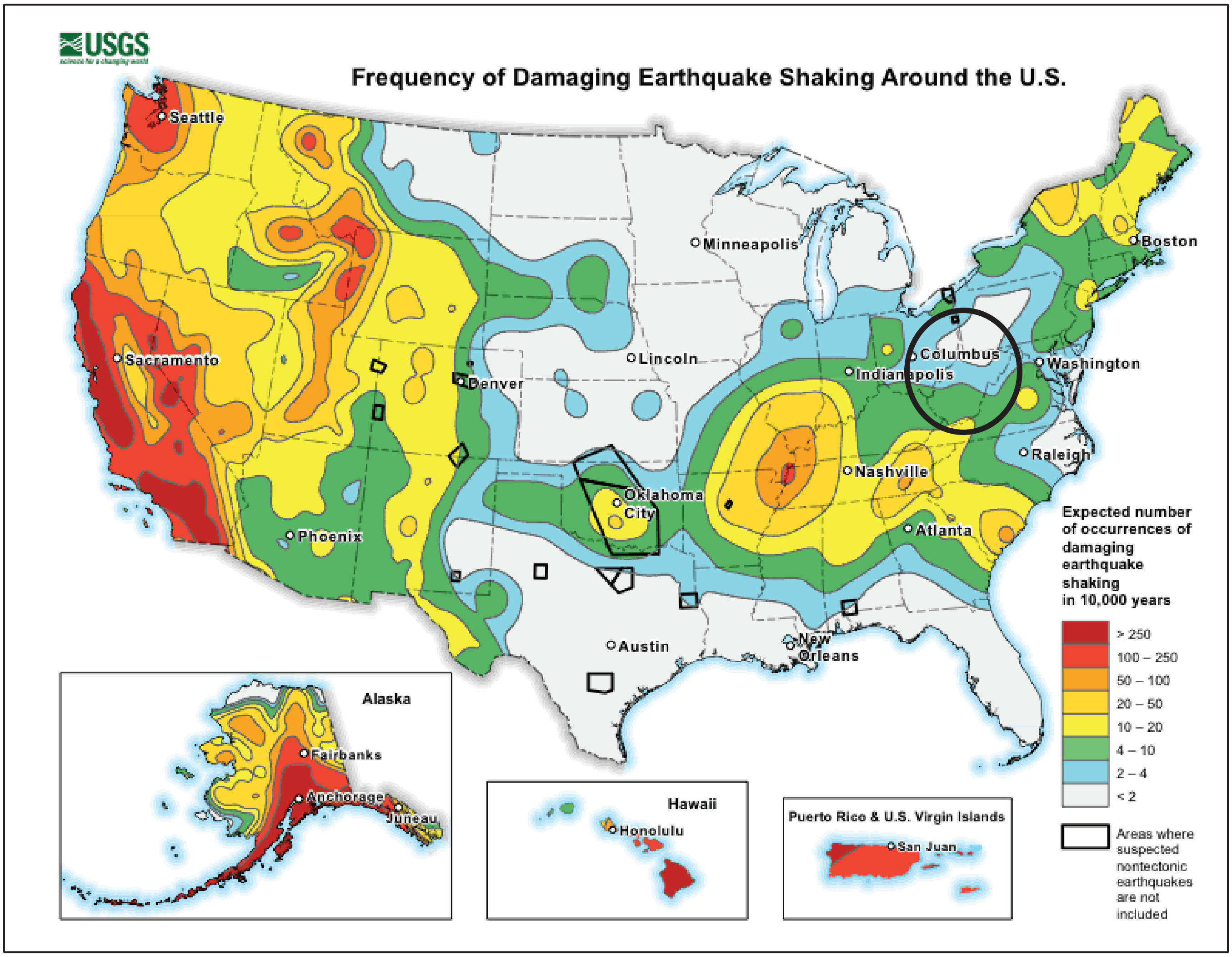
Sources: FEMA 2023; U.S. Geological Survey 2023; West Virginia Emergency Management Division 2018; West Virginia Geological and Economic Survey 2

Probability of Future Hazard Events

Overall Probability

Figure 5.3-6 shows how many times earthquakes can cause damaging earthquakes (MMI VI or greater) in 10,000 years. However, earthquakes of any magnitude can happen at any time in West Virginia. The figure is showing that the northern portion of the state can expect between 2 and 4 damaging earthquakes in 10,000 years. The southern portion of the state can expect between 4 and 10 damaging earthquakes in 10,000 years (U.S. Geological Survey 2022).

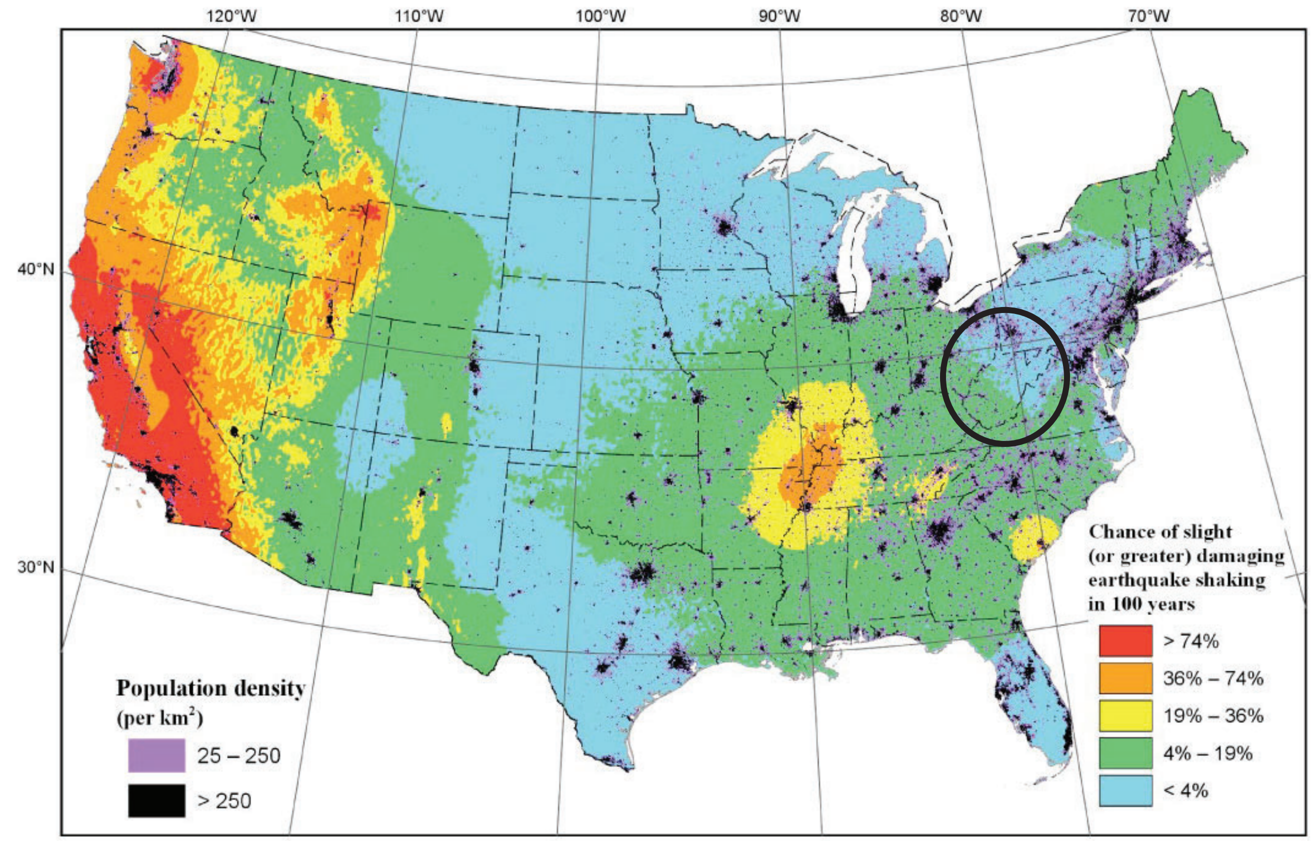
Figure 5.3-6. Frequency of Damaging Earthquake Shaking Around the United States



Source: U.S. Geological Survey 2022
Note: The location of West Virginia is shown with a black oval.

Figure 5.3-7 shows the locations of major populations and the chance of slight, or greater, damaging earthquake shaking occurring in 100 years. Southwestern West Virginia is shown as having between a 4 and 19 percent chance of a damaging earthquake occurring in 100 years, with the northeastern West Virginia having less than a 4 percent chance of a damaging earthquake.

Figure 5.3-7. Chance of Slight or Greater Damaging Earthquake Shaking in 100 Years



Source: U.S. Geological Survey 2022
Note: The location of West Virginia is shown with a black oval.

According to USGS, the West Virginia Geological and Economic Survey, and the 2018 SHMP, the State experienced 109 earthquakes with epicenters in West Virginia between 1824 and 2022, as summarized in Table 5.3-3. Overall, the state is likely to experience one earthquake every two years.

Table 5.3-3. Probability of Future Earthquake Events in West Virginia

Hazard Type	Number of Occurrences between 1824 and 2022	Percent Chance of Occurrence in Any Given Year
Earthquake	109	54.8%

Sources: West Virginia Geological and Economic Survey 2023; U.S. Geological Survey 2023

Projected Future Conditions

The potential direct impacts of projected future conditions on earthquake probability are unknown. Some scientists believe that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the Earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity. Additionally, changes in the Earth's crust from periods of drought can be significant. Similarly, pumping of groundwater from underground aquifers for human use, which is exacerbated during times of drought, has been shown to impact patterns of stress loads by "unweighting" the Earth's crust (NASA 2019).

Secondary impacts of earthquakes could be magnified by projected future conditions. Earthquakes can cause large and sometimes disastrous landslides. Any steep slope is vulnerable to slope failure. Rising air temperatures can facilitate soil breakdown, allowing more water to penetrate soils and affect the rates of erosion, sediment control, and the likelihood of landslides. Projected future conditions may also increase the probability of more frequent, intense rainstorms. This can result in greater erosion, higher sediment transport in rivers and streams, and a higher probability of landslides, primarily as a result of higher soil content (University of Washington 2014).

5.3.2 Vulnerability Assessment

Probabilistic earthquake data in Hazus version 6.0 was used to assess the earthquake hazard in West Virginia. This section discusses statewide vulnerability of exposed state assets (state buildings and state roads), community lifelines, and critical facilities to the earthquake hazard.

State Assets

The total replacement cost value of state buildings is an estimated $6.1 million. Table 5.3-4 summarizes the values overall for the state. The potential damage estimated to state buildings associated with the 500-year probabilistic earthquake event is approximately $920 million, which represents approximately 15 percent of the inventory's total replacement cost value.

Table 5.3-4. State Buildings Exposure and Potential Losses to the 500-year Probabilistic Earthquake Event

Jurisdiction	Total Replacement Cost Value (RCV)	Earthquake 500-Year MRP	
		Estimated Total Damage	Percent of Total Building and Contents Replacement Cost Value
West Virginia State (Total)	$6,103,990,956	$920,036,000	15.07%

Sources: Hazus v6.0; U.S. Census 2020
Note: Results were not reported at the county level due to how minimal the results were

Critical Facilities and Community Lifelines

Transportation routes, including bridges and highways, are vulnerable to earthquakes, especially those exposed to the 500-year earthquake event. Aging infrastructure and those already in poor condition are most vulnerable. Additionally, interruption of utility infrastructure services can be impacted, affecting vulnerable populations and facilities that need to be in operation during a disaster. Table 5.3-5 summarizes the estimated damages to State-owned critical facilities, by community lifeline, exposed to the 500-year probabilistic earthquake event. Transportation lifelines have the highest percentage of total building and contents replacement cost value, followed by safety and security lifelines.

Table 5.3-5. State Critical Facilities and Community Lifelines and Potential Losses to the 500-year Probabilistic Earthquake Event

Lifeline Category	Total Replacement Cost Value (RCV)	Earthquake 500-Year MRP	
		Estimated Total Damage	Percent of Total Building and Contents Replacement Cost Value
Communications	$10,240,007	$2	0.00%
Energy	$0	$0	0.00%
Food, Water, Shelter	$2,384,067	$179,929	7.55%
Hazardous Material	$0	$0	0.00%
Health & Medical	$17,805,006	$2,415,003	13.56%
Safety & Security	$890,655,329	$299,248,433	33.60%
Transportation	$44,654,481	$24,932,095	55.83%
West Virginia State (Total)	$965,738,890	$326,775,462	33.84%

Sources: Hazus v6.0; U.S. Census 2020

Population

As seen in Figure 5.3-5, earthquakes have impacted all portions of the state; therefore, the entire population has the potential to be affected by an earthquake. However, the degree of exposure is dependent on many factors, including the age and type of construction people live in, the soil types their homes are located on, and the intensity of the earthquake. Populations considered most vulnerable are those located in/near the built environment, particularly those near unreinforced masonry construction. Whether directly or indirectly impacted, residents may be faced with business closures, road closures that could isolate population, and loss of function of critical facilities and utilities. As a result of an earthquake event, residents may be displaced or require temporary to long-term sheltering. The planning effort to develop the 2023 SHMP did not include running Hazus throughout the state. Statistics on the population affected, displaced, or requiring shelter can be found in the local hazard mitigation plans.

Impacts on Socially Vulnerable Populations

Overall, the entire population of the State is exposed and vulnerable to earthquakes. Therefore, the exposed socially vulnerable population to earthquake is equal to the statewide percentage: 60.4 percent of the total population. Factors leading to higher susceptibility for socially vulnerable populations include decreased mobility and financial ability to react or respond during a hazard and the location and construction quality of their housing.

Future Changes That May Impact State Vulnerability

Understanding future changes that may impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The state considered the following factors in examining potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including impacts of future conditions

Potential or Projected Development

Any sections of growth and development, especially developing in areas near fault lines like the southern portion of the state, could be impacted by earthquakes.

Projected Changes in Population

While statewide population has declined over the past 10 years, population has increased in several areas throughout the state (e.g., Berkely, Jefferson, and Monongalia Counties). From 2010 to 2019, the state's overall population decreased by 3.3 percent, and it is projected to decrease 7.8 percent by 2040 (West Virginia Department of Transportation 2020). As the overall population decreases, fewer people will be exposed to earthquakes and its impacts. However, counties with projected population increases, especially those in areas in and around fault zones, will have an increased risk of earthquake impacts.

Other Factors of Change

As discussed above, it is unknown whether project future conditions will increase earthquake events. Refer to Projected Future Conditions for details on how future conditions can impact earthquakes.

5.3.3 Consequence Analysis

IMPACTS TO THE PUBLIC

It is anticipated that the State will be impacted by smaller earthquakes less than once every two years. Because of this probability, the impact to the public is assumed minimal. However, when an earthquake does occur, there is risk to the health and safety to the public from falling debris. If a strong earthquake occurs, it has the potential to impact the public, causing deaths, injuries, and extensive property damage (West Virginia Emergency Management Division 2018).

IMPACTS TO RESPONDERS

Because of the low probability of a strong earthquake, the impact to the first responders is considered minimal. However, first responders will assist during and after an earthquake event, so they could be injured due to falling debris. First responders will follow state and county emergency procedures.

IMPACTS TO CONTINUITY OF OPERATIONS

Little to no impacts to operations are anticipated in West Virginia due to the probability and severity of earthquakes in the state.

IMPACTS TO PROPERTY, FACILITIES, AND INFRASTRUCTURE

Overall, minimal impacts are expected if an earthquake occurs. However, if a strong earthquake occurs, the impacts can be severe and cause significant damage. Ground shaking can lead to the collapse of buildings and bridges and disruption of gas and electric lines, phone service, and other critical utilities (West Virginia Emergency Management Division 2018).

Secondary impacts from earthquakes can impact buildings and infrastructure as well. These impacts include fire, hazardous material release, landslides, flash flooding, avalanches, and dam failure, all having the potential to cause significant damage in West Virginia (West Virginia Emergency Management Division 2018).

Impacts to the Environment

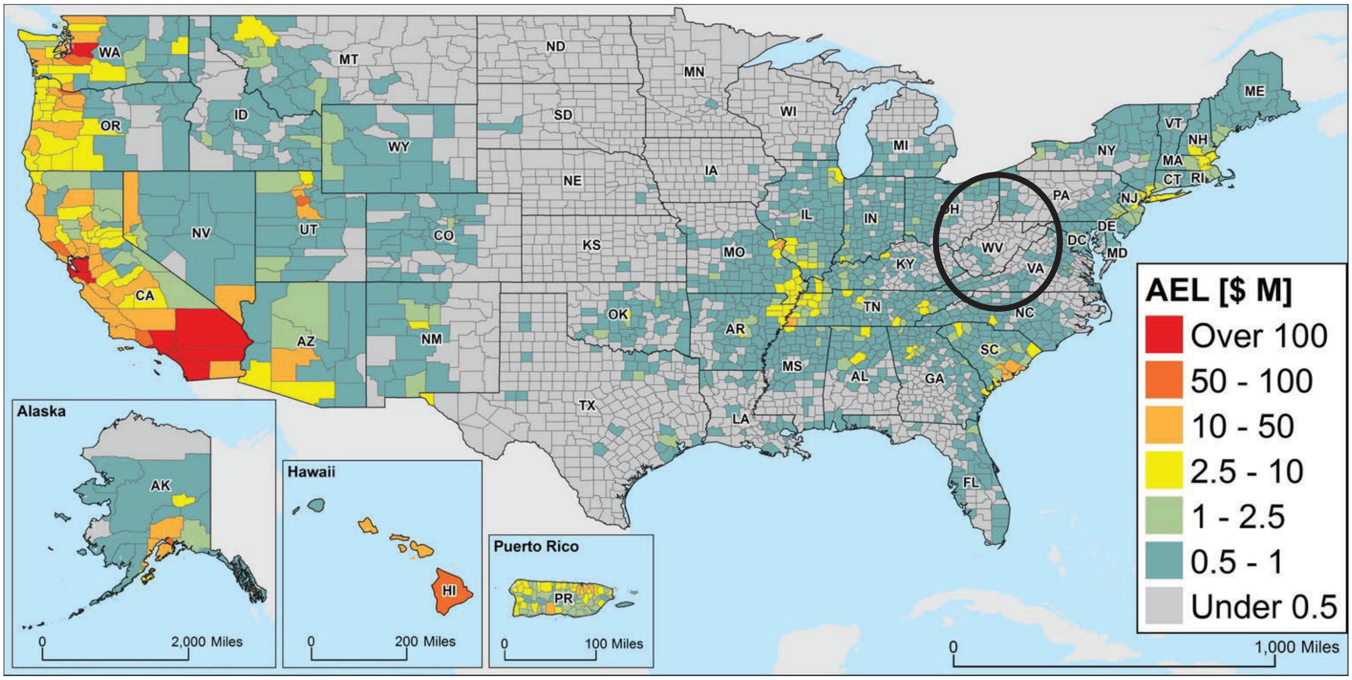
According to USGS, earthquakes can cause damage to the surface of the Earth in various forms depending on the magnitude and distribution of the event (USGS 2020). Surface faulting is one of the major seismic components to earthquakes that can create wide ruptures in the ground. Ruptures can have a direct impact on the landscape and natural environment because it can disconnect habitats for miles, isolating animal species or tearing apart plant roots.

Furthermore, ground failure as a result of soil liquefaction can have an impact on soil pores and retention of water resources (USGS 2020). The greater the seismic activity and liquefaction properties of the soil, the more likely drainage of groundwater can occur, which depletes groundwater resources. In areas where there is higher pressure of groundwater retention, the pores can build up more pressure and make soil behave more like a fluid rather than a solid increasing risk of localized flooding and deposition or accumulation of silt.

Impacts to the Economic Condition of the State

In April 2017, FEMA released a report that conducted a nationwide evaluation of earthquake losses in the United States: HAZUS-MH Estimated Annualized Earthquake Losses for the United States. FEMA’s evaluation ranked West Virginia 41st in the Nation for Annualized Earthquake Loss Ratio (AELR) ($7.4 million) and 44th for Annualized Earthquake Losses (AEL) ($1.4 million) (West Virginia Emergency Management Division 2018). Figure 5.3-8 shows that a majority of West Virginia has minimal damages associated with earthquakes. There is a narrow band of counties with annualized damages between $500,000 and $1 million.

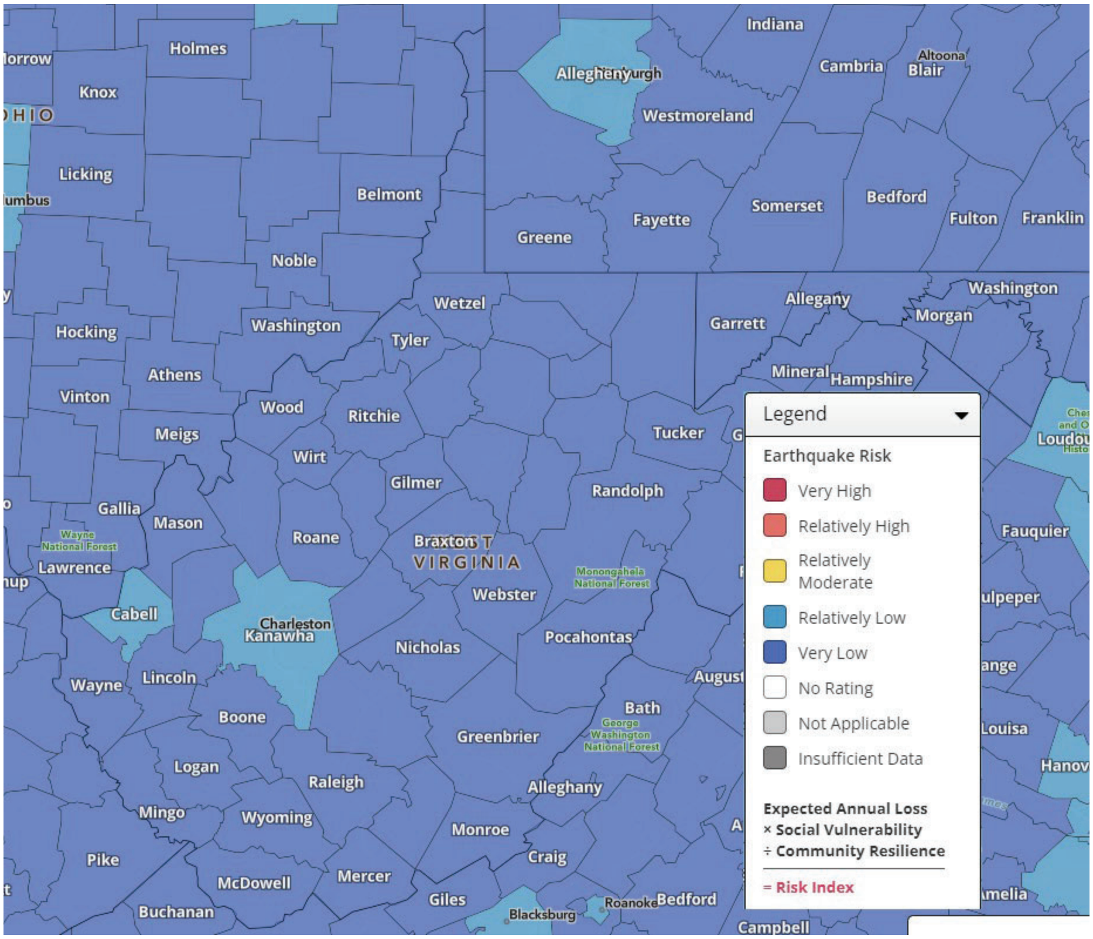
Figure 5.3-8. Annualized Earthquake Loss by County



Source: West Virginia Emergency Management Division 2018
Note: The location of West Virginia is shown with a black oval.

According to FEMA's National Risk Index, nearly all of West Virginia has very low expected annual losses ($3.6 million), with just two counties (Cabell [$360,000] and Kanawha [$507,000]) having a relatively low expected annual losses due to earthquakes (FEMA 2023).

Figure 5.3-9. FEMA National Risk Index – Earthquake



Source: FEMA 2023

IMPACTS TO PUBLIC CONFIDENCE IN STATE GOVERNANCE

Public confidence would largely depend upon how effectively the State and county and local governments prepare for and respond to an earthquake event. Little impact to public confidence in the state's governance is expected.

5.4 Extreme Temperature

2023 SHMP Update Changes

- Extreme temperature events that occurred in the State of West Virginia (the State) from January 1, 2018, through December 31, 2022, were researched for this 2023 State Hazard Mitigation Plan (SHMP) update.
- New and updated figures from federal and State agencies are incorporated.
- A qualitative vulnerability assessment was conducted, at the State level, to discuss extreme temperature impacts to State assets, critical facilities and lifelines, population, socially vulnerable population, and future changes.

5.4.1 Hazard Profile

Hazard Description

Extreme temperature includes both heat and cold events, which can have a significant impact to human health, commercial/agricultural businesses, and primary and secondary effects on infrastructure (such as burst pipes and power failure). What constitutes "extreme cold" or "extreme heat" can vary across different areas of the country based on the population's experience.

Extreme Cold

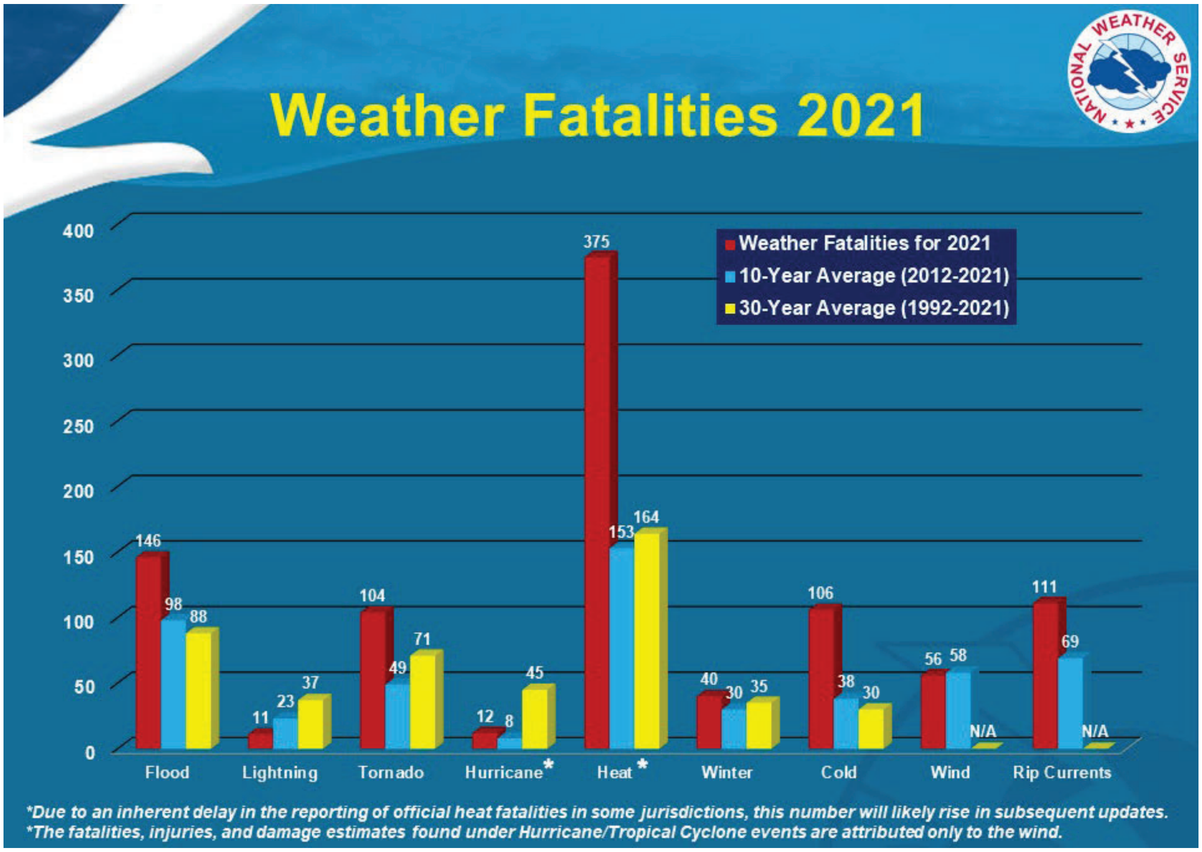
Extreme cold events occur when temperatures drop well below normal in an area. Extreme cold temperatures are generally characterized in temperate zones by the ambient air temperature dropping to approximately 0°F or below. Extreme cold temperatures often accompany a winter storm, which can cause power failures and icy roads. Staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, but individuals may also face indoor hazards. Many homes will be too cold, either due to a power failure or because the heating system is not adequate for the weather. According to the Centers for Disease Control and Prevention (CDC), the use of space heaters and fireplaces to keep warm increases the risk of household fires and carbon monoxide poisoning (CDC 2012).

Extreme Heat

Extreme heat is defined as summertime temperatures that are much hotter and/or humid than average. Because some areas are hotter than others, extreme heat temperatures depend on what is considered average for a particular location at that time of year (CDC 2012). A heat wave is a period of abnormally hot weather generally lasting more than two days. Heat waves can occur with or without high humidity. They have the potential to cover a large area, exposing a high number of people to hazardous heat (NOAA 2009).

Extreme heat is the number one weather-related cause of death in the U.S. On average, nearly 150 people die each year in the United States from excessive heat (NWS 2021). Figure 5.4-1 shows the number of weather fatalities based on a 10-year average and a 30-year average. Heat caused the highest average of weather-related fatalities between 2012 and 2021.

Figure 5.4-1. Average Number of Weather-Related Fatalities in the U.S.



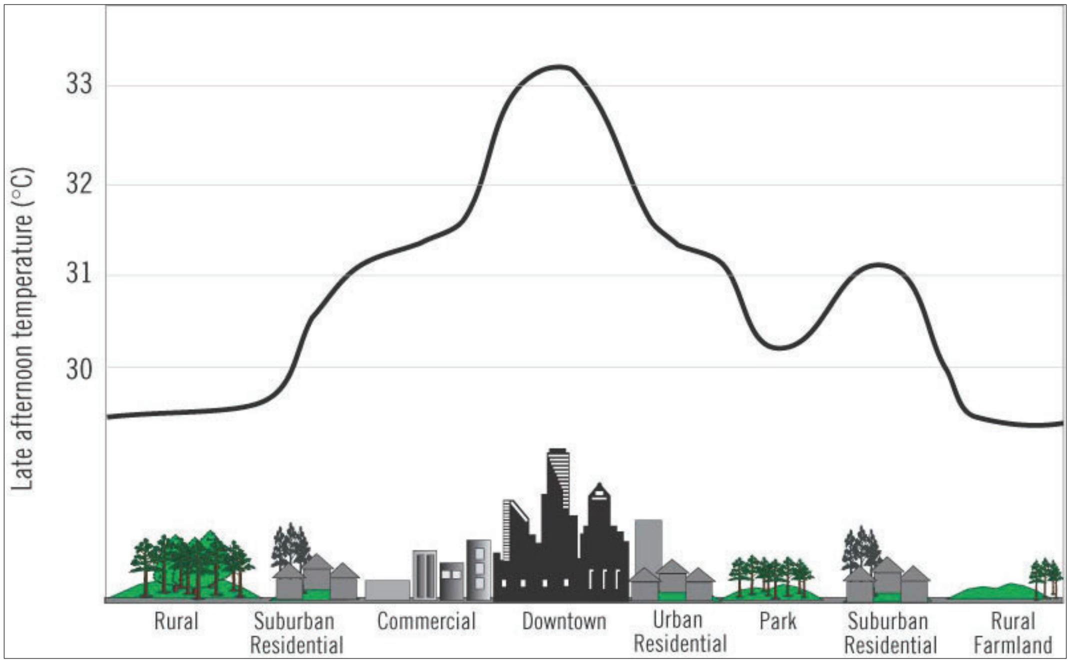
Source: NWS 2021

Location

All of West Virginia is vulnerable to extreme temperature events. Due to the State's rugged topography, temperature conditions vary considerably. West Virginia's elevation—the highest average elevation east of the Mississippi River—moderates summer temperatures. Summer average maximum temperatures range from around 85°F in the southwest, near the Ohio River, to less than 80°F in the east-central mountains. Winter average minimum temperatures range from the low 20s (°F) in the mountainous central and northeastern portions of the State to around 30°F in the far south (NOAA NCEI 2022).

Urbanized areas and urbanization exacerbate risk during an extreme heat event compared to rural and suburban areas in the State, as indicated in Figure 5.4-2. As these urban areas develop and change, so does the landscape. Buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry. These changes cause urban areas to become warmer than the surrounding areas. This forms an "island" of higher temperatures. This effect increases energy costs (e.g., for air conditioning), air pollution levels, and heat-related illness and mortality (U.S. EPA 2022).

Figure 5.4-2. Urban Heat Island Profile



Source: NWS 2021

EXTENT

Extreme Cold

The extent (severity or magnitude) of extreme cold temperatures is generally measured through the Wind Chill Temperature (WCT) Index, illustrated in Figure 5.4-3. The WCT Index uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from wind chill. For details regarding the WCT Index, refer to: http://www.nws.noaa.gov/om/winter/windchill.shtml

Figure 5.4-3. National Weather Service WCT Chart

Temperature (°F)

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

Frostbite Times: 30 minutes | 10 minutes | 5 minutes

Source: NWS n.d.

Warning Time

Warnings, watches, and advisories related to colder temperatures are issued by the NWS, typically within a 24 to 36 hour period. Table 5.4-1 describes the general alerts related to extreme cold events.

Table 5.4-1. NWS Alerts for Extreme Cold

Alert	Criteria
Wind Chill	
Wind Chill Warning: Take Action!	NWS issues a wind chill warning when dangerously cold wind chill values are expected or occurring. If you are in an area with a wind chill warning, avoid going outside during the coldest parts of the day. If you do go outside, dress in layers, cover exposed skin, and make sure at least one other person knows your whereabouts. Update them when you arrive safely at your destination.
Wind Chill Watch: Be Prepared	NWS issues a wind chill watch when dangerously cold wind chill values are possible. As with a warning, adjust your plans to avoid being outside during the coldest parts of the day. Make sure your car has at least a half a tank of gas, and update your winter survival kit.
Wind Chill Advisory: Be Aware	NWS issues a wind chill advisory when seasonably cold wind chill values but not extremely cold values are expected or occurring. Be sure you and your loved ones dress appropriately and cover exposed skin when venturing outdoors.
Freeze	
Hard Freeze Warning: Take Action!	NWS issues a hard freeze warning when temperatures are expected to drop below 28°F for an extended period of time, killing most types of commercial crops and residential plants.
Freeze Warning: Take Action!	When temperatures are forecasted to go below 32°F for a long period of time, NWS issues a freeze warning. This temperature threshold kills some types of commercial crops and residential plants.
Freeze Watch: Be Prepared	NWS issues a freeze watch when there is a potential for significant, widespread freezing temperatures within the next 24-36 hours. A freeze watch is issued in the autumn until the end of the growing season and in the spring at the start of the growing season.
Frost Advisory: Be Aware	A frost advisory means areas of frost are expected or occurring, posing a threat to sensitive vegetation.

Source: NWS 2023

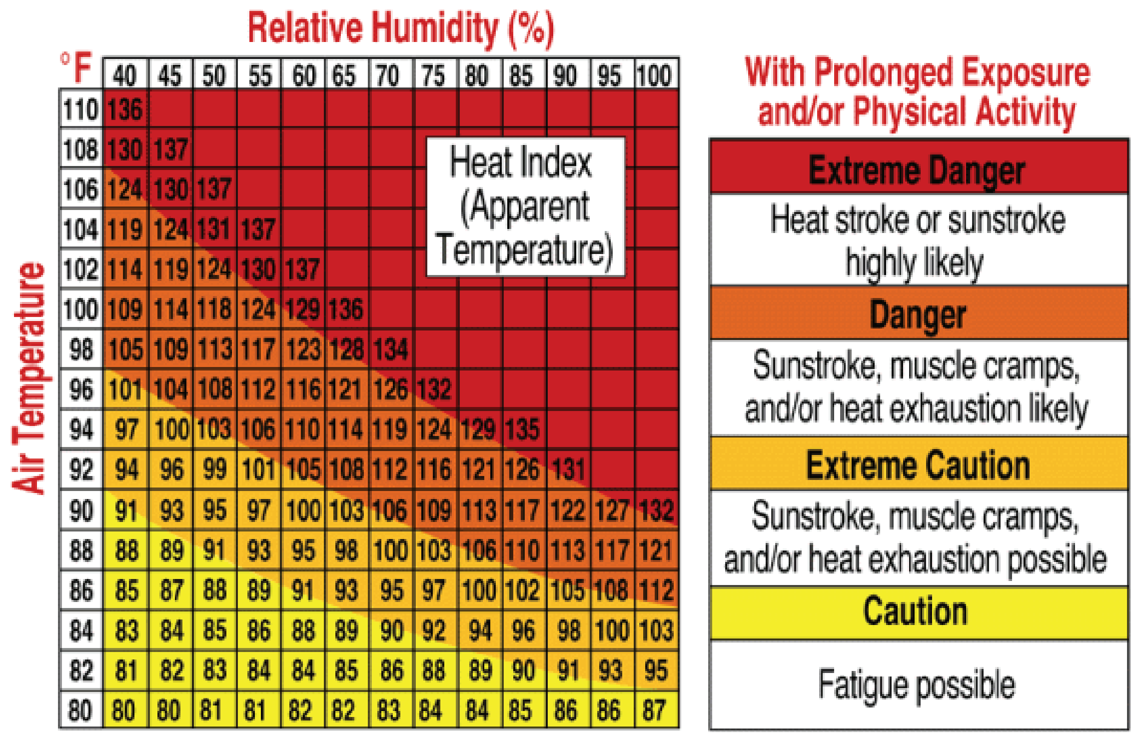
More specifically, the NWS Weather Forecast Offices in West Virginia will issue advisories and warnings for extreme cold events. For West Virginia, the NWS issues the following related to colder temperatures:

- **Freeze Warning** – Widespread temperatures are forecast to be 32°F or below for 2 hours or more during the growing season.
- **Frost Advisory** – Widespread frost during the growing season.
- **Wind Chill Advisory** – Wind chills of 10 below to 24 below are expected for 3 hours or more with wind speeds greater than 5 mph.
- **Wind Chill Watch/Warning** – Wind chills of 25 below or colder are expected for 3 hours or more with wind speeds greater than 5 mph (Charleston, WV Weather Forecast Office 2023).

Extreme Heat

Extreme heat temperatures generally is measured through the heat index, identified in Figure 5.4-4. Created by the NWS, the heat index is a chart that accurately measures what the temperature feels like to the human body when relative humidity is combined with the air temperature (NWS n.d.). To determine the heat index, the temperature and relative humidity are needed. Once both values are identified, the heat index is the corresponding number of both values. This provides a measure of how temperatures feel; however, the values are devised for shady, light wind conditions. Exposure to full sun can increase the index by up to 15°F.

Figure 5.4-4. NWS Heat Index



°F	40	45	50	55	60	65	70	75	80	85	90	95	100
110	136												
108	130	137											
106	124	130	137										
104	119	124	131	137									
102	114	119	124	130	137								
100	109	114	118	124	129	136							
98	105	109	113	117	123	128	134						
96	101	104	108	112	116	121	126	132					
94	97	100	103	106	110	114	119	124	129	135			
92	94	96	99	101	105	108	112	116	121	126	131		
90	91	93	95	97	100	103	106	109	113	117	122	127	132
88	88	89	91	93	95	98	100	103	106	110	113	117	121
86	85	87	88	89	91	93	95	97	100	102	105	108	112
84	83	84	85	86	88	89	90	92	94	96	98	100	103
82	81	82	83	84	84	85	86	88	89	90	91	93	95
80	80	80	81	81	82	82	83	84	84	85	86	86	87

Source: NWS 2023

Warning Time

Warnings, watches, and advisories related to warmer temperatures are issued by the NWS, typically within a 24 to 36 hour period.

Table 5.4-2. NWS Alerts for Extreme Heat

Alert	Criteria
Excessive Heat Warning—Take Action!	An Excessive Heat Warning is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Warning is when the maximum heat index temperature is expected to be 105° or higher for at least 2 days and nighttime air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas not used to extreme heat conditions. If you do not take precautions immediately when conditions are extreme, you may become seriously ill or even die.
Excessive Heat Watches—Be Prepared!	Heat watches are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. A Watch is used when the risk of a heat wave has increased but its occurrence and timing is still uncertain.
Heat Advisory—Take Action!	A Heat Advisory is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Advisory is when the maximum heat index temperature is expected to be 100° or higher for at least 2 days, and nighttime air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas that are not used to dangerous heat conditions. Take precautions to avoid heat illness. If you do not take precautions, you may become seriously ill or even die.
Excessive Heat Outlooks—Be Aware!	The outlooks are issued when the potential exists for an excessive heat event in the next 3-7 days. An Outlook provides information to those who need considerable lead-time to prepare for the event.

Source: NWS 2023

More specifically, the NWS Weather Forecast Offices in West Virginia will issue advisories and warnings for extreme heat events. For West Virginia, the NWS issues the following related to warmer temperatures:

- **Excessive Heat Warning** – Issued when the heat index is expected to reach around 105°F or higher for a period of at least 2 hours. A warning would also be appropriate if heat advisory criteria are expected to be reached for 4 consecutive days.
- **Heat Advisory** – Issued for heat index of equal to 100°F and less than 105°F for a period of at least 2 hours (Charleston, WV Weather Forecast Office 2023).

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1954 and 2022, West Virginia was not included in any major disaster (DR) or emergency (EM) declarations for extreme temperature-related events (FEMA 2023).

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was included in nine extreme temperature-related agricultural disaster declarations. Table 5.4-3 provides the USDA Secretarial disaster declarations in all West Virginia counties from January 1, 2012, through December 31, 2022 (USDA 2023).

Table 5.4-3. Extreme Temperature-Related USDA Declarations, 2012 to 2022

Date(s) of Event	Designation Number	Description of Disaster	Counties Declared
February – September 2012	USDA-S3384	Heat, Excessive Heat, High Temperatures	Brooke, Hancock, Marshall, Ohio, Pleasants, Tyler, Wetzel, Wood
March 1 – August 25, 2015	USDA-S3934	Excessive Rain, Flash Flooding, Flooding, Excessive Heat, Landslides, Mudslides, High Winds, Hail, and Lightning	Cabell, Hancock, Jackson, Marshall, Mason. Ohio, Pleasants, Tyler, Wayne, Wetzel, Wood
June – December 2017	USDA-S4297	Drought and Excessive Heat	Hardy
June – December 2019	USDA-S4605	Drought and Excessive Heat	McDowell, Mercer, Mingo, Monroe, Summers
July – December 2019	USDA-S4589	Drought and High Temperatures	Wayne
April 10 – May 30, 2020	USDA-S4733	Excessive Moisture and Cold Temperatures	Pleasants, Tyler, Wood
April 10 – May 30, 2020	USDA-S4735	Excessive Rain and Cold Temperatures	Cabell, Jackson, Mason, Wayne, Wood
April 23 – June 5, 2020	USDA-S4747	Excessive Rain and Cold Temperatures	Wood
May 5 – September 30, 2021	USDA-S5122	Drought and Excessive Heat	Berkeley, Jefferson, and Morgan

Source: USDA 2023
Notes: USDA U.S. Department of Agriculture

Previous Events

West Virginia has experienced numerous extreme heat and cold events. The 2018 SHMP did not chronicle past extreme temperature events. Table 5.4-4 lists prominent events since 2018 that resulted in property damage, crop damage, or casualties. Table 5.4-5 summarizes the number of extreme temperature events, including those reported to NOAA-NCEI and the recorded highs and lows at weather stations located throughout the State.

Table 5.4-4. Extreme Temperature Events in the State of West Virginia (2018 to 2022)

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
June – December 2019 (no specific dates)	Drought and Excessive Heat	S4605 (USDA)	McDowell, Mercer, Mingo, Monroe, and Summers	In June and July, hot and humid conditions were exp Temperatures ranged from 96°F to over 100°F. The were experienced through October. This resulted in Section 5.2 for details on this drought). Over $200,00 drought and heat, impacting the soybean, corn, and
July – December 2019 (no specific dates)	Drought and High Temperatures	S4589 (USDA)	Wayne	No losses recorded.
April 10 – May 30, 2020	Excessive Moisture and Cold Temperatures	S4733 (USDA)	Pleasants, Tyler, and Wood	No losses recorded.
April 10 – May 30, 2020	Excessive Rain and Cold Temperatures	S4735 (USDA)	Cabell, Jackson, Mason, Wayne, and Wood	No losses recorded.
April 23 – June 5, 2020	Excessive Rain and Cold Temperatures	S4747 (USDA)	Wood	No losses recorded.
May 5 – September 30, 2021	Drought and Excessive Heat	S5122 (USDA)	Berkeley, Jefferson, and Morgan	Over $800,000 in crop losses related to drought and corn, and other crops in the state.
December 23-25, 2022	Extreme Cold/Wind Chill	N/A	Statewide	Temperatures dropped more than 40 degrees over t Virginia, residents were without water due to water temperatures, with some not having water until Janu counties were Raleigh and Wayne, where millions of frozen pipes from water main breaks. Overall, the st property damage from this event.

Sources: FEMA 2023; NOAA NCEI 2023; USDA 2023

Table 5.4-5. Summary of Extreme Temperature Events in West Virginia, 1954 to 2022

Hazard Type	Number of Occurrences	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Excessive Heat	14	Not recorded	Not recorded	Not recorded	Not recorded
Extreme Cold/Wind Chill	40	Not recorded	Not recorded	$7.4 million	Not recorded
≥100°F	87	-	-	-	-
≤0°F	156	-	-	-	-

Sources: NOAA NCEI 2023; Midwest Regional Climate Center 2023
Notes:

- *Excessive heat events occur whenever the heat index values meet or exceed locally/regionally established Excessive Heat Warning thresholds.*
- *Heat events occur whenever heat index values meet or exceed locally/regionally established advisory thresholds.*
- *Extreme Cold/Wind Chill are periods of extremely low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined warning criteria.*

Probability of Future Hazard Events

Overall Probability

According to FEMA, USDA, NOAA-NCEI, and the 2018 SHMP, the State experienced over 14 extreme heat and 40 extreme cold events between 1996 and 2002, as summarized in Table 5.4-6. Overall, the State is likely to experience about one excessive heat day every two years and two excessive cold days each year, with the possibility of an increase in frequency due to future changing conditions.

Table 5.4-6. Probability of Future Extreme Temperature Events in West Virginia

Hazard Type	Number of Occurrences Between 1996 And 2022	Percent Chance of Occurrence in Any Given Year
Excessive Heat/Heat	14	51.85%
Extreme Cold/Wind Chill	40	100%
Total	**54**	**100%**

Sources: NOAA NCEI 2023

Projected Future Conditions

If warming occurs, there may be an increase in the intensity of extreme heat events and a decrease in intensity of extreme cold events. If temperatures rise, snow may melt earlier in spring and increase evaporation, thereby drying the soil during summer and fall. As a result, the projected change in future conditions may intensify droughts during summer and fall.

5.4.2 Vulnerability Assessment

State Assets

All State assets are exposed to extreme temperatures; however, direct impacts are expected to be minimal. This includes all 1,117 State facilities, 185 community lifelines, and 3,924 miles of State-owned roads.

Extreme heat generally does not affect buildings; however, losses may be associated with overheating of heating, ventilation, and air conditioning (HVAC) systems. Extreme cold temperature events can damage buildings through freezing and bursting pipes and freeze/thaw cycles. Additionally, antiquated or poorly constructed facilities may have inadequate capabilities to withstand extreme temperatures.

Functional downtime associated with power interruption is the most significant impact on critical facilities and community lifelines from extreme temperature events. The level of impact depends on the amount of time it takes to restore power to operational status at impacted facilities.

Critical Facilities and Community Lifelines

Similar to State assets, all critical facilities and community lifelines are exposed and vulnerable to the extreme temperature hazard. However, direct impacts are expected to be minimal. Impacts to critical facilities are the same as were described for general State assets. Additionally, it is essential that critical facilities remain operational during natural hazard events. 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. Backup power is recommended for critical facilities and infrastructure.

Population

In West Virginia, the entire population is exposed and vulnerable to the extreme temperature hazard.

Extreme Heat

Extreme heat is one of the leading causes of weather-related deaths in the United States, killing more than 600 people in the United States each year (CDC 2023). Heat-related illness includes a spectrum of illnesses ranging from heat cramps to severe heat exhaustion and life-threatening heat stroke. Table 5.4-7 describes common heat-related illnesses are listed.

Table 5.4-7. Typical Heat-Related Illnesses

Definition	Symptoms	First Aid
Heat Stroke		
Heat stroke occurs when the body can no longer control its temperature: the body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down. When heat stroke occurs, the body temperature can rise to 106°F or higher within 10 to 15 minutes.	Confusion, altered mental status, slurred speech; loss of consciousness (coma); hot, dry skin or profuse sweating; seizures; very high body temperature; fatal if treatment delayed	• Call 911 • Stay with sufferer until help arrives • Move sufferer to a shaded, cool area and remove outer clothing • Circulate air to speed cooling • Place cold wet cloths or ice on head, neck, armpits, and groin
Heat Exhaustion		
Heat exhaustion is the body's response to an excessive loss of water and salt, usually through excessive sweating. Heat exhaustion is most likely to affect older adults, infants and children, people with chronic medical conditions, athletes, pregnant women, and those working outdoors or in a hot environment.	Headache; nausea; dizziness; weakness; irritability; thirst; heavy sweating; elevated body temperature; decreased urine output	• Take sufferer to a clinic or emergency room for medical evaluation and treatment • Call 911 if medical care is unavailable • Stay with sufferer until help arrives • Remove sufferer from hot area and give liquids to drink • Remove unnecessary clothing • Cool the sufferer with cold compresses or cold water • Encourage frequent sips of cool water

Definition	Symptoms	First Aid
Rhabdomyolysis		
Rhabdomyolysis is a medical condition associated with heat stress and prolonged physical exertion. It causes the rapid breakdown, rupture, and death of muscle. When muscle tissue dies, electrolytes and large proteins are released into the bloodstream. This can cause irregular heart rhythms, seizures, and damage to the kidneys.	Muscle cramps/pain; abnormally dark urine; weakness; exercise intolerance	• Stop activity • Drink more liquids (water preferred) • Seek immediate care at the nearest medical facility • Ask to be checked for rhabdomyolysis
Heat Syncope		
Heat syncope is a fainting (syncope) episode or dizziness that usually occurs when standing for too long or suddenly standing up after sitting or lying. Factors that may contribute to heat syncope include dehydration and lack of acclimatization.	Fainting (short duration); dizziness; light-headedness from standing too long or suddenly rising from a sitting or lying position	• Sit or lie down in a cool place • Slowly drink water, clear juice, or a sports drink
Heat Cramps		
Heat cramps usually affect workers who sweat a lot during strenuous activity. This sweating depletes the body's salt and moisture levels. Low salt levels in muscles cause painful cramps. Heat cramps may also be a symptom of heat exhaustion.	Muscle cramps, pain, or spasms in the abdomen, arms, or legs	• Drink water and have a snack or drink that replaces carbohydrates or electrolytes every 15 to 20 minutes • Avoid salt tablets • Get help if the sufferer has heart problems, is on a low-sodium diet, or has cramps that do not subside within 1 hour
Heat Rash		
Heat rash is a skin irritation caused by excessive sweating during hot, humid weather.	Red clusters of pimples or small blisters, usually on the neck, upper chest, groin, under the breasts, and in elbow creases	• Work in a cooler, less humid environment if possible • Keep rash area dry • Apply powder to increase comfort • Do not use ointments or creams

Source: CDC 2022

Impacts on Socially Vulnerable Populations

Overall, the entire population of the State is exposed and vulnerable to extreme heat. Therefore, the exposed socially vulnerable population to extreme heat is equal to the statewide percentage: 60.4 percent of the total population. Older populations, infants and children, pregnant people, and people with chronic illnesses can be especially sensitive to heat exposure. Low-income individuals are more likely to live in poorly ventilated dwellings, lack air conditioning, or be unable to afford cooling; people experiencing homelessness lack shelter, cooling apparatus, and consistent access to water to minimize heat impacts (Center for Climate and Energy Solutions 2021).

Extreme Cold

Extreme cold is a dangerous situation that can bring on health emergencies in susceptible people, such as those without shelter or who are stranded, or who live in a home that is poorly insulated or without heat. In addition, extreme cold can cause serious health problems when exposed to prolonged periods of cold. The most common cold-related problems are hypothermia and frostbite.

- **Hypothermia** is caused by prolonged exposures to very cold temperatures. While hypothermia is most likely at very cold temperatures, it can occur even at cool temperatures (above 40°F) if a person becomes chilled from rain, sweat, or submersion in cold water. The most vulnerable to hypothermia include older adults with inadequate food, clothing, or heating; babies sleeping in cold bedrooms; people who remain outdoors for long periods—the homeless, hikers, hunters, etc.; and people who drink alcohol or use illicit drugs (CDC 2023).

- **Frostbite** is a type of injury caused by freezing. It leads to a loss of feeling and color in the areas it affects, usually extremities such as the nose, ears, cheeks, chin, fingers, and toes. Frostbite can permanently damage the body, and severe cases can lead to amputation (removing the affected body part). Those with poor blood circulation or those not properly dressed for extremely cold temperatures are most at risk to develop frostbite (CDC 2023).

Impacts on Socially Vulnerable Populations

Overall, the entire population of West Virginia is exposed and vulnerable to extreme cold. Therefore, the exposed socially vulnerable population to extreme cold is equal to the statewide percentage: 60.4 percent of the total population. Cold temperatures most immediately impact populations who lack the resources to access a warm environment during the cold weather event.

Future Changes That May Impact State Vulnerability

Understanding future changes that may impact vulnerability in the State can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors in examining potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including impacts of future conditions

Potential or Projected Development

Because all areas of West Virginia are exposed to the extreme temperature hazard, any sections of growth and development could be impacted by extreme temperatures.

Projected Changes in Population

While statewide population has declined over the past 10 years, population has increased in several areas throughout the State (e.g., Berkeley, Jefferson, and Monongalia Counties). From 2010 to 2019, the State's overall population decreased by 3.3 percent, and it is projected to decrease 7.8 percent by 2040 (West Virginia Department of Transportation 2020). As the overall population decreases, fewer people will be exposed to extreme temperatures and its impacts. However, counties with projected population increases, especially those with higher percentages of socially vulnerable populations, may have increased risk of extreme temperature impacts.

Other Factors of Change

As discussed above, projected future conditions for West Virginia indicate more frequent extreme temperature events due to rising temperatures and changing precipitation patterns. Refer to Probability of Future Hazard Events for details on how future conditions can impact extreme temperatures.

5.4.3 Consequence Analysis

Impacts to the Public

In West Virginia, extreme temperature constitutes a low risk to the general populace. The elderly, small children, the chronically ill, and pets are considered to be more vulnerable to excessive heat and cold than the general population (West Virginia Emergency Management Division 2018).

Impacts to Responders

Limited impacts to first responders related to extreme temperatures are anticipated in West Virginia. However, extreme heat conditions may increase the severity of wildfires and limit water supplies available for firefighting activities. Extreme cold conditions could create hazardous roadways for emergency personnel.

Impacts to Continuity of Operations

As noted previously, extreme heat and cold events can sometimes cause short periods of utility failures. Backup power is recommended for critical facilities and infrastructure. While extreme temperatures can impact all of West Virginia, it is not anticipated that hot or cold conditions will impact the State's ability to continue operations during and after an extreme temperature event if backup power is in place.

Impacts to Property, Facilities, and Infrastructure

As stated above, the entire State is exposed and vulnerable to extreme temperatures. Functional downtime associated with power interruption is the most significant impact from extreme temperature events. The level of impact depends on the amount of time it takes to restore power to operational status at impacted facilities.

Impacts to the Environment

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.

Impacts to the Economic Condition of the State

Extended periods of hot and cold weather can have significant impacts on crops, livestock, and people in West Virginia. According to the current Census of Agriculture 2017 State Profile, there are 23,622 farms across West Virginia covering more than 3.6 million acres. The Counties of Preston (4.8 percent), Jackson (4.2 percent), and Berkeley (4.0 percent) have the greatest percentage of farms in the State. The market value of products sold is estimated at $754.2 million (USDA 2017). Table 5.4-8 provides a summary of the market value for crops and livestock in the State.

Table 5.4-8. State of West Virginia Agriculture Market Value (2017)

Agricultural Products Sold	Market Value
Value of crops, including nursery and greenhouse	$153,117,000.00
Value of livestock, poultry, and their products	$601,162,000.00
Total value of agricultural products sold	**$754,279,000.00**

Source: USDA 2017

IMPACTS TO PUBLIC CONFIDENCE IN STATE GOVERNANCE

Public confidence would largely depend upon how effectively the State and county and local governments prepare for and respond to an extreme temperature event. While establishing warming or cooling centers is a county and/or local responsibility, the public's perception of the State's governance in extreme temperature events will be impacted by the general trend of how well local governments perform in keeping their residents safe during these events. That is, if there are reports across the State of injuries or fatalities due to the extreme temperatures, the public's perception may be that the State should have done a better job responding to the event.

5.5 Flood

2023 SHMP Update Changes

- The flood hazard is now divided into several separate flood-related hazards. This profile explains the event-based flooding hazard in the State of West Virginia (the State).
- The hazard profile was reorganized and significantly enhanced to include detailed descriptions of the following: hazard definition, location, extent, previous occurrences, and probability of future occurrences (including how future conditions may impact the hazard).
- Flood events that occurred in the State from January 1, 2018, through December 31, 2022, were researched for this 2023 State Hazard Mitigation Plan (SHMP) update.
- New and updated figures from federal and state agencies are incorporated.
- The 1 percent annual chance flood or special flood hazard area (SFHA) served as the basis for the exposure analysis for state assets, critical facilities, population, general building stock, and environmental resources.
- Hazus was used to generate estimated potential losses for state buildings, critical facilities, and general building stock located in the SFHA.

5.5.1 Hazard Profile

Summary of Key Terms

Special Flood Hazard Area (SFHA)

*The 1 percent annual chance flood as depicted on the FEMA Flood Insurance Rate Maps. The hazard area is called the **Special Flood Hazard Area** (SFHA).*

Source: FEMA 2020

A flood is an overflow of water from oceans, rivers, groundwater, or rainfall that submerges areas that are usually dry. This natural phenomenon can be exacerbated by features of the built environment.

Flood is a natural hazard that can occur during any season. Flooding typically occurs during prolonged rainfalls over several days or due to intense rainfalls over a short period of time. The most common cause of flooding is due to rain or snowmelt that accumulates faster than soils can absorb it, or rivers can carry it away. Flooding can also result from the failure of a water control structure (NWS 2019). For information on dam failure or levee failure in West Virginia, refer to Section 5.1 and Section 5.8, respectively.

Floods are one of the most frequent and costly natural hazards in the State in terms of human hardship, environmental impacts, and economic loss, particularly to communities that lie within flood-prone areas or floodplains of a major water source. Flooding is a general and temporary condition of partial or complete inundation on normally dry land from the following:

- Riverine overbank flooding
- Flash floods
- Alluvial fan floods
- Mudflows or debris floods

- Dam- and levee-break floods
- Local draining or high groundwater levels
- Fluctuating lake levels
- Ice jams (NWS 2019)

Flooding from snowmelt and ice jams are identified by the National Weather Service as being one of the major flood concerns for West Virginia. Snowmelt flooding occurs when the major source of water involved in a flood is caused by melting snow. The mountainous areas of West Virginia are particularly susceptible to snowmelt flooding. Snowpack can store the water for an extended amount of time until temperatures rise above freezing and the snow melts; this delays the arrival of water to the soil for days, weeks, or even months. Once the snow begins to melt and reaches the soil, water from snowmelt behaves much as it would if it had come from rain instead of snow by either infiltrating into the soil, running off, or both. Ice jams are common during the winter and spring along rivers, streams, and creeks in the mountainous regions of West Virginia but can occur statewide. As ice or debris moves downstream, it may get caught on any sort 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 (NWS 2019).

For the purpose of this SHMP and as deemed appropriate by the West Virginia State Planning Team, excessive localized rainfall, flash, riverine, and stormwater flooding are the main flood types of concern for the county. These types of flooding are further discussed below.

Hazard Description

Historically, flooding has affected each of the 32 major watersheds and 55 counties within the state. Federally declared flood disasters are far too common in the Mountain State. Many communities across West Virginia suffered from the effects of the June 2016 flood, and those impacts were exacerbated by lingering impacts from floods earlier that year. Repeated flood damage to city infrastructures has been exasperated by decreased tax revenues that resulted in negative effects from postponed maintenance and flood-associated repairs. Repeated damage from flooding has affected the infrastructure of several communities, resulting in systems that are now in need of major repairs and upgrades that require relocation of major components of the systems (State of West Virginia 2018).

Flooding has historically been the most damaging hazard to infrastructure and residents in the State.

Four types of flooding frequently occur in West Virginia. They can occur separately or simultaneously.

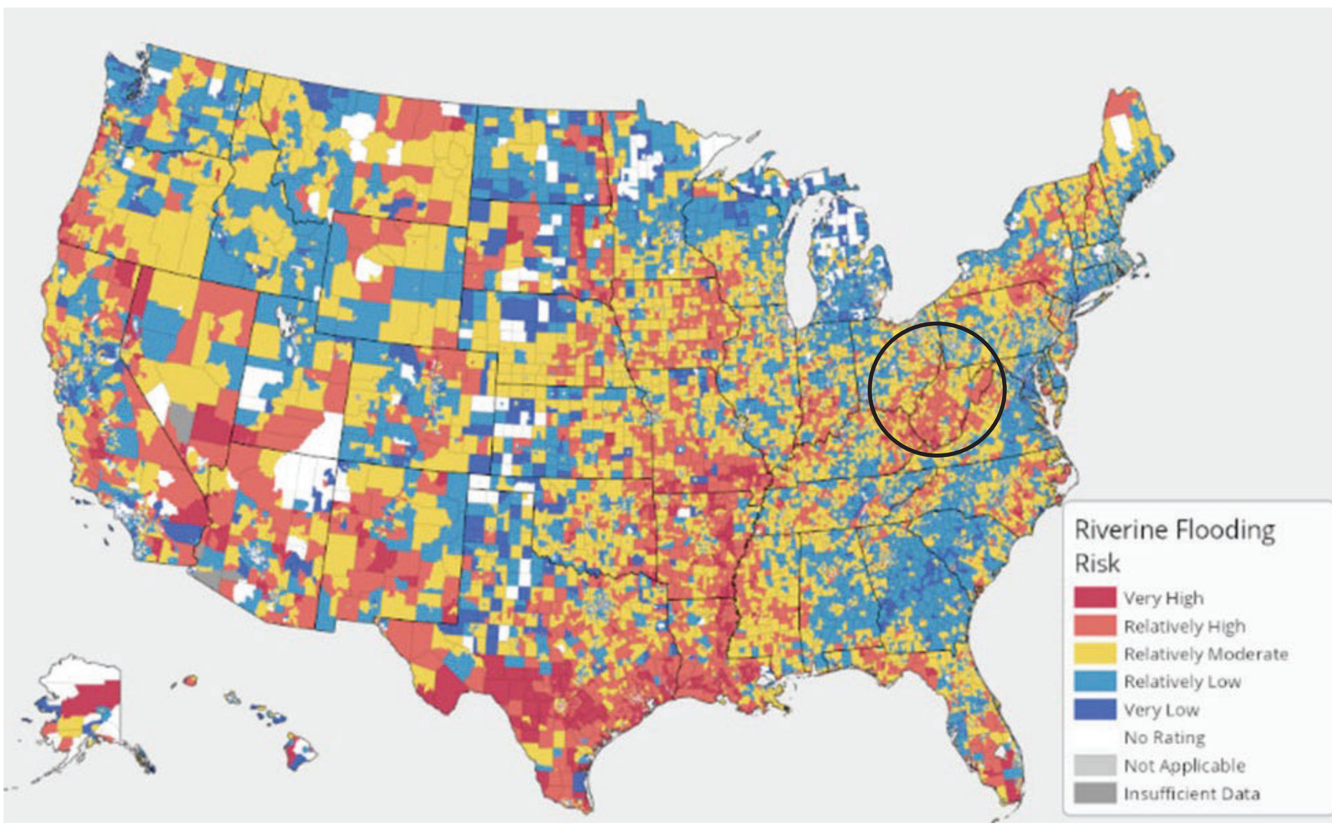
Excessive Localized Rainfall is also referred to as “heavy precipitation”. Excessive localized rainfall refers to instances during which the amount of rain experienced in a location substantially exceeds what is normal. What constitutes a period of excessive localized rainfall varies according to location and season (U.S. EPA 2022).

Flash Flood is a rapid inundation of low-lying areas caused by heavy rain associated with severe thunderstorms, tropical systems, or melting water from ice or snow. Flash flooding also occurs far away from water bodies when a large volume of water cannot be absorbed by the soil or storm water systems and travels overland unimpeded. The intensity of the rainfall, the location and distribution of the rainfall, the land use and topography, vegetation types and growth/density, soil type, and soil water-content all determine how quickly the flash flooding may occur and influence where it may occur (NWS 2019). Flash floods can also occur due to dam or levee breaks and/or mudslides (debris flow) (NWS 2009).

Riverine Flooding is when streams and rivers exceed the capacity of their natural or constructed channels to accommodate water flow and water overflows the banks, spilling out into adjacent low-lying, dry land. This occurs when the flow of a river exceeds the bank sides and causes damage or obstruction to a nearby floodplain. Riverine flooding can turn into a flash flood if the river is at or above its flood stage and if the soil is saturated (FEMA 2019). The National Risk Index indicates that the State has a relatively moderate to very high likelihood of riverine flooding (FEMA 2019). Figure 5.5-1 below shows the risk of riverine flooding in the United States. The State is identified by a black circle.

Stormwater Flooding occurs when flooding results from poorly designed or blocked drainage systems. Local (urban) drainage systems collect groundwater from heavy rainfall in developed areas. Water that does not evaporate or become absorbed by the ground is carried by conduits to waterways such as creeks and rivers. These systems have two purposes: (1) to control storm water runoff during periods of heavy rainfall, and (2) to minimize disruption of activity from more frequently occurring, less significant storms. Flooding occurs when runoff exceeds system capacity or because systems are blocked from lack of maintenance (NOAA 2022).

Figure 5.5-1. Riverine Flooding Risk in the United States



Source: FEMA 2019
Note: The State is identified by a black circle

Location

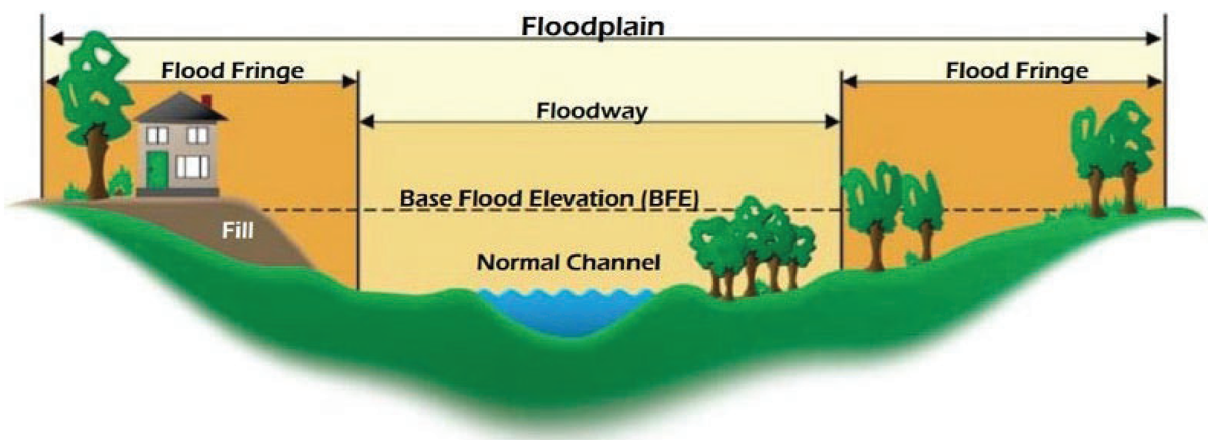
West Virginia's topographic, climatological, and meteorological features create an environment conducive to year-round flooding. The mountainous topography of West Virginia contributes greatly to the hazards threatening the state. A review of its early history shows that development in West Virginia occurred primarily along rivers. Steep inclines and rocky terrain discouraged development on the mountainsides and resulted in the establishment of cities and towns in the valleys. Heavy rains, which commonly occur in West Virginia, often result in flooding in those same valleys. Warm weather flooding is caused by severe thunderstorms bringing heavy rainfall that leads to flash floods and riverine flooding. Bank erosion and sediment deposits exacerbate flooding by blocking and re-directing the natural flow of waterways. While West Virginia is not affected by storm surge from hurricanes or tropical storms, severe rainfall associated with these systems can result in flooding.

In West Virginia, floodplains line the rivers and streams of the state. The boundaries of the floodplains are altered as a result of changes in land use, the amount of impervious surface, placement of obstructing structures in floodways, changes in precipitation and runoff patterns, improvements in technology for measuring topographic features, and utilization of different hydrologic modeling techniques.

Floodplain

A floodplain is land adjacent to a river, creek, or stream that is subject to periodic inundation. The floodplain describes the area inundated by the "100-year" flood or a flood that has a 1 percent chance in any given year of being equaled or exceeded (National Geographic 2022).

Figure 5.5-2. Characteristics of a Floodplain



Source: FEMA 2022

Floodplains serve multiple functions. They moderate flooding, maintain water quality, recharge groundwater, reduce erosion, redistribute sand and sediment, and support fish and wildlife habitat. Areas subject to flooding include the following:

- Locations that experience greater than the 1 percent annual chance flood, often referred to as the 100-year flood

- Sites that experience shallow flooding, storm water flooding, or drainage problems that do not meet the National Flood Insurance Program (NFIP) mapping criteria
- Places affected by flood-related hazards such as riverine erosion (National Geographic 2023)

Table 5.5-1 lists the area of each county in West Virginia located within the 1 percent and 0.2 percent annual chance flood event. See Figure 5.5-3. through Figure 5.5-14. on the following pages which visualize the FEMA-designated SFHA for the State.

Table 5.5-1. Area Located in the SFHA by County

County	Total Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Flood Hazard Areas			
		Total Acres Located in the 1 percent Annual Chance Flood Event	Percent of Total	Total Acres Located in the 0.2 percent Annual Chance Flood Event	Percent of Total
Barbour	218,598	6,708	3.1%	6,790	3.1%
Berkeley	205,141	10,440	5.1%	10,928	5.3%
Boone	321,687	8,057	2.5%	8,057	2.5%
Braxton	328,023	9,843	3.0%	9,843	3.0%
Brooke	59,321	4,136	7.0%	4,554	7.7%
Cabell	184,109	15,166	8.2%	16,438	8.9%
Calhoun	179,487	6,487	3.6%	6,487	3.6%
Clay	219,951	5,796	2.6%	5,828	2.6%
Doddridge	205,051	5,672	2.8%	5,672	2.8%
Fayette	427,276	7,456	1.7%	8,126	1.9%
Gilmer	217,274	7,119	3.3%	8,007	3.7%
Grant	305,479	7,902	2.6%	7,911	2.6%
Greenbrier	654,360	22,362	3.4%	22,676	3.5%
Hampshire	412,248	26,568	6.4%	27,364	6.6%
Hancock	56,222	4,621	8.2%	4,869	8.7%
Hardy	373,689	17,429	4.7%	17,435	4.7%
Harrison	266,023	9,363	3.5%	11,726	4.4%
Jackson	300,968	19,105	6.3%	19,599	6.5%
Jefferson	134,920	9,157	6.8%	9,336	6.9%
Kanawha	582,312	25,784	4.4%	35,235	6.1%
Lewis	246,359	7,410	3.0%	7,678	3.1%
Lincoln	280,594	11,307	4.0%	11,746	4.2%
Logan	291,325	5,517	1.9%	6,156	2.1%
Marion	199,006	6,125	3.1%	6,941	3.5%
Marshall	199,304	9,730	4.9%	10,140	5.1%
Mason	284,059	31,514	11.1%	35,215	12.4%
McDowell	342,174	4,371	1.3%	4,856	1.4%
Mercer	268,828	7,667	2.9%	8,149	3.0%
Mineral	210,134	9,169	4.4%	9,734	4.6%
Mingo	270,756	6,071	2.2%	7,651	2.8%
Monongalia	232,200	6,735	2.9%	7,174	3.1%
Monroe	302,704	7,783	2.6%	7,803	2.6%
Morgan	146,880	8,447	5.8%	8,554	5.8%

County	Total Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Flood Hazard Areas			
		Total Acres Located in the 1 percent Annual Chance Flood Event	Percent of Total	Total Acres Located in the 0.2 percent Annual Chance Flood Event	Percent of Total
Nicholas	415,482	11,807	2.8%	12,015	2.9%
Ohio	69,666	4,316	6.2%	4,611	6.6%
Pendleton	446,485	14,422	3.2%	14,422	3.2%
Pleasants	85,837	6,625	7.7%	6,734	7.8%
Pocahontas	601,520	14,450	2.4%	14,874	2.5%
Preston	415,612	10,346	2.5%	10,381	2.5%
Putnam	223,706	13,078	5.8%	17,953	8.0%
Raleigh	388,484	10,416	2.7%	10,892	2.8%
Randolph	664,970	26,563	4.0%	26,600	4.0%
Ritchie	290,396	8,123	2.8%	8,123	2.8%
Roane	309,410	7,087	2.3%	7,105	2.3%
Summers	233,898	4,931	2.1%	5,535	2.4%
Taylor	110,892	3,412	3.1%	3,440	3.1%
Tucker	265,897	10,568	4.0%	10,842	4.1%
Tyler	166,857	10,464	6.3%	10,563	6.3%
Upshur	226,613	6,773	3.0%	6,950	3.1%
Wayne	325,702	15,322	4.7%	17,692	5.4%
Webster	355,637	22,215	6.2%	22,877	6.4%
Wetzel	231,289	8,830	3.8%	8,888	3.8%
Wirt	150,356	8,268	5.5%	8,278	5.5%
Wood	241,020	25,122	10.4%	26,872	11.1%
Wyoming	320,602	5,383	1.7%	5,635	1.8%
Total	**15,466,796**	**599,538**	**3.9%**	**639,960**	**4.1%**

Source: FEMA 2022; USGS 2022; West Virginia University Geographic Information Systems (GIS) Technical Center (WVU GISTC) 2022
Notes: The acreage in this table excludes waterbody area

Figure 5.5-3. SFHA in Region 1 of the State of West Virginia

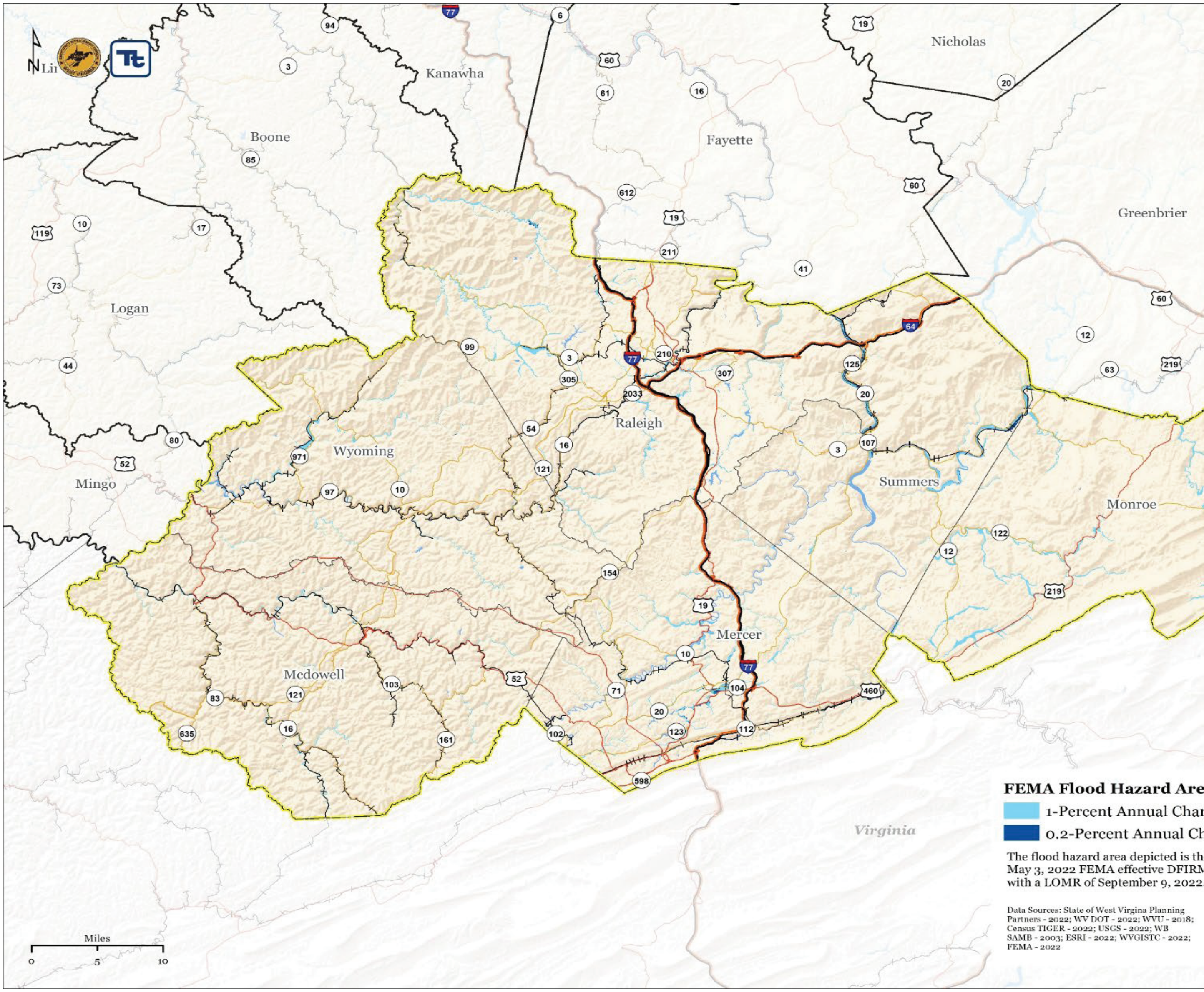


Figure 5.5-4. SFHA in Region 2 of the State of West Virginia

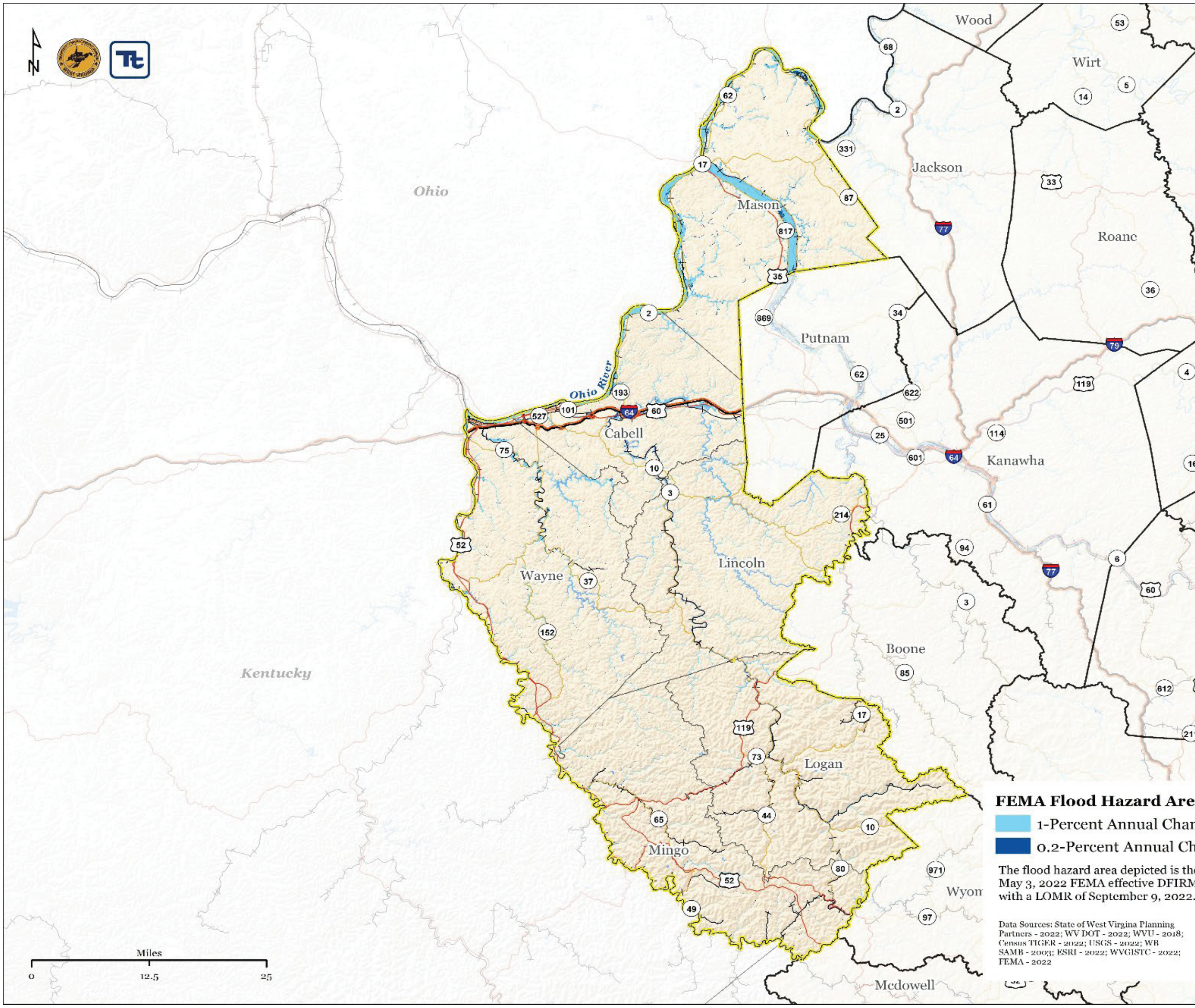


Figure 5.5-5. SFHA in Region 3 of the State of West Virginia

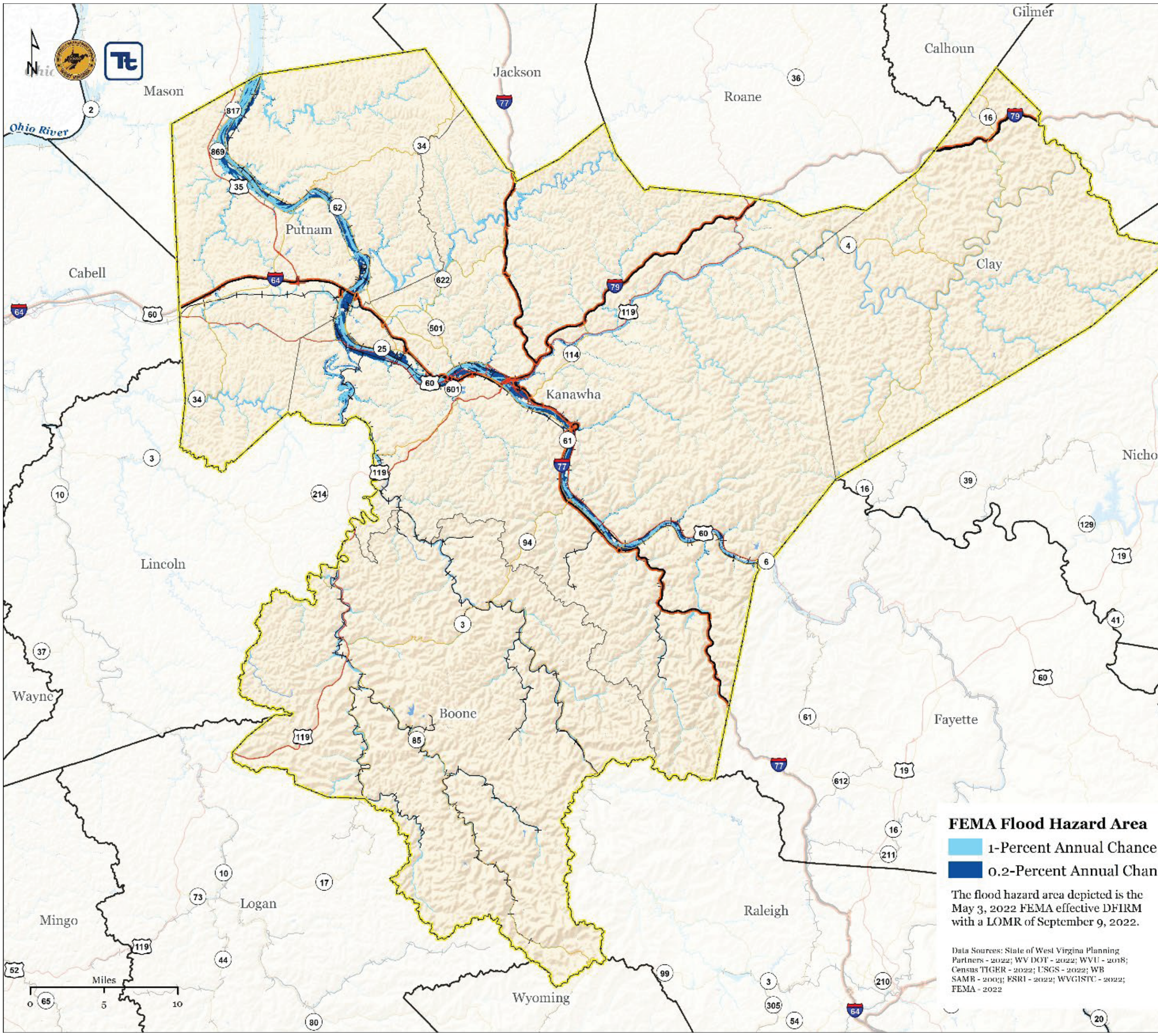


Figure 5.5-6. SFHA in Region 4 of the State of West Virginia

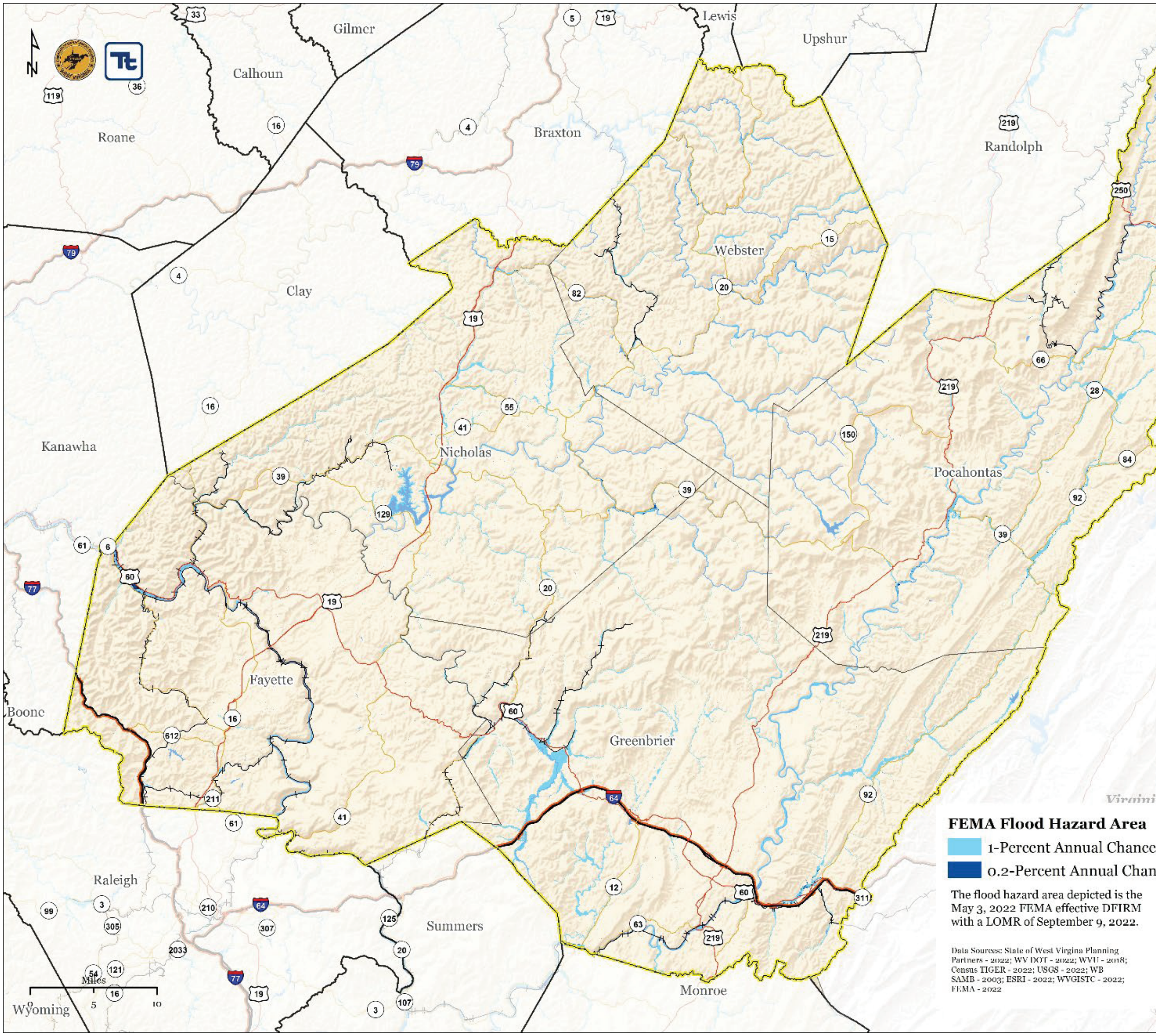


Figure 5.5-7. SFHA in Region 5 of the State of West Virginia

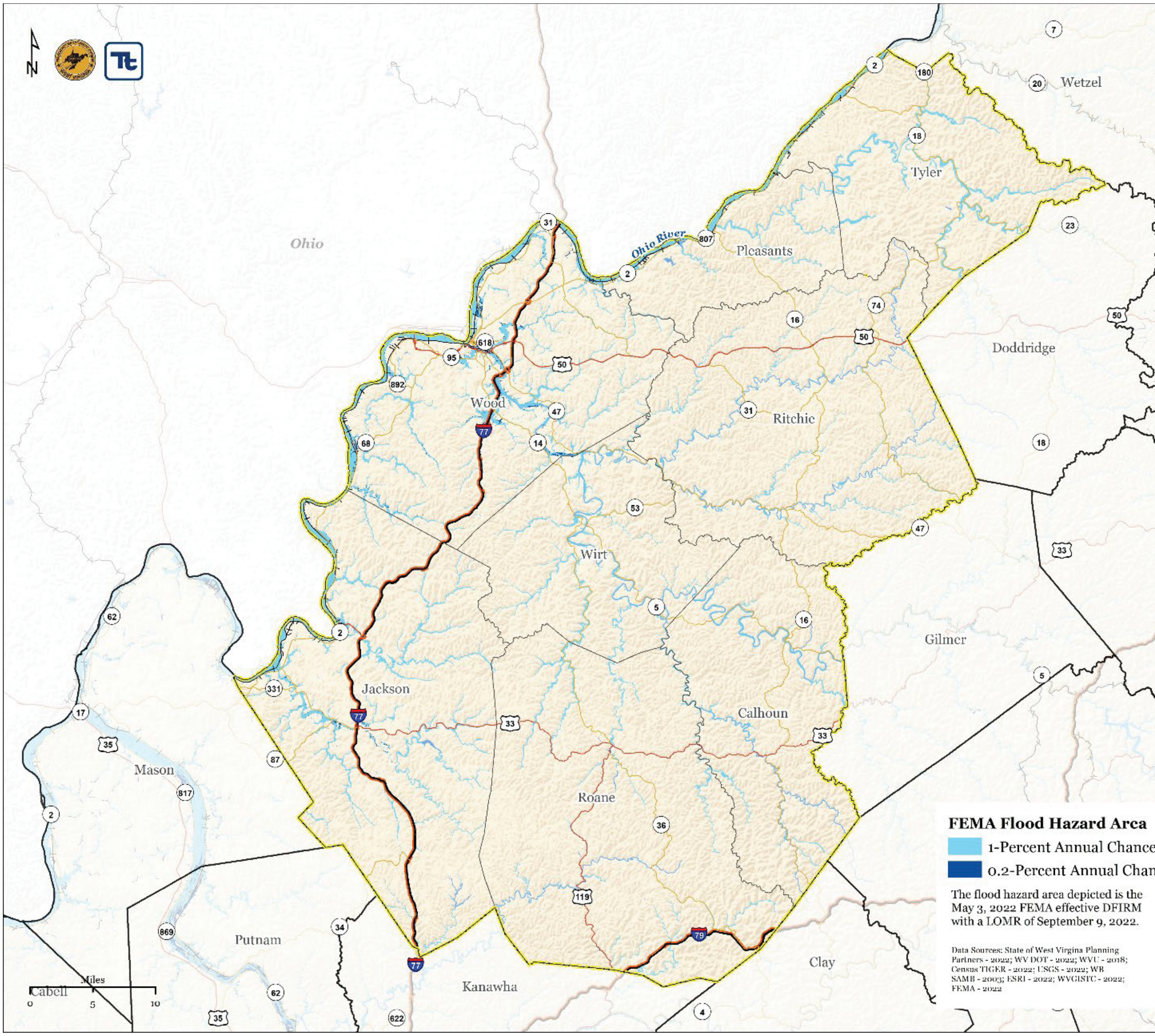


Figure 5.5-8. SFHA in Region 6 of the State of West Virginia

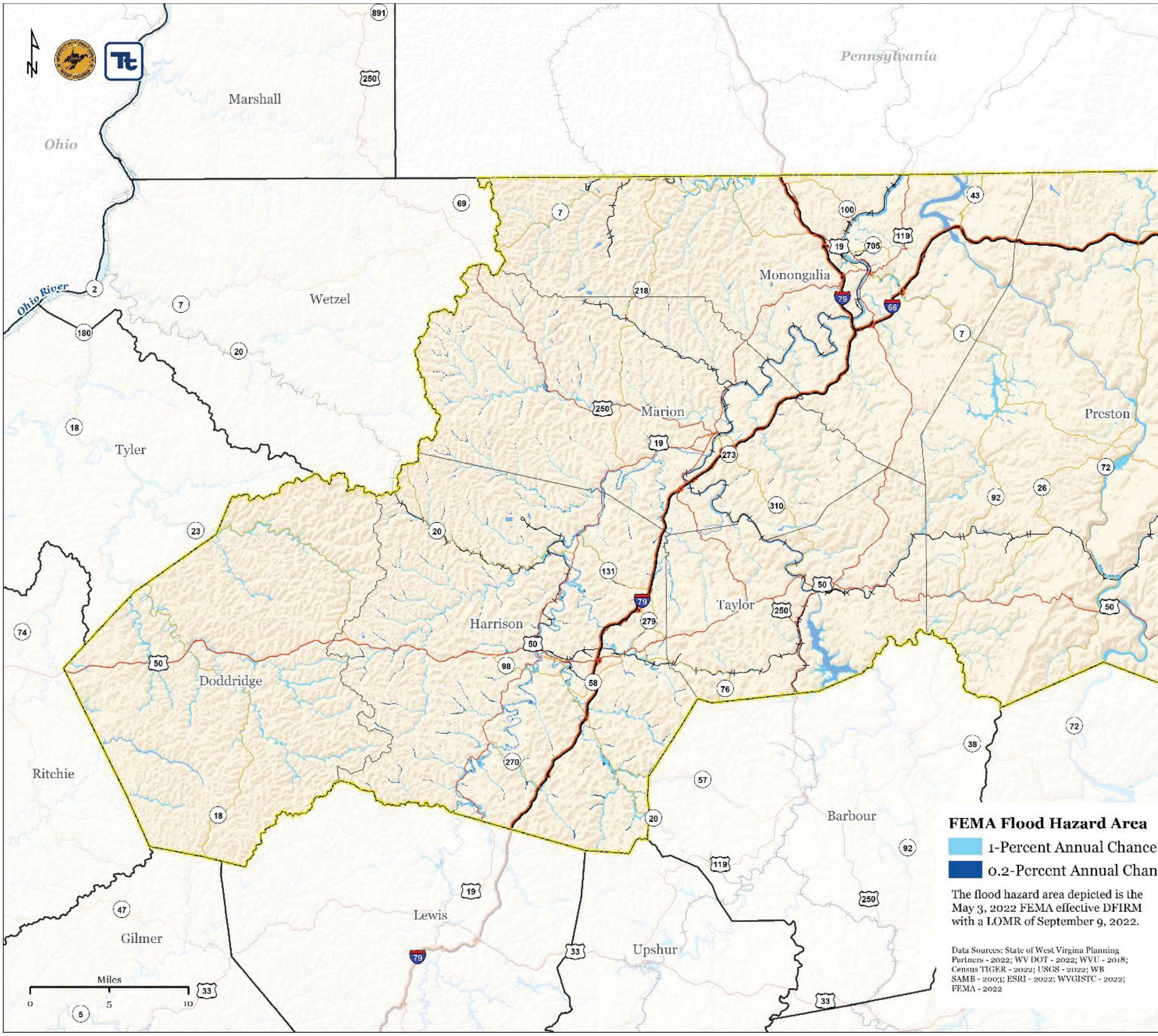


Figure 5.5-9. SFHA in Region 7 of the State of West Virginia

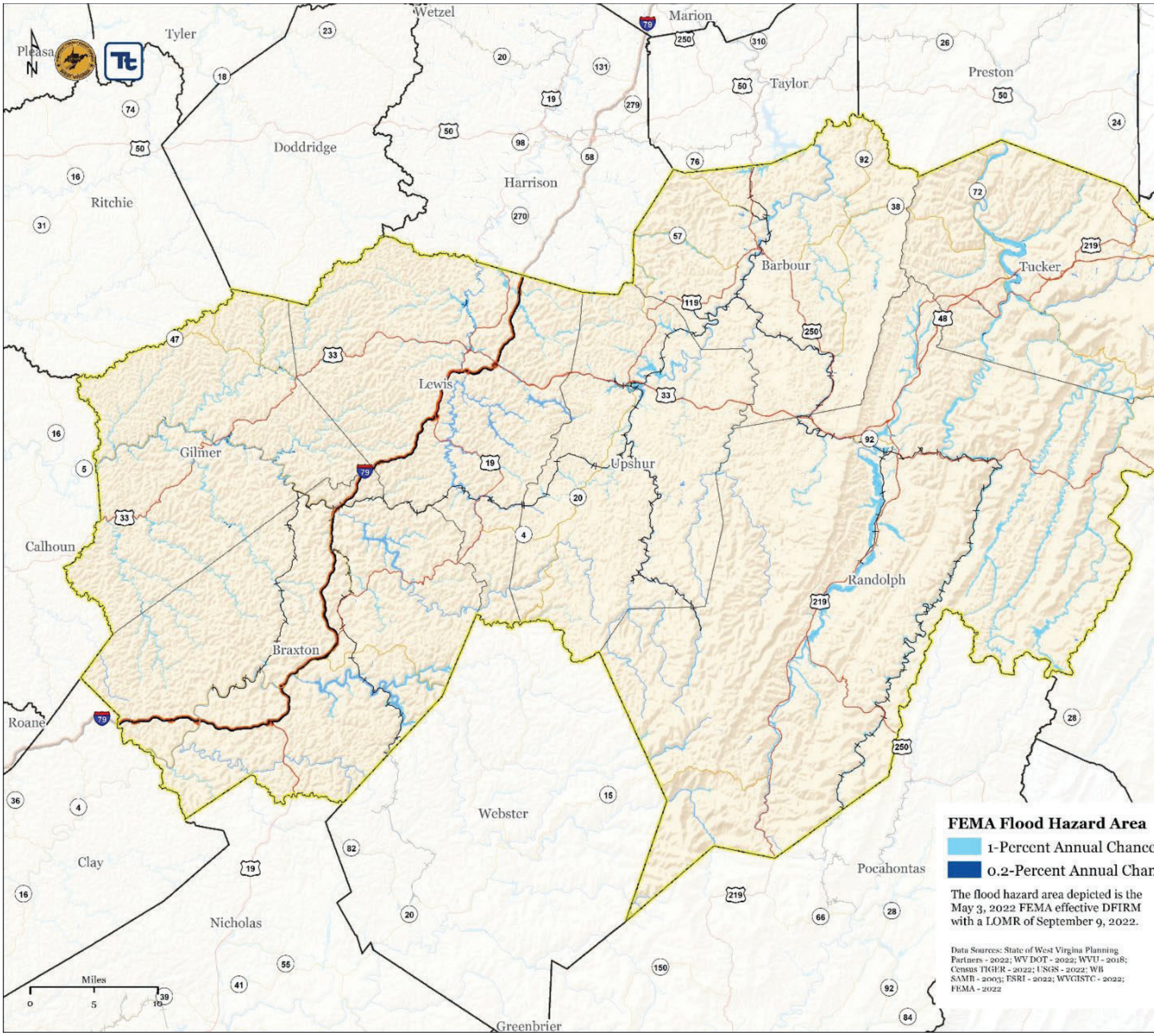


Figure 5.5-10. SFHA in Region 8 of the State of West Virginia

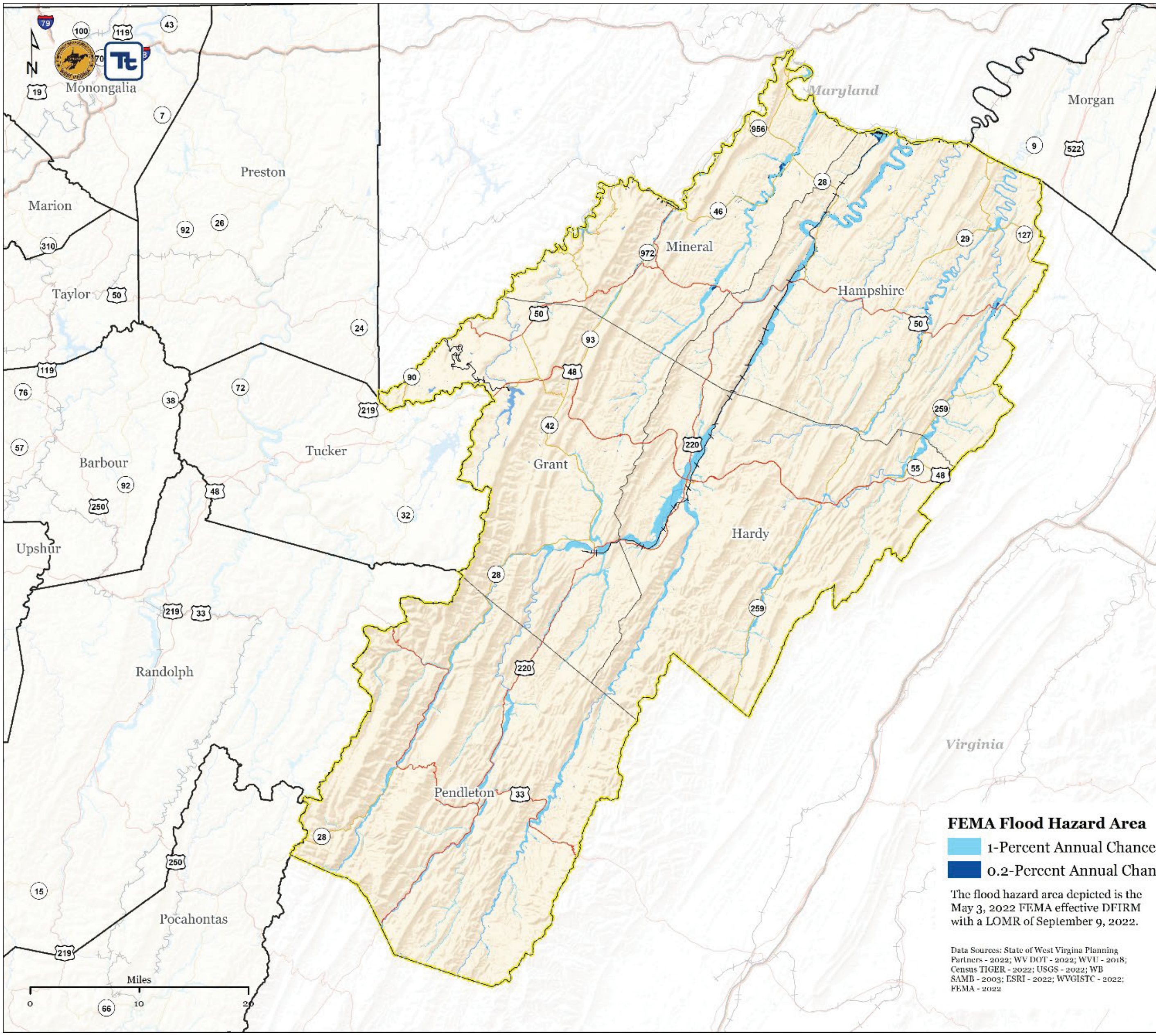


Figure 5.5-11. SFHA in Region 9 of the State of West Virginia

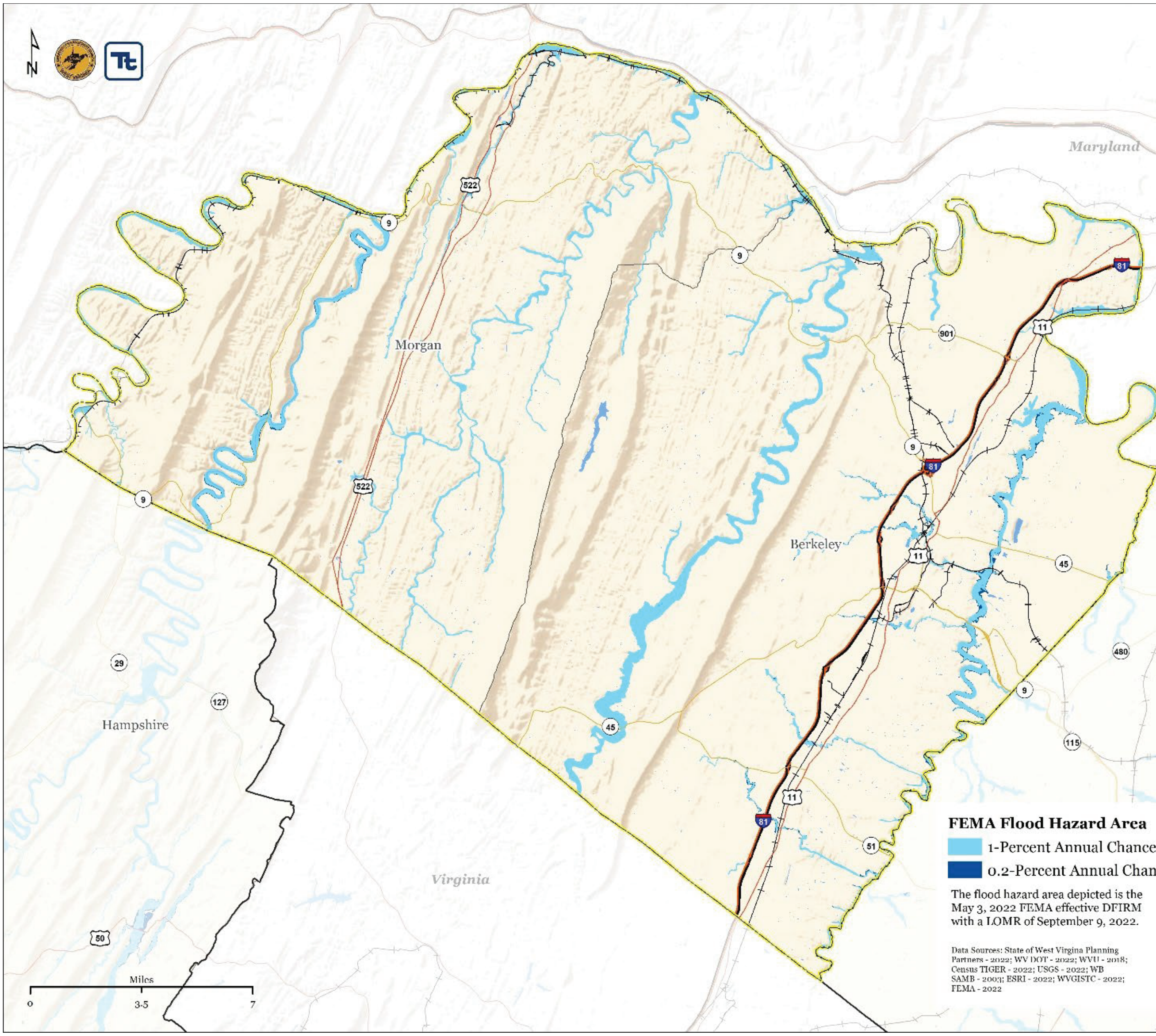


Figure 5.5-12. SFHA in Region 10 of the State of West Virginia

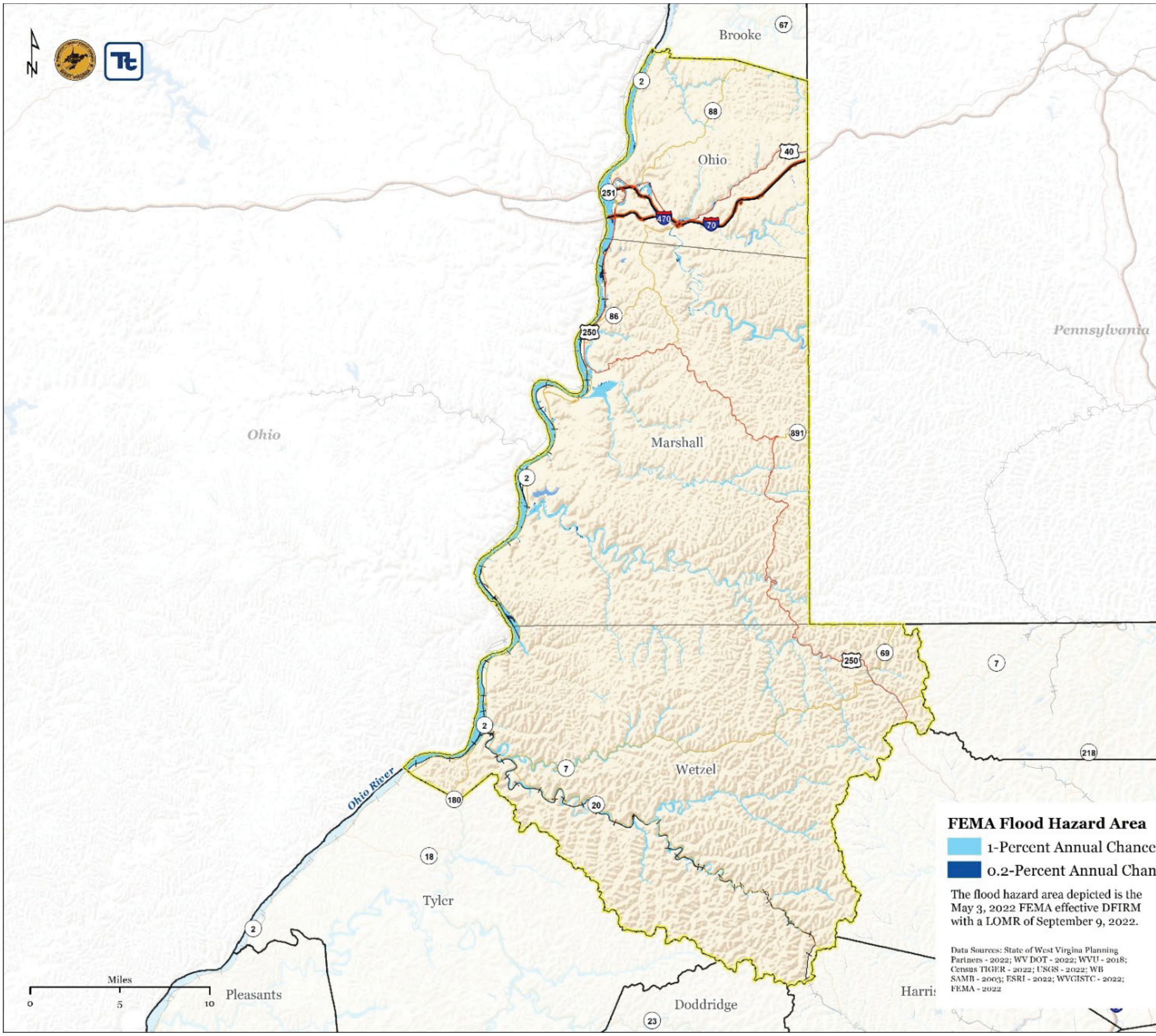


Figure 5.5-13. SFHA in Region 11 of the State of West Virginia

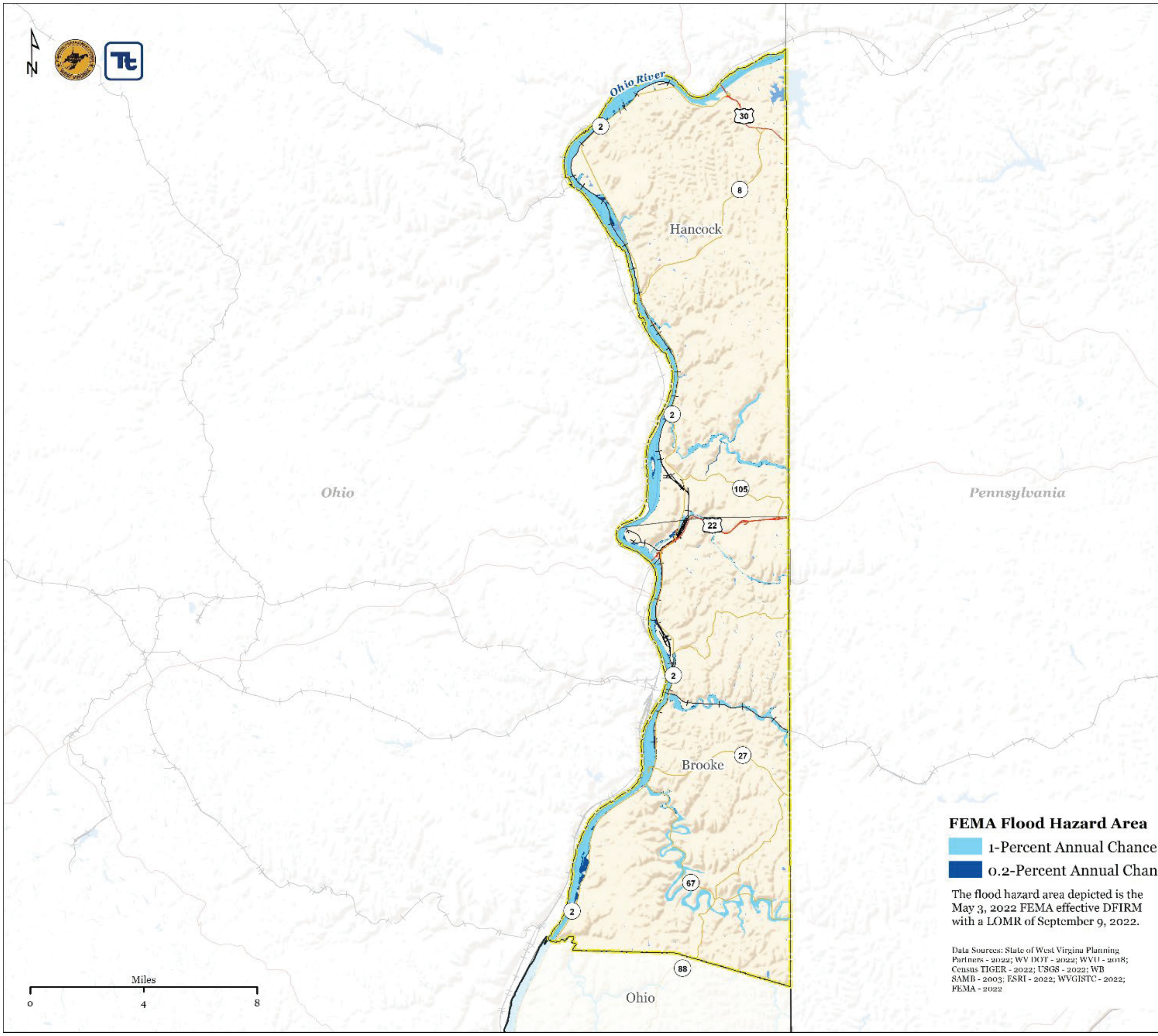
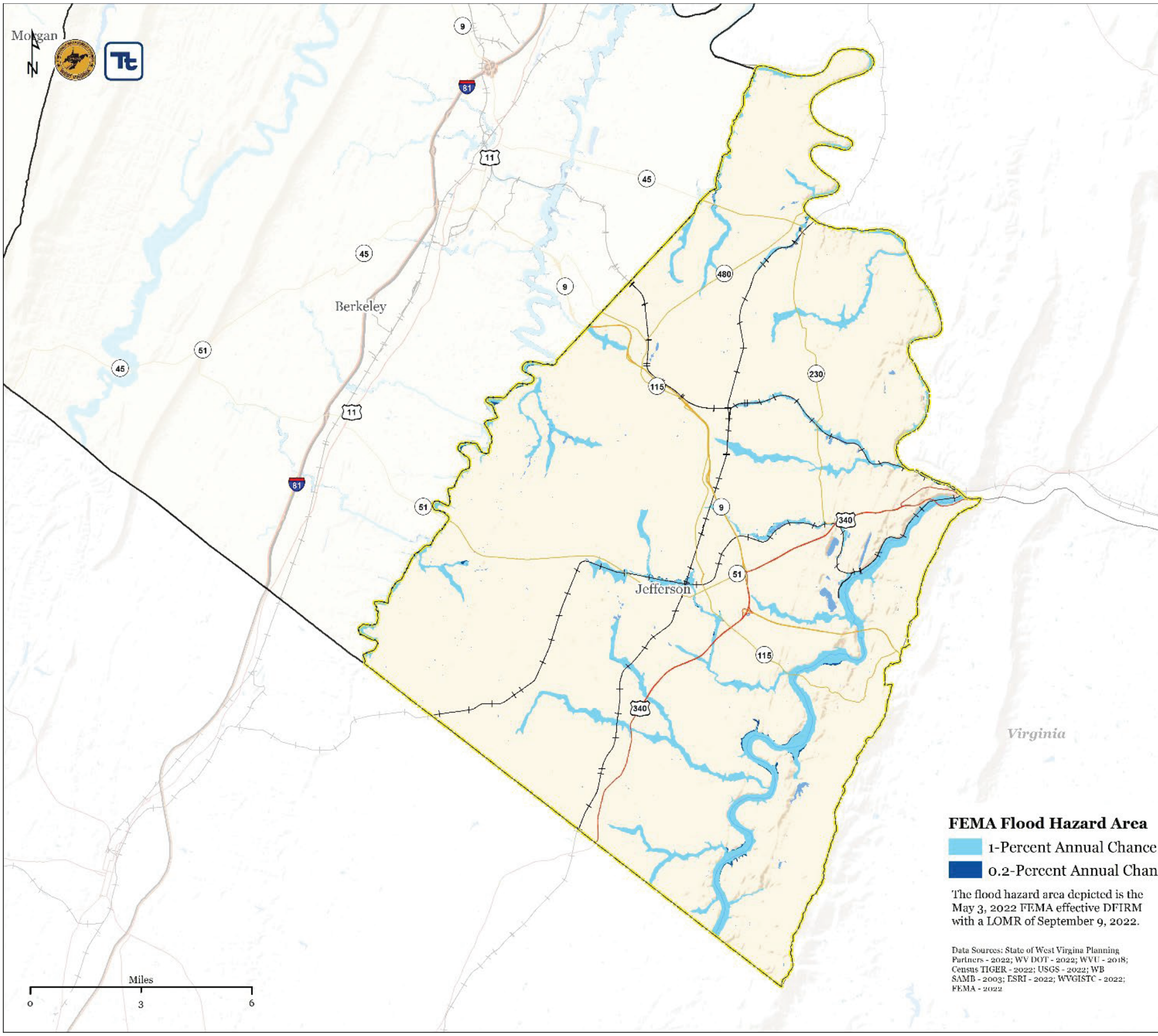


Figure 5.5-14. SFHA in Region 12 of the State of West Virginia



FEMA Flood Insurance Study (FIS)

A FEMA FIS is an engineering study performed to determine a community's risk to flood hazards. A FIS is a compilation and presentation of flood hazard areas along rivers, streams, coasts, and lakes within a community. A FIS is based on different information, including historic information such as river flow, rainfall data, meteorological data, topographic data, hydrologic data, open-space conditions, flood control works, and development (FEMA 2020).

There are a total of 55 counties in the State. Table 5.5-2 identifies the county, the dates of the FIS, and the total number of Flood Insurance Rate Map (FIRM) panels of all the incorporated jurisdictions within each county in the state. It can be common to see a single county with multiple FIS reports, as not all portions of a county may be covered in one FIS report and must be covered in a second or portions of one county were covered in a neighboring county's FIS report.

Table 5.5-2. West Virginia FIS and FIRM Panel Identification by County

County	FIS Report Effective Date(s)	Total Number of FIRM Panels
Barbour County	May 3, 2011	27
Berkeley County	July 7, 2009	34
Boone County	May 16, 2013	36
Braxton County	April 19, 2010	39
Brooke County	April 19, 2010	36
Cabell County	February 19, 2014	71
Calhoun County	June 18, 2010	20
Clay County	February 6, 2013	34
Doddridge County	October 4, 2011	25
Fayette County	September 3, 2010	32
Gilmer County	June 16, 2009	44
Grant County	February 1, 2019	23
Greenbrier County	June 7, 2002, October 16, 2012	57
Hampshire County	November 7, 2002	93
Hancock County	April 19, 2010	28
Hardy County	September 2, 2009	25
Harrison County	October 2, 2012	104
Jackson County	February 18, 2004	70
Jefferson County	December 18, 2009	26
Kanawha County	February 6, 2008 September 3, 2010	132
Lewis County	April 9, 2010	20
Lincoln County	October 16, 2013	89
Logan County	February 6, 2008	59
Marion County	April 5, 2019	66
Marshall County	September 25, 2009	31
Mason County	December 3, 2013	40
McDowell County	June 16, 2005	54
Mercer County	March 2, 2005	80

County	FIS Report Effective Date(s)	Total Number of FIRM Panels
Mineral County	March 19, 2013	39
Mingo County	August 17, 2016	86
Monongalia County	April 5, 2019	35
Monroe County	June 17, 2002	40
Morgan County	September 25, 2009	29
Nicholas County	September 24, 2021	57
Ohio County	July 17, 2006	24
Pendleton County	May 9, 2023	23
Pleasants County	May 5, 2014	30
Pocahontas County	November 4, 2010	108
Preston County	June 5, 2012	42
Putnam County	February 6, 2008 February 2, 2012	56
Raleigh County	June 16, 2009	87
Randolph County	September 29, 2010	46
Ritchie County	February 2, 2012	22
Roane County	March 2, 2012	28
Summers County	October 7, 2021	29
Taylor County	August 2, 2011	19
Tucker County	July 6, 2010	32
Tyler County	September 25, 2009 May 3, 2010	27
Upshur County	September 29, 2010	21
Wayne County	February 19, 2014 September 2, 2016	85
Webster County	May 3, 2022	53
Wetzel County	September 25, 2009	29
Wirt County	August 2, 2012	16
Wood County	November 6, 2013	118
Wyoming County	May 16, 2006	70

Source: FEMA 2023

EXTENT

The strength or magnitude of a flood varies based meteorological, environmental, and geological factors, including latitude, altitude, topography, and atmospheric conditions. Flooding is also affected by seasonal variation, storm characteristics, warning time, speed of onset, and duration. Most floods are preceded by a warning period that allows emergency managers to communicate the need to prepare for the event. A flood may last from minutes to days (O'Connor, Grant and Costa 2002).

Warnings issued through official sources, such as the National Weather Service (NWS) and the Storm Prediction Center, provide the most reliable and timely preparedness information, but the exact flood location and depth depends on the amount, duration, and location of rainfall. Many floods, especially flash floods, occur outside of FEMA-designated flood zones.

In the case of riverine flood hazard, once a river reaches flood stage, the flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category has a definition based on property damage and public threat:

- Minor Flooding - Minimal or no property damage, but possibly some public threat or inconvenience.
- Moderate Flooding - Some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding - Extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations (NOAA 2021).

Flood Advisory Definitions

Flash Flood Watch: Issued generally when there is the possibility of flash flooding or urban flooding over an area within the next 36 hours.

Flash Flood Warning: Issued when flash flooding is imminent, generally within the next 1 to 3 hours. Usually issued based on observed heavy rainfall (measured or radar estimated), but may also be issued for significant dam breaks that have occurred or are imminent.

Flood Watch: Issued when there is the possibility of widespread general flooding over an area within the next 36 hours.

Flood Warning for River Forecast Point: Issued when a river gauge has exceeded, or is forecast to exceed, a predetermined flood stage.

Flood Advisory: Issued when flooding is imminent or occurring, generally within the next 1 to 3 hours, but is not expected to substantially threaten life and property.

The severity of a flood depends not only on the amount of water that accumulates in a period of time but also on the land's ability to manage this water. The size of rivers and streams in an area and infiltration rates are significant factors. When it rains, soil acts as a sponge. When the land is saturated or frozen, infiltration rates decrease and any more water that accumulates must flow as runoff (Harris 2001).

The frequency and severity of riverine flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge has a 1 percent chance of being equaled or exceeded in any given year. The “annual flood” is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river (USGS 2018).

The extent of flooding associated with a 1 percent annual probability of occurrence (the base flood or 100-year flood) is used by the NFIP as the standard for floodplain management and to determine the need for flood insurance, as well as the regulatory flood boundary by many agencies. Also referred to as the SFHA, this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the water elevation resulting from a given discharge level, which is one of the most important factors used in estimating flood damage. A structure located within an SFHA shown on an NFIP map has a 26 percent chance of suffering flood damage during the term of a 30-year mortgage (FEMA n.d.).

The term “500-year flood” is the flood that has a 0.2 percent chance of being equaled or exceeded each year. The 500-year flood could occur more than once in a relatively short period of time. Statistically, the 0.2 percent (500-year) flood has a 6 percent chance of occurring during a 30-year period of time, the length of many mortgages. The 500-year floodplain is referred to as Zone X500 for insurance purposes on FIRMs. Base flood elevations or depths are not shown within this zone, and insurance purchase is not required in this zone (FEMA 2022).

Flood Control Structures

Flood control structures can significantly alter the extent of flooding in an area. Major flood control structures in the state include dams and levees. For details regarding dams, refer to Section 5.1 (Dam Failure); for details regarding levees, refer to Section 5.8 (Levee Failure).

Warning Time

It is unusual for a flood to occur without warning. Warning time for floods are typically between 24 and 48 hours. Flood warnings and watches are issued by the local National Weather Service (NWS) office. The NWS will update the watches and warnings and will notify the public when they are no longer in effect.

The NWS issues the following flood advisories, watches, and warnings (National Weather Service n.d.):

- **Flood Watch**—A Flood Watch means heavy rain leading to flash flooding is possible. People in the area of a flash flood watch should be prepared for heavy rains and potential flooding. Flood Watches may be issued up to 48 hours before flash flooding is expected.
- **Flood Advisory**—A Flood Advisory means nuisance flooding is occurring or imminent. A Flood Advisory may be upgraded to a Flash Flood Warning if flooding worsens and poses a threat to life and property.
- **Flash Flood Watch**—A Flash Flood Watch means flash flooding is possible due to either 1) causes other than heavy rain (e.g., dam or levee failure), or 2) heavy rain on burn scars leading to the threat of flash flooding and debris flows.
- **Flash Flood Warning**—A Flash Flood Warning means that flooding is occurring or will develop quickly. If a Flash Flood Warning is issued for an area, the population needs to take shelter and/or move to high ground as necessary. Never drive or walk across a flooded roadway.

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, the State was included in 63 disaster (DR) or emergency (EM) declarations for flood-related events. Generally, these disasters cover a wide region of the state; therefore, they can impact many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2022). Table 5.5-3 summarizes the flood-related FEMA disaster declarations between January 1, 1953 and December 31, 2022.

Table 5.5-3. Flood-Related Federal Declarations (1953 to 2022)

Date(s) of Event	Incident	Federal Designation	Counties Affected
August 4, 1954	Flood	DR-21-WV	Statewide
January 31, 1957	Flood	DR-67-WV	Statewide
July 23, 1961	Floods	DR-117-WV	Statewide

Date(s) of Event	Incident	Federal Designation	Counties Affected
March 9, 1962	Severe Storm, High Tides, and Flooding	DR-125-WV	Statewide
March 13, 1963	Severe Storms and Flooding	DR-147-WV	Statewide
March 20, 1964	Severe Storms and Flooding	DR-165-WV	Statewide
March 13, 1967	Flooding	DR-224-WV	Barbour, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Greenbrier, Hampshire, Hardy, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Marion, Mason, Mercer, Mineral, Mingo, Monroe, Morgan, Nicholas, Pocahontas, Putnam, Raleigh, Summers, Tucker, Upshur, Wayne, Wirt, Wood, Wyoming
September 3, 1969	Severe Storms and Flooding	DR-278-WV	Greenbrier, Nicholas, Pocahontas
September 24, 1969	Severe Storms and Flooding	DR-279-WV	Greenbrier
February 27, 1972	Heavy Rains and Flooding	DR-323-WV	Boone, Kanawha, Lincoln, Logan, Mingo, Raleigh, Wyoming
July 3, 1972	Tropical Storm Agnes	DR-344-WV	Barbour, Berkeley, Brooke, Greenbrier, Hampshire, Hancock, Hardy, Jefferson, Marshall, Monongalia, Monroe, Morgan, Ohio, Preston, Wetzel
August 23, 1972	Heavy Rains and Flooding	DR-349-WV	Logan, McDowell, Mingo, Wyoming
January 29, 1974	Severe Storms and Flooding	DR-416-WV	Kanawha, Lincoln, Logan, Mingo, Wayne,
April 11, 1974	Severe Storms and Flooding	DR-426-WV	Fayette, Greenbrier, Raleigh, Wyoming
September 12, 1975	Heavy Rains and Flooding	DR-481-WV	Marshall, Ohio
April 7, 1977	Severe Storms and Flooding	DR-531-WV	Cabell, Greenbrier, Lincoln, Logan, McDowell, Mercer, Mingo, Raleigh, Summers, Wayne, Wyoming
August 24, 1977	Severe Storms, Landslides, and Flooding	EM-3052-WV	Boone, Logan, Mingo
December 14, 1978	Severe Storms and Flooding	DR-569-WV	Cabell, Jackson, Lincoln, Mingo, Wayne
August 15-22, 1980	Severe Storms and Flooding	DR-628-WV	Fayette, Hancock, Harrison, Jackson, Kanawha, Marion, Marshall, Monongalia, Nicholas, Ohio, Preston, Putnam, Raleigh, Taylor, Webster
May 15, 1984	Severe Storms and Flooding	DR-706-WV	Logan, McDowell, Mingo, Wayne
November 3-7, 1985	Severe Storms and Flooding	DR-753-WV	Barbour, Berkeley, Braxton, Calhoun, Doddridge, Gilmer, Grant, Greenbrier, Hampshire, Hardy, Harrison, Jefferson, Lewis, Marion, Mineral, Monongalia, Monroe, Morgan, Nicholas, Pendleton, Pocahontas, Preston, Randolph, Summers, Taylor, Tucker, Tyler, Upshur, Webster
June 23-28, 1995	Severe Storms, Heavy Rains, Flooding, Mudslides	DR-1060-WV	Mercer, Mineral, Nicholas

Date(s) of Event	Incident	Federal Designation	Counties Affected
January 19-February 2, 1996	Flooding	DR-1096-WV	Berkeley, Brooke, Grant, Greenbrier, Hampshire, Hancock, Hardy, Jefferson, Marshall, Mason, Mercer, Minera, Monroe, Morgan, Nicholas, Ohio, Pendleton, Pleasants, Pocahontas, Preston, Raleigh, Randolph, Summers, Tucker, Tyler, Webster, Wetzel, Wood
May 15-June 10, 1996	Flooding, Heavy Winds	DR-1115-WV	Barbour, Boone, Harrison, Lincoln, Logan, McDowell, Mercer, Mingo, Pendleton, Pocahontas, Raleigh, Randolph, Tucker, Upshur, Wayne, Wetzel, Wyoming
July 18-31, 1996	Flooding	DR-1132-WV	Barbour, Braxton, Clay, Gilmer, Monongalia, Nicholas, Randolph, Webster
September 5-8, 1996	Hurricane Fran	DR-1137-WV	Berkeley, Grant, Hampshire, Hardy, Mineral, Morgan, Pendleton, Tucker
February 28-March 15, 1997	Heavy and Wind Driven Rain, High Winds, Flooding, Landslides, and Mudslides	DR-1168-WV	Braxton, Cabell, Calhoun, Clay, Gilmer, Jackson, Kanawha, Lincoln, Mason, Putnam, Roane, Tyler, Wayne, Wetzel, Wirt, Wood
June 26-July 27, 1998	Severe Storms, Flooding and Tornadoes	DR-1229-WV	Braxton, Calhoun, Clay, Doddridge, Gilmer, Harrison, Jackson, Kanawha, Lewis, Marion, Marshall, Ohio, Pleasants, Ritchie, Roane, Tyler, Webster, Wetzel, Wirt, Wood
May 15-September 4, 2001	Severe Storms & Flooding	DR-1378-WV	Boone, Cabell, Calhoun, Clay, Doddridge, Fayette, Greenbrier, Kanawha, Lincoln, Logan, Marion, Mason, McDowell, Mercer, Mingo, Nicholas, Preston, Putnam, Raleigh, Roane, Summers, Taylor, Wayne, Wyoming
May 2-20, 2002	Severe Storms, Flooding, and Landslides	DR-1410-WV	Kanawha, Logan, McDowell, Mercer, Mingo, Raleigh, Summers, Wyoming
June 11-July 15, 2003	Severe Storms, Flooding and Landslides	DR-1474-WV	Berkeley, Boone, Cabell, Doddridge, Harrison, Kanawha, Lincoln, Logan, Marion, Mason, McDowell, Mingo, Monongalia, Nicholas, Preston, Putnam, Ritchie, Tucker, Wayne, Wyoming
September 18-30, 2003	Hurricane Isabel	DR-1496-WV	Berkeley, Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan, Pendleton, Randolph, Tucker
November 11-30, 2003	Severe Storms, Flooding, and Landslides	DR-1500-WV	Barbour, Boone, Braxton, Calhoun, Clay, Doddridge, Fayette, Gilmer, Greenbrier, Harrison, Kanawha, Lewis, Lincoln, Logan, Marion, Marshall, McDowell, Mercer, Monongalia, Monroe, Nicholas, Pendleton, Pocahontas, Putnam, Raleigh, Ritchie, Summers, Taylor, Upshur, Wayne, Webster, Wetzel, Wyoming
May 27-June 28, 2004	Severe Storms, Flooding and Landslides	DR-1522-WV	Boone, Braxton, Cabell, Calhoun, Clay, Fayette, Gilmer, Jackson, Kanawha, Lewis, Lincoln, Logan, Mason, McDowell, Mercer, Mingo, Nicholas, Putnam, Raleigh, Roane, Wayne, Webster, Wirt, Wyoming
July 22-September 1, 2004	Severe Storms, Flooding, and Landslides	DR-1536-WV	Fayette, Lincoln, Logan, Mingo

Date(s) of Event	Incident	Federal Designation	Counties Affected
September 16-27, 2004	Severe Storms, Flooding and Landslides (Hurricane Ivan)	DR-1558-WV	Berkeley, Boone, Brooke, Cabell, Clay, Hancock, Jackson, Kanawha, Lincoln, Logan, Marshall, Mason, Mingo, Morgan, Ohio, Pleasants, Putnam, Tyler, Wayne, Wetzel, Wirt, Wood
January 4-25, 2005	Severe Storms, Flooding, and Landslides	DR-1574-WV	Brooke, Hancock, Marshall, Ohio, Tyler, Wetzel
April 14-18, 2007	Severe Storms, Flooding, Landslides, and Mudslides	DR-1696-WV	Barbour, Boone, Cabell, Gilmer, Grant, Hardy, Lewis, Lincoln, Logan, McDowell, Mingo, Pendleton, Pocahontas, Putnam, Upshur, Wayne, Webster, Wyoming
June 3-7, 2008	Severe Storms, Tornadoes, Flooding, Mudslides, and Landslides	DR-1769-WV	Barbour, Braxton, Calhoun, Clay, Doddridge, Gilmer, Harrison, Jackson, Jefferson, Lewis, Marion, Ritchie, Taylor, Tucker, Tyler, Webster, Wetzel, Wirt
May 3-June 8, 2009	Severe Storms, Flooding, Mudslides, and Landslides	DR-1838-WV	Calhoun, Gilmer, Lewis, McDowell, Mercer, Mingo, Raleigh, Roane, Upshur, Wirt, Wyoming
March 12-April 9, 2010	Severe Storms, Flooding, Mudslides, and Landslides	DR-1893-WV	Fayette, Greenbrier, Kanawha, Mercer, Raleigh, Summers
June 12-29, 2010	Severe Storms, Flooding, Mudslides, and Landslides	DR-1918-WV	Lewis, Logan, McDowell, Mingo, Wyoming
February 29-March 5, 2012	Severe Storms, Tornadoes, Flooding, Mudslides, and Landslides	DR-4059-WV	Doddridge, Harrison, Lincoln, Marion, Mingo, Monongalia, Preston, Ritchie, Roane, Taylor, Wayne
March 15-31, 2012	Severe Storms, Flooding, Mudslides, and Landslides	DR-4061-WV	Lincoln, Logan, Mingo
October 29-November 8, 2012	Hurricane Sandy	EM-3358-WV	Statewide
October 29-November 8, 2012	Hurricane Sandy	DR-4093-WV	Barbour, Boone, Braxton, Clay, Fayette, Kanawha, Lewis, Nicholas, Pendleton, Pocahontas, Preston, Raleigh, Randolph, Taylor, Tucker, Upshur, Webster, Wyoming
June 13, 2013	Severe Storms and Flooding	DR-4132-WV	Mason, Roane
March 3-14, 2015	Severe Winter Storm, Flooding, Landslides, and Mudslides	DR-4210-WV	Barbour, Boone, Braxton, Cabell, Doddridge, Fayette, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Marshall, McDowell, Mercer, Mingo, Monongalia, Putnam, Raleigh, Ritchie, Roane, Summers, Tucker, Tyler, Upshur, Wayne, Webster, Wetzel, Wirt, Wood, Wyoming
April 3-5, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4219-WV	Boone, Cabell, Lincoln, Logan, Mingo, Wayne
April 8-11, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4220-WV	Braxton, Brooke, Doddridge, Gilmer, Jackson, Lewis, Marshall, Ohio, Pleasants, Ritchie, Tyler, Wetzel
April 13-15, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4221-WV	Cabell, Calhoun, Greenbrier, Jackson, Pleasants, Roane, Summers, Wirt

Date(s) of Event	Incident	Federal Designation	Counties Affected
July 10-14, 2015	Severe Storms, Straight-line Winds, Flooding, Landslides, and Mudslides	DR-4236-WV	Braxton, Clay, Jackson, Lincoln, Logan, Nicholas, Roane, Webster, Wood
June 22-29, 2016	Severe Storms, Flooding, Landslides, and Mudslides	DR-4273-WV	Clay, Fayette, Greenbrier, Jackson, Kanawha, Lincoln, Monroe, Nicholas, Pocahontas, Roane, Summers, Webster
July 28-29, 2017	Severe Storms, Flooding, Landslides, and Mudslides	DR-4331-WV	Doddridge, Harrison, Marion, Marshall, Monongalia, Ohio, Preston, Randolph, Taylor, Tucker, Tyler, Wetzel
February 14-20, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4359-WV	Brooke, Cabell, Calhoun, Doddridge, Hancock, Harrison, Lincoln, Logan, Marshall, Mason, Monongalia, Ohio, Pleasants, Preston, Ritchie, Taylor, Tyler, Wayne, Wetzel, Wirt, Wood
May 28-June 3, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4378-WV	Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan, Pendleton
June 29-30, 2019	Severe Storms, Flooding, Landslides, and Mudslides	DR-4455-WV	Grant, Pendleton, Preston, Randolph, Tucker
February 27-March 4, 2021	Severe Storms and Flooding	DR-4605-WV	Boone, Kanawha, Lincoln, Logan, Mingo, Wayne
July 12-13, 2022	Severe Storms, Flooding, Landslides, and Mudslides	DR-4678-WV	McDowell
August 14-15, 2022	Severe Storms, Flooding, Landslides, and Mudslides	DR-4679-WV	Fayette

Source: FEMA 2023

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was included in 14 flood-related agricultural disaster declarations, as shown in Table 5.5-4.

Table 5.5-4. Flood-Related USDA Declarations (2012 to 2022)

Date(s) of Event	USDA Designation	Description of Disaster	Counties Declared
May 2-4, 2019	USDA-S3386	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity	Cabell, Jackson, Mason, Wood
March 1-August 25, 2015	USDA-S3934	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity	Cabell, Hancock, Jackson, Marshall, Mason, Ohio, Pleasants, Tyler, Wayne, Wetzel, Wood
July 21, 2018-continuing	USDA-S4465	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity	Brook, Hancock, Marshall, Monongalia, Ohio, Preston, Wayne, Wetzel
April 1-December 31, 2018	USDA-S4480	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity / Hail	Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Greenbrier, Jackson, Kanawha, Lewis, Mason, Nicholas, Pleasants, Pocahontas, Putnam, Randolph, Ritchie, Roane, Tyler, Upshur, Webster, Wirt, Wood
April 15, 2018-continuing	USDA-S4493	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity / Hail	Hardy, Pendleton

Date(s) of Event	USDA Designation	Description of Disaster	Counties Declared
January 20-February 1, 2019	USDA-S4498	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity	Pleasants, Tyler, Wood
January 1-August 13, 2019	USDA-S4532	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity	Cabell, Jackson, Mason, Pleasants, Tyler, Wayne, Wood
January 19-September 4, 2019	USDA-S4541	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity	Marshall, Ohio, Tyler, Wetzel
January 1-August 20, 2019	USDA-S4539	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity	Brooke, Hancock, Ohio,
April 10-May 30, 2020	USDA-S4733	Excessive Rain, Moisture, Humidity	Pleasants, Tyler, Wood
April 10-May 30, 2020	USDA-S4734	Excessive Rain, Moisture, Humidity	Cabell, Wayne
April 10-May 30, 2020	USDA-S4735	Excessive Rain, Moisture, Humidity	Cabell, Jackson, Mason, Wood
April 23-June 5, 2020	USDA-S4747	Excessive Rain, Moisture, Humidity	Wood
July 26-29, 2022	USDA-S5322	Flood, Flash Flooding / Excessive Rain, Moisture, Humidity	Mingo, Wayne

Source: USDA 2023

Previous Events

Many sources provided flooding information regarding previous occurrences and losses associated with flooding events throughout the State. The 2018 SHMP discussed specific flooding events that occurred in the State through 2018. For this 2023 SHMP, flood events were summarized between January 1, 2018, and December 31, 2022.

Table 5.5-5 includes details of major flooding events that occurred in the state between 2018 and 2022. Major events include those that resulted in losses or fatalities, as reported by the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) events that led to a FEMA disaster declaration, and/or event that led to a USDA declaration. Due to over 1,000 events having been recorded between 2018 and 2022, the following criteria was used to narrow the events shown in Table 5.5-5:

- USDA-declared disasters are not included in the below table and can instead be found in Table 5.5-4.
- Only events from the NOAA NCEI Storm Events Database were used in Table 5.5-5.
- Episode narratives are used for the event description.
- Event narratives are not included in the event description.
- Events with fewer than $100,000 in property and/or crop damages are not included in Table 5.5-5.

Table 5.5-5. Flood Events in the State of West Virginia 2018 to 2022

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
February 16-21, 2018	Flood	DR-4359-WV	Barbour, Cabell, Doddridge, Gilmer, Jackson, Harrison, Kanawha, Lewis, Lincoln, Logan, Mason, Pleasants, Putnam, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Wood	A wave of low pressure and surface front crossed West Virginia, p on the 16th. Generally, 1 to 2 inches of rain fell on already saturat creek and stream flooding on the 16th and into the 17th. As the ra river system, smaller main stem rivers flooded. This eventually led Ohio River. $168,500 of property damages were incurred from thi
April 15-18, 2018	Flood, Flash Flood, Heavy Rain	N/A	Barbour, Berkeley, Braxton, Fayette, Gilmer,Grant, Greenbrier, Hampshire, Hardy, Harrison, Jefferson, Lewis, Marion, Mason,McDowell, Monongalia, Monroe, Morgan, Nicholas, Pendleton,Pocahontas, Preston,Randolph, Taylor, Tyler, Upshur, Webster	A strong upper-level system combined with a lot of low-level mois heavy rainfall on the 15th into the 16th. Widespread rainfall amou in 24 to 36 hours from north-central West Virginia into the mount led to flooding on many rivers and streams. Over-saturated groun rounds of rain across the area also lead to several landslides, whic problems in western Pennsylvania and northern West Virginia. He fell in portions of the state, causing flooding mainly in Grant, Penc Counties. This water then moved downstream, causing flooding o 17th and 18th. $136,000 of property damages were incurred from
May 5- 6, 2018	Flood	N/A	Cabell, Greenbrier, Kanawha, Lincoln, Monroe, Pocahontas, Putnam, Randolph, Summers	An upper trough and frontal passage on May 5-6 brought pockets rainfall with amounts of 2 to 3 inches across portions of southeast two inches of rain fell in 6-12 hours. With saturated ground in pla this led to flooding of small creeks, streams, and rivers. $114,000 were incurred from this event.
May 16-23, 2018	Flood, Flash Flood	N/A	Berkeley, Calhoun, Gilmer, Grant, Greenbrier,	Moderate rain over a two-day period totaled 1-3 inches and was e some flooding during the afternoon of May 16th. Additional heav eastern West Virginia panhandle during the evening hours of the

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
			Hampshire, Jefferson, Marshall, Mineral, Monroe, Morgan, Tyler, Webster	inches of rain and causing additional flooding. Moderate rain cont 18th, causing stream flooding beginning the 17th and continuing t morning hours of the 21st. Another band of heavy rain fell in Grar with 1-3 inches of rain causing flooding in the southeastern part o of slow-moving thunderstorms over the central portion of the cou inches of rain in about a 3-hour period showers and thunderstorm unstable airmass on the afternoon and evening of the 22nd. The r led isolated flooding. $234,000 of property damages and $1,000 ir incurred from this event.
May 26-28, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4378-WV	Braxton, Cabell, Kanawha, Lewis, Mercer, Mineral, Putnam, Summers	The combination of daytime heating and an approaching upper-le scattered thunderstorm development on the afternoon and eveni and 28th. While these storms were slow-moving, most moved enc However, several storms stalled out or kept regenerating over one flooding. Locally heavy downpours over central Mercer County pr several small basins near Athens, WV. $3.291 million of property c from this event.
July 27-30, 2018	Flash Flood, Heavy Rain	N/A	Braxton, Calhoun, Kanawha, Mercer, Roane	Showers and thunderstorms formed on the 27th as a cold front m areas also experienced repetitive storms, causing high water in sp cluster of thunderstorms centered between Princeton and Spanis amounts of 4 to 6 inches. Most of the rain fell within about a thre to 1130 PM. A warm front lifted through West Virginia on the mor resulted in a slow-moving thunderstorm that produced excessive of Central West Virginia. $310,000 of property damages were incu
August 3-7, 2018	Flood, Flash, Flood	N/A	Berkeley, Braxton, Jackson, Marshall, Putnam, Wirt,	An upper-level disturbance moved through West Virginia on the 3 showers and thunderstorms with heavy rain, leading to isolated fl downpours combined with convection training over the same are the Opequon Creek. Isolated thunderstorms managed to form in a pattern. Localized flash flooding took place in Marshall County. Sh thunderstorms on the 7th, produced heavy rainfall and flash flood $515,000 of property damages were incurred from this event.
February 20-25, 2019	Flood, Heavy Rain	N/A	Doddridge, Fayette, Harrison, Jackson, Kanawha, Lincoln,	From February 20th to 25th, multiple rounds of precipitation pass West Virginia resulting in liquid accumulations ranging from arour storm started out on the 20th as a combination of snow, sleet and

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
			Logan, Mason, McDowell, Mercer, Mineral, Mingo, Monroe, Ritchie, Tyler	the mountains with liquid equivalents of 0.50 up to 2 inches. The late on February 21st, with warmer air arriving with the system al to fall mainly as rain, which helped to quickly melt the frozen prec during the 24-36 hours prior. With soils already saturated from pr runoff from this storm caused mainly minor stream flooding and a landslide. A warm front lifted northward into West Virginia on the promoting widespread showers and a few isolated thunderstorms an approaching cold front. Generally, 1 to 1.75 inches of rain fell b the 23rd and the morning of the 24th. This led to flooding across s portions of the state. Combined with the soggy ground, high wind power outages due to downed trees and power lines. $120,000 of were incurred from this event, of which $70,000 were attributed t
June 30, 2019	Flood, Flash Flood	DR-4455-WV	Grant, Pendleton, Preston, Randolph, Tucker	An unstable environment, plus residual outflow boundaries from helped to expand thunderstorm coverage during the evening of th early morning hours of the 30th ahead of a sagging cold front. Sto Preston and Tucker Counties starting after 10 PM on the 29th. Per heavy rain occurred until around 5 AM the following morning as b continued through the night. Rainfall totals of 2 to 4 inches were portions of Preston County and over much of Tucker County, resu flash flooding. A few water rescues were necessary at Arnold Park as in Jenningston. Heavy amounts of rain in a short period of time Appalachian Mountains in West Virginia. The heavy amounts of ra streams to rapidly rise out of their banks. $1.053 million of proper incurred from this event.
June 17-21, 2020	Flood, Flash Flood, Heavy Rain	N/A	Calhoun, Greenbrier,Monroe, Pendleton, Summers, Webster	Persistent rainfall led to flooding. There were repeated rounds of widespread amounts of 2 to 5 inches. The most notable rainfall w thunderstorm near Alderson, WV that caused severe flash flood d afternoon of June 17th. An upper-level disturbance parked over th in afternoon showers and thunderstorms on the 18th and 19th ac Virginia. This spawned local flooding issues in Calhoun and Webst rainfall and slow-moving storms contributed to high water issues $1.341 million of property damages were incurred from this even

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
July 30, 2020	Flash Flood	N/A	Braxton, Calhoun, McDowell, Upshur	Slow-moving showers and storms produced very heavy rainfall thr and evening. In the areas of heaviest rain, which stretched from H northeastward to near Elkins, 2 to 4 inches of rain was common, a indicated more than 4 fell. In fact, two gauges around Grantsville of rain. A second, more localized, area of heavy rain fell in Tazewe northward into the headwaters of the Dry Fork of the Tug River in Counties. Runoff from this heavy rain flowed down the Dry Fork o overnight causing flooding. $471,000 of property damages were i
August 27-28, 2020	Flood, Flash Flood	N/A	Braxton, Clay, Nicholas, Ohio, Roane, Webster, Wirt	Tropical moisture from the remnants of Marco and Laura led to sh thunderstorms on the 27th. Multiple rounds of rain resulted in a r almost 5 inches of rain across the foothills of West Virginia. Comp previous rainfall earlier in the week made this area very susceptib to local high water issues along the roadways. Flooding was also r $105,000 of property damages were incurred from this event.
February 27-March 2, 2021	Flood, Flash Flood, Heavy Rain	DR-4605-WV	Barbour, Boone, Braxton, Cabell, Clay, Fayette, Greenbrier, Hampshire, Kanawha, Jackson, Jefferson,Lincoln, Logan, Mason, McDowell, Mercer, Mineral, Mingo, Morgan, Pocahontas, Putnam, Raleigh, Randolph, Ritchie, Roane, Summers, Tyler, Wayne, Webster, Wirt, Wood, Wyoming	Rainfall amounts ranging generally from 1.25 to nearly 2 inches ac Most of the rain fell across a 4- to 5-hour period during the morni heavy at times, moved across the region during the afternoon of F the morning of March 1st. Creeks and streams rose out of their ba February, resulting in flooded roadways across West Virginia. Seve conducted in Putnam County on the 28th due to vehicles becomin rising water. An additional inch or two of rainfall on February 28th melting of snowpack in the mountains, led to some isolated flood Virginia. Over 4 inches of rain fell across West Virginia from the fir through the morning of Monday, March 1st. Multiple disturbance state during this time and caused periods of heavy rain. The most south of the I-64 corridor, but the entire state observed at least 1 the span of four days. This contributed to notable flooding across creeks rose out of their banks and spilled onto local roadways. Mo took place during the first few days of March, with some river gau crests, including the Coal, Elk, and Tug Fork Rivers. $554,560 of pr incurred from this event.
June 9-11, 2021	Flood, Flash Flood	N/A	Braxton, Cabell, Calhoun, Clay,	Showers and thunderstorms occurred over the span of a few days several instances of flash flooding in West Virginia. The most subs

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
			Doddridge, Gilmer, Hampshire, Hardy, Harrison, Jackson, Jefferson, Kanawha, Lewis, Lincoln, Logan, Marion, Mason, Mineral, Upshur, Webster	place near the Town of Hamlin in Lincoln County, where 25 home were destroyed due to a washed-out culvert. $1.265 million of pr incurred from this event.
June 13-14, 2021	Flood, Flash Flood	N/A	Braxton, Boone, Calhoun, Clay, Doddridge, Gilmer, Harrison, Lewis, Marion, Monongalia, Pocahontas, Preston, Roane, Tyler, Upshur, Wood	A strong cold front in accordance with a passing low-pressure syst Virginia. Strong to severe thunderstorms on the evening of June 1 downpours. Several counties observed flash flooding. The most n in Gilmer County, where a large shed on a golf course was swept high water, and Pocahontas County, where a swift water rescue w town of Frost. Several thunderstorms on June 14th became sever resulted in downed trees and power lines due to damaging wind g previous day's severe weather primed the area for flash flooding on the 14th ultimately resulted in high water issues in the Buckha property damages were incurred from this event.
August 31-September 1, 2021	Flood, Flash Flood, Heavy Rain	N/A	Barbour, Braxton, Brooke, Cabell, Clay, Jefferson, Lincoln, McDowell, Mingo, Ohio, Preston, Tucker, Upshur, Wayne, Wyoming	The remnant low pressure center of Hurricane Ida passed across V Central Appalachian Mountains from late August 31st through Se abundant moisture associated with the low intersected a frontal z stalled in the Ohio Valley, leading to periods of heavy rain over ea two-day period, both from thunderstorms ahead of the low and fr rainfall during the morning of the 1st. Rain tapered off by the afte of Ida pulled towards the Mid-Atlantic coast. Rainfall totals over t across the northern panhandle were highest in Brooke and Ohio C inches observed. The Town of Bethany had a notable number of c totals were seen in Preston and Tucker Counties as well, with mar received. Roads feeding into the Cheat Valley Highway were impa Tunnelton, Rowlesburg, and Terra Alta reported many road closu homes were evacuated along Horseshoe Run Road. $152,000 of p incurred from this event.

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
May 6-8, 2022	Flood, Flash Flood	N/A	Barbour, Berkeley, Boone, Cabell, Calhoun, Clay, Doddridge, Gilmer, Hampshire, Jackson, Jefferson, Kanawha, Lincoln, Mason, Mineral, Morgan, Putnam, Randolph, Roane, Tyler, Upshur, Wayne	Heavy rainfall May 6th. A swath of 3 to 4 inches of rain fell in a na Huntington northeastward to Elkins, with a few isolated pockets o led to considerable flash flooding. Multiple water rescues took pla Metro Valley, including a man who was swept away while working County. Additionally, several vehicles were submerged in floodwa homes were impacted by high water, with the hardest hit area be community of Huntington. Flooding occurred across many roadwa Virginia, leaving multiple roads impassable for a time until the wa the rain had concluded, several rivers in the state rose out of thei several days. This resulted in flooding along areas adjacent to the million of property damages were incurred from this event.
July 12, 2022	Flood, Flash Flood	DR-4678-WV	Kanawha, McDowell, Putnam, Raleigh	Showers and storms with strong winds, large hail, and heavy dow water issues across the state. Roughly $1.008 million of property from this event.
July 27-August 2, 2022	Flood, Flash Flood	N/A	Braxton, Cabell, Clay, Fayette, Greenbrier, Jackson, McDowell,Mingo, Wayne, Webster, Wyoming	A deluge of showers and thunderstorms continuously rocked Wes final week of July as a stationary frontal boundary remained drape prolonged period. Waves of energy flowing along the front contri heavy rainfall, which gradually tarnished soil conditions. Up to 5 in spots south of the Interstate 64 corridor between July 26th and 2 during this time resulted in local creeks and streams rising out of onto roads, primarily in Mingo, Fayette, McDowell, and Wyoming community in Fayette County was evacuated during the early mor due to the abundance of high water impacting the township. Low front beginning on the afternoon of August 1st. In advance of this heating and residing unstable conditions contributed to the devel showers and thunderstorms. Antecedent rainfall ahead of this eve susceptible soil conditions, which coupled with heavy rainfall tha flooding. Mingo County was inundated with heavy rain on the mo continued to see rain occur into the early afternoon. The quick ris of water of the local creeks and streams resulted in flooding along roadways. Residential bridges were washed out because of these homes within the county were damaged. The cold front arrived in morning of August 2nd, which continued the threat for flash flooc

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
				portions of the state. The boundary stalled nearby that afternoon rounds of showers and strong thunderstorms. Braxton County obs strong winds and heavy rainfall, resulting in downed trees and flo Roughly $1.630 million of property damages were incurred from t
August 10-11, 2022	Flood, Flash Flood	N/A	Cabell, Calhoun, Doddridge, Gilmer, Hampshire, Harrison, Jackson, Kanawha, Nicholas, Ritchie, Wayne, Wood	The combination of slow-moving and repetitive storms led to hea August 10th and 11th. 24-hour rainfall amounts reported by local stations ranged from 1.5 to 3 inches in most places, with locally hi upwards of 5 inches observed across north-central West Virginia. the northern half of the state became flooded, primarily during th storms were at their strongest. This resulted in a few water rescu submerged by the inundating rainfall. Several homes in Ritchie Co surrounded by water for a period of time as well. The most signific in Doddridge County, where the building of the local senior cente off its foundation due to the deluge of water. Roughly $2.445 mill damages were incurred from this event.
August 15-16, 2022	Flash Flood	DR-4679-WV	Fayette, Greenbrier, Kanawha	A narrow band of heavy rain fell across the I-64 corridor during th of August 15th. The Charleston airport reported 4.33 inches of rai previous evening, with radar estimates ranging from 2 to 5 inches Fayette Counties. The Campbells Creek area of Kanawha County o damage from flash flooding, with damage costs extending close to Flash flooding was also observed in the Scrabble Creek area of Fay Governor of West Virginia declared a State of Emergency for Kana Counties due to the flooding, and recovery and clean-up efforts sp event occurred. Another round of showers and storms transpired on the afternoo once again caused high water issues within Fayette County. Rough property damages were incurred from this event.

Sources: NOAA NCEI 2023; FEMA 2023
FEMA Federal Emergency Management Agency
N/A Not Applicable
USDA U.S. Department of Agriculture

Probability of Future Hazard Events

Overall Probability

Flooding is common in the State and can take place any time of the year; however, flooding is more frequent during the rainy season, which runs from May through July (NOAA 2022). In recent decades, the state has had flood-related disaster declarations nearly every year. These disasters have often been associated with heavy rainstorms that also caused landslides and mudslides (U.S. EPA 2016). Based on the history of flooding events and the potential impacts from changing future conditions, flooding events will most likely become more frequent throughout the state. Based on the historic flood events in the State, it is clear that there is a high probability of future flood events for the future.

According to FEMA-Designated Disasters, USDA Designated Disasters, the NOAA NCEI Storm Events Database, and the 2018 SHMP, the State experienced over 1,000 flood-related events between 2018 and 2022, as summarized in Table 5.5-6.

Table 5.5-6. Probability of Future Flood Events in West Virginia

Hazard Type	Number of Occurrences between 2018 and 2022	Percent Chance of Occurrence in Any Given Year
Excessive Localized Rainfall (Heavy Rain)	71	98.61
Flash Flood	428	100
Riverine and Stormwater Flood (Flood)	571	100
Total	1,070	100

Sources: FEMA 2023; NOAA NCEI 2023; USDA 2023; State of West Virginia 2018

Based on the history of flood events and the impending impacts of changing future conditions, flood events may become more frequent throughout West Virginia.

Projected Future Conditions

In the future, severe rain events are expected to become more frequent and more intense across the United States (U.S. Global Change Research Program 2018).

Moderate flooding events are expected to become more frequent in most of the Northeast during the 21st century because of more intense precipitation. These extreme precipitation events will likely increase rates of erosion on waterways across the State, particularly in areas without natural or built protection (U.S. Global Change Research Program 2018).

5.5.2 Vulnerability Assessment

To assess the state's risk to the flood hazard, a spatial analysis was conducted using the best available spatially delineated flood hazard areas. In summary, to determine exposure, the hazard areas were overlaid with the assets to determine the total number and replacement cost value located in the hazard areas. If the asset is in the hazard area, it is deemed exposed to the hazard and potentially vulnerable to loss. FEMA's Hazus flood model was used to estimate potential losses to structures from event-based flooding by looking at the depth of flooding at each structure location.

State Assets

The exposure analysis for the event-based flooding hazard shown in Table 5.5-7. , determined there are 98 State buildings located in the SFHA and 245 in the 0.2 percent annual chance floodplain. Kanawha County has the most State buildings (9), and Preston County has the greatest total replacement cost value ($44.3 million) exposed to the 1 percent annual chance flood. Kanawha County also has the most State buildings (118) and total replacement cost ($507.9 million) exposed to the 0.2 percent annual chance flood.

Table 5.5-7. State Buildings Located in the 1 percent and 0.2 percent Annual Chance Floodplain by County

County	State Buildings in the 1% Annual Chance Floodplain		State Buildings in the 0.2% Annual Chance Floodplain	
	Number	Total Replacement Cost Value (Structure + Contents)	Number	Total Replacement Cost Value (Structure + Contents)
Barbour	4	$898,389	4	$898,389
Berkeley	0	$0	0	$0
Boone	4	$19,654,600	4	$19,654,600
Braxton	0	$0	0	$0
Brooke	2	$60,000	2	$60,000
Cabell	5	$7,801,796	6	$7,805,796
Calhoun	1	$300,000	1	$300,000
Clay	0	$0	0	$0
Doddridge	3	$39,029,601	3	$39,029,601
Fayette	0	$0	1	$31,836,767
Gilmer	0	$0	1	$0
Grant	0	$0	0	$0
Greenbrier	2	$0	2	$0
Hampshire	0	$0	0	$0
Hancock	1	$60,000	1	$60,000
Hardy	0	$0	0	$0
Harrison	1	$1,050,077	3	$5,124,114
Jackson	0	$0	0	$0
Jefferson	0	$0	0	$0
Kanawha	9	$11,355,713	118	$507,895,312
Lewis	5	$848,000	6	$3,088,145
Lincoln	0	$0	0	$0
Logan	3	$15,000	3	$15,000
Marion	3	$525,000	3	$525,000
Marshall	0	$0	2	$514,600
Mason	0	$0	0	$0
McDowell	7	$1,830,000	7	$1,830,000
Mercer	0	$0	7	$2,033,785
Mineral	1	$50,000	2	$50,000
Mingo	0	$0	7	$835,300
Monongalia	2	$754,425	2	$754,425
Monroe	1	$0	1	$0
Morgan	4	$678,600	4	$678,600

County	State Buildings in the 1% Annual Chance Floodplain		State Buildings in the 0.2% Annual Chance Floodplain	
	Number	Total Replacement Cost Value (Structure + Contents)	Number	Total Replacement Cost Value (Structure + Contents)
Nicholas	0	$0	2	$15,000
Ohio	5	$13,735,834	8	$14,918,593
Pendleton	1	$6,900	1	$6,900
Pleasants	0	$0	0	$0
Pocahontas	2	$65,000	2	$65,000
Preston	2	$44,274,475	2	$44,274,475
Putnam	3	$28,928,546	10	$74,341,198
Raleigh	3	$35,000	3	$35,000
Randolph	0	$0	0	$0
Ritchie	2	$434,000	2	$434,000
Roane	2	$2,105,840	2	$2,105,840
Summers	0	$0	0	$0
Taylor	1	$7,096,492	1	$7,096,492
Tucker	1	$52,300	1	$52,300
Tyler	0	$0	1	$10,000
Upshur	0	$0	1	$85,000
Wayne	5	$1,239,769	6	$1,239,769
Webster	2	$55,000	2	$55,000
Wetzel	3	$75,900	3	$75,900
Wirt	1	$28,500	1	$28,500
Wood	6	$949,800	6	$949,800
Wyoming	1	$113,400	1	$113,400
Total (WV State)	**98**	**$184,107,957**	**245**	**$768,891,601**

Source:State of West Virginia Emergency Management Division; FEMA 2022
Note: Replacement cost for structure and contents were provided by the State. Values for various facilities were not provided.

Table 5.5-8 summarizes State buildings and total replacement costs of those buildings located in the SFHA by agency. The Division of Highways has the greatest number of State buildings (13), and the State Armory Board has the highest total replacement cost value ($74.2 million) exposed in the 1 percent annual chance floodplain. The Department of Health and Human Resources has the greatest number of State buildings (29), and the General Services Division of the Department of Administration has the highest total replacement cost value ($162.0 million) exposed in the 0.2 percent annual chance floodplain.

Table 5.5-8. Replacement Cost Value for State Facilities within the 1 percent and 0.2 percent Annual Chance Floodplain by Agency

Agency	State Buildings in the 1% Annual Chance Floodplain		State Buildings in the 0.2% Annual Chance Floodplain	
	Number	Total Replacement Cost Value (Structure + Contents)	Number	Total Replacement Cost Value (Structure + Contents)
Adjutant General's Office State of West Virginia	0	$0	0	$0
Administration, Secretary of Department of Administration	0	$0	1	$112,000
Agriculture, Department of State of West Virginia	0	$0	1	$10,000

Agency	State Buildings in the 1% Annual Chance Floodplain		State Buildings in the 0.2% Annual Chance Floodplain	
	Number	Total Replacement Cost Value (Structure + Contents)	Number	Total Replacement Cost Value (Structure + Contents)
Air And Environmental Quality Boards State of West Virginia	0	$0	1	$60,000
Alcohol Beverage Control Administration State of West Virginia	0	$0	1	$13,773,535
Architects, Board of State of West Virginia	0	$0	1	$17,000
Armory Board State of West Virginia	7	$74,203,098	10	$106,847,027
Arts, Culture & History, Department of State of West Virginia	1	$6,384	2	$6,384
Attorney General, Office of The State of West Virginia	0	$0	0	$0
Aviation, Division of	0	$0	0	$0
Bar, State State of West Virginia	0	$0	0	$0
Barbers & Cosmetologists, Board of State of West Virginia	0	$0	1	$100,000
Blue Ridge Community & Technical College	0	$0	0	$0
Bluefield State College	0	$0	0	$0
Board of Treasury Investments	0	$0	1	$70,000
Bridgevalley Community & Tech College	0	$0	1	$31,836,767
Cedar Lakes Conference Center State of West Virginia	0	$0	0	$0
Chiropractic Examiners Board State of West Virginia	0	$0	1	$100,000
Commission For National And Community Service, WV	0	$0	1	$80,000
Concord University	0	$0	0	$0
Conservation Agency, West Virginia State of West Virginia	0	$0	1	$9,600
Consolidated Public Retirement Board Department of Administration	0	$0	0	$0
Consumer Advocate, Division of WV Public Service Commission	0	$0	1	$150,000
Corrections, Division of State of West Virginia	2	$38,772,601	6	$51,215,601
Courthouse Facilities Improvement Authority	0	$0	0	$0
Dentistry, Board of State of West Virginia	1	$35,000	1	$35,000
Department of Transportation	0	$0	0	$0
Dietitians, Board of Licensed	0	$0	0	$0
Eastern Panhandle Instructional Coop	2	$515,000	2	$515,000
Eastern WV Community & Tech. College	0	$0	0	$0
Economic Development Authority State of West Virginia	0	$0	0	$0
Economic Development, WV Dept of	0	$0	0	$0
Education, Department of State of West Virginia	3	$19,874,800	4	$19,899,800
Educational Broadcasting Authority State of West Virginia	0	$0	0	$0
Enterprise Resource Planning Board, WV	0	$0	1	$2,000,000
Environmental Protection, Department of State of West Virginia	4	$1,712,680	8	$3,005,439
Ethics Commission, West Virginia Department of Administration	0	$0	1	$130,000
Examiners In Counseling, Board of State of West Virginia	0	$0	1	$6,000
Fairmont State University	0	$0	0	$0
Fire Commission State of West Virginia	0	$0	1	$500,000
Fleet Management Office, Dept of Admin State of West Virginia	0	$0	1	$50,000

Agency	State Buildings in the 1% Annual Chance Floodplain		State Buildings in the 0.2% Annual Chance Floodplain	
	Number	Total Replacement Cost Value (Structure + Contents)	Number	Total Replacement Cost Value (Structure + Contents)
Forestry, Division of State of West Virginia	6	$490,000	6	$490,000
General Services Division Department of Administration	1	$5,143,522	8	$161,979,223
Geological And Economic Survey State of West Virginia	0	$0	0	$0
Glenville State College	0	$0	0	$0
Governor, Office of The State of West Virginia	0	$0	1	$2,000,000
Health & Human Resources, Department of State of West Virginia	9	$4,630,000	29	$159,905,000
Higher Education Policy Commission, WV	0	$0	1	$1,542,246
Highways, Division of State of West Virginia	13	$4,418,259	28	$36,673,672
Homeland Security & Emergency Management Division	0	$0	1	$205,000
Insurance Commissioner, Office of The State of West Virginia	0	$0	0	$0
Investment Management Board, WV State of West Virginia	0	$0	1	$2,500,000
Joint Committee On Government & Finance State of West Virginia	0	$0	0	$0
Justice & Community Services, Div. of	0	$0	1	$750,000
Juvenile Services, Division of	2	$168,200	5	$1,058,200
Labor, Division of State of West Virginia	0	$0	0	$0
Land Division/Dept of Agriculture State of West Virginia	0	$0	0	$0
Landscape Architects, Board of State of West Virginia	0	$0	1	$2,500
Library Commission State of West Virginia	0	$0	0	$0
Lottery Commission State of West Virginia	0	$0	1	$54,700,000
Marshall University	0	$0	0	$0
Military Affairs, Secretary of And Public Safety	0	$0	1	$350,000
Miner's Health Safety, Division of And Training, State of West Virginia	1	$25,000	1	$25,000
Motor Vehicles, Division of State of West Virginia	1	$125,000	6	$1,284,710
Mountain State Esc	0	$0	0	$0
Mountwest Community & Technical College	0	$0	0	$0
National Coal Heritage Area Authority	0	$0	0	$0
Natural Resources, Division of State of West Virginia	5	$721,900	6	$1,721,900
New River Community & Technical College	0	$0	0	$0
Northern Community & Tech College, WV College Square	1	$10,900,000	1	$10,900,000
Occupational Therapy Board State of West Virginia	0	$0	0	$0
Office of Technology/Is&C Department of Administration	0	$0	5	$22,382,000
Osteopathic Medicine, WV Board of State of West Virginia	0	$0	1	$25,000
Osteopathic Medicine, WV School of	0	$0	1	$12,900
Parks, West Virginia State C\O Division of Natural Resources	9	$15,316,188	9	$15,316,188
Pharmacy, Board of State of West Virginia	0	$0	0	$0
Physical Therapy, Board of State of West Virginia	0	$0	0	$0
Pierpont Community And Technical College	0	$0	0	$0
Practical Nurses, Board of State of West Virginia	0	$0	0	$0
Prosecuting Attorneys Institute, WV	0	$0	1	$121,000
Psychologists Examiners, Board of State of West Virginia	0	$0	1	$45,000
Public Service Commission State of West Virginia	0	$0	2	$18,209,069

Agency	State Buildings in the 1% Annual Chance Floodplain		State Buildings in the 0.2% Annual Chance Floodplain	
	Number	Total Replacement Cost Value (Structure + Contents)	Number	Total Replacement Cost Value (Structure + Contents)
Purchasing, Division of Department of Administration	1	$905,000	2	$1,351,000
Rail Authority State of West Virginia	0	$0	0	$0
Real Estate Commission State of West Virginia	0	$0	1	$150,000
Regional Jail & Corr. Fac. Authority State of West Virginia	0	$0	0	$0
Registered Nurses, Board of State of West Virginia	0	$0	1	$250,000
Rehabilitation Services Division of Commerce	3	$463,825	9	$6,614,074
Respiratory Care, WV Board of	0	$0	0	$0
School Building Authority, West Virginia	0	$0	0	$0
Schools For The Deaf And The Blind State of West Virginia	0	$0	0	$0
Senior Services, Bureau of State of West Virginia	0	$0	0	$0
Shepherd University	0	$0	0	$0
Southern Educational Services Coop	0	$0	0	$0
Southern WV Community & Tech College	0	$0	0	$0
Speech Pathology & Audiology Examiners West Virginia Board of	0	$0	0	$0
State Police, West Virginia Dept of Military Affairs & Public Safety	9	$90,000	15	$9,174,223
Supreme Court of Appeals State of West Virginia	9	$468,000	15	$914,100
Tax Appeals, WV Office of	0	$0	1	$130,000
Tax Department State of West Virginia	0	$0	3	$5,110,000
Treasurer of State State of West Virginia	0	$0	1	$365,000
University Physicians And Surgeons	1	$50,000	3	$405,000
Unknown	3	$0	15	$0
Veterans Assistance, Department of State of West Virginia	0	$0	0	$0
Veterinary Medicine, Board of State of West Virginia	0	$0	0	$0
Water Development Authority State of West Virginia	0	$0	1	$7,500,000
West Liberty University	1	$2,500,000	1	$2,500,000
West Virginia Parkways Authority	1	$2,433,500	3	$8,158,500
West Virginia State University - Institute	0	$0	0	$0
West Virginia State University - Malden	0	$0	0	$0
West Virginia University	0	$0	0	$0
West Virginia University Arthurdale	0	$0	0	$0
West Virginia University At Parkersburg	0	$0	0	$0
West Virginia University Beckley	0	$0	0	$0
West Virginia University Bruceton Mills	0	$0	0	$0
West Virginia University Charleston	0	$0	1	$791,798
West Virginia University Fort Ashby	0	$0	0	$0
West Virginia University Granville	0	$0	0	$0
West Virginia University Jacksons Mill	0	$0	0	$0
West Virginia University Kearneysville	0	$0	0	$0
West Virginia University Keyser	0	$0	0	$0
West Virginia University Montgomery	0	$0	0	$0
West Virginia University Reedsville	0	$0	0	$0

Agency	State Buildings in the 1% Annual Chance Floodplain		State Buildings in the 0.2% Annual Chance Floodplain	
	Number	Total Replacement Cost Value (Structure + Contents)	Number	Total Replacement Cost Value (Structure + Contents)
West Virginia University Union	0	$0	0	$0
West Virginia University Wardensville	0	$0	0	$0
West Virginia University Weston	0	$0	1	$2,240,145
Workforce West Virginia	2	$140,000	3	$225,000
WV Public Employees Grievance Board	0	$0	1	$285,000
WVsom Clinic Inc Dba Robert C Byrd Clinic	0	$0	0	$0
Total (WV State)	**98**	**$184,107,957**	**245**	**$768,891,601**

Source: State of West Virginia Emergency Management Division; FEMA 2022

Note: There is a slight Total Replacement Cost Value (RCV) discrepancy when compared with the table organized by County due to default cost values ($1) needing to be assigned where it didn't previously exist to appropriately run our analyses.

Statewide, there are 530.47 miles of state roads exposed to event-based flooding. There is a major public safety hazard when residents attempt to drive on flooded roadways. Many state roads serve as evacuation routes to higher ground. Not only will these roads be closed during a flood event and potentially isolate communities, but the floodwaters may also accelerate the degradation of these roads leading to increased repair and replacement costs. Bridges exposed to flood events can be extremely vulnerable due to the forces transmitted by the velocity and by the impact of debris carried by the water. Table 5.5-9 shows the mileage of state roads in the SFHA by county. Mason County has the greatest number of miles (34.68 miles) exposed, followed by Boone County (32.70 miles) in the 1 percent annual chance floodplain. In the 0.2 percent annual chance floodplain, Kanawha County (55.80 miles) has the greatest number of miles exposed, followed by Mason County (47.31 miles).

Table 5.5-9. State Road Exposure to the 1 percent and 0.2 percent Annual Chance Flood Event by County

County	State Roads located within the 1% Annual Chance Floodplain	State Roads located within the 0.2% Annual Chance Floodplain
	Mileage of Roadway	Mileage of Roadway
Barbour	4.14	4.14
Berkeley	1.49	1.56
Boone	32.70	32.70
Braxton	4.89	4.89
Brooke	4.93	7.56
Cabell	8.39	10.51
Calhoun	9.01	9.01
Clay	7.68	8.07
Doddridge	14.00	14.00
Fayette	7.22	9.55
Gilmer	4.46	19.22
Grant	4.35	4.72
Greenbrier	3.82	4.08
Hampshire	10.36	11.20
Hancock	2.60	3.39
Hardy	2.53	2.53

County	State Roads located within the 1% Annual Chance Floodplain	State Roads located within the 0.2% Annual Chance Floodplain
	Mileage of Roadway	Mileage of Roadway
Harrison	4.70	6.63
Jackson	6.22	8.63
Jefferson	2.56	2.72
Kanawha	22.83	55.80
Lewis	0.23	0.23
Lincoln	18.83	25.23
Logan	24.99	30.70
Marion	1.50	1.61
Marshall	4.06	7.20
Mason	34.68	47.31
McDowell	24.00	30.03
Mercer	11.86	14.31
Mineral	6.42	6.63
Mingo	7.52	14.32
Monongalia	10.22	11.75
Monroe	8.61	8.83
Morgan	3.78	4.18
Nicholas	9.90	11.02
Ohio	2.09	2.77
Pendleton	8.18	8.18
Pleasants	4.75	6.35
Pocahontas	9.64	10.50
Preston	8.86	9.12
Putnam	17.53	34.70
Raleigh	14.40	14.98
Randolph	2.07	2.07
Ritchie	7.33	7.33
Roane	3.63	3.63
Summers	8.75	14.26
Taylor	0.55	0.55
Tucker	1.79	1.98
Tyler	22.30	23.12
Upshur	0.90	1.06
Wayne	20.21	25.03
Webster	10.66	11.78
Wetzel	22.22	22.90
Wirt	8.43	8.43
Wood	10.31	15.75
Wyoming	20.39	24.55
Total	**530.47**	**683.29**

Source: State of West Virginia DOT 2021; FEMA 2022
Notes: GIS Geographic Information System
DOT State Department of Transportation

Critical Facilities and Community Lifelines

Critical transportation hubs and critical infrastructure located in the 1 percent and 0.2 percent annual chance floodplains are exposed to the flood hazard. Utility lines commonly follow roads and those located underground may be impacted, resulting in disruption of services.

Table 5.5-10 summarizes the total number of critical facilities by lifeline category located in the 1 percent annual chance floodplain by county. Kanawha County has the greatest number of critical facilities (3) exposed. Table 5.5-11 summarizes the total number of critical facilities by lifeline category located in the 0.2 percent annual chance floodplain by county. Kanawha County has the greatest number of critical facilities (45) exposed, followed by Mingo County with two critical facilities exposed.

Table 5.5-12 summarizes the critical facilities exposure and potential losses by lifeline category for the 1 percent annual chance floodplain. Safety and Security lifelines have the greatest estimated potential loss at $5 million, followed by the Health and Medical lifeline with $52,556.

Table 5.5-10. Critical Facilities Located in the 1 percent Annual Chance Floodplain by County

County	Lifeline Category of Critical Facilities							
	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health & Medical	Safety & Security	Transportation	Total in the 1% Annual Chance Floodplain
Barbour	0	0	0	0	0	1	0	1
Berkeley	0	0	0	0	0	0	0	0
Boone	0	0	0	0	0	1	0	1
Braxton	0	0	0	0	0	0	0	0
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	0	0	0
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	1	0	1
Fayette	0	0	0	0	0	0	0	0
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	0	0	0	0	0	0
Hampshire	0	0	0	0	0	0	0	0
Hancock	0	0	0	0	0	0	0	0
Hardy	0	0	0	0	0	0	0	0
Harrison	0	0	0	0	0	0	0	0
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	0	0	0	0	0	0
Kanawha	0	0	0	0	1	2	0	3
Lewis	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	1	0	1
Marion	0	0	0	0	0	0	0	0
Marshall	0	0	0	0	0	0	0	0
Mason	0	0	0	0	0	0	0	0

County	Lifeline Category of Critical Facilities							
	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health & Medical	Safety & Security	Transportation	Total in the 1% Annual Chance Floodplain
McDowell	0	0	0	0	0	1	0	1
Mercer	0	0	0	0	0	0	0	0
Mineral	0	0	0	0	0	0	0	0
Mingo	0	0	0	0	0	0	0	0
Monongalia	0	0	0	0	0	0	0	0
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	0	0	0
Ohio	0	0	1	0	0	0	0	1
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	0	0	0
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0
Putnam	0	0	0	0	0	0	0	0
Raleigh	0	0	0	0	0	0	0	0
Randolph	0	0	0	0	0	0	0	0
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	0	0	0
Summers	0	0	0	0	0	0	0	0
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0
Tyler	0	0	0	0	0	0	0	0
Upshur	0	0	0	0	0	0	0	0
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0	0
Total	**0**	**0**	**1**	**0**	**1**	**7**	**0**	**9**

Source: West Virginia Emergency Management Division; FEMA 2022

Table 5.5-11. Critical Facilities Located in the 0.2% Annual Chance Floodplain by County

County	Lifeline Category of Critical Facilities							
	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health & Medical	Safety & Security	Transportation	Total in the 0.2% Annual Chance Floodplain
Barbour	0	0	0	0	0	1	0	1
Berkeley	0	0	0	0	0	0	0	0
Boone	0	0	0	0	0	1	0	1
Braxton	0	0	0	0	0	0	0	0
Brooke	0	0	0	0	0	0	0	0

County	Lifeline Category of Critical Facilities							
	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health & Medical	Safety & Security	Transportation	Total in the 0.2% Annual Chance Floodplain
Cabell	0	0	0	0	0	0	0	0
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	1	0	1
Fayette	0	0	0	0	0	0	0	0
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	0	0	0	0	0	0
Hampshire	0	0	0	0	0	0	0	0
Hancock	0	0	0	0	0	0	0	0
Hardy	0	0	0	0	0	0	0	0
Harrison	0	0	0	0	0	0	0	0
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	0	0	0	0	0	0
Kanawha	5	0	1	0	3	34	2	45
Lewis	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	0	0	0
Marion	0	0	0	0	0	1	0	1
Marshall	0	0	0	0	0	0	0	0
Mason	0	0	0	0	0	0	0	0
McDowell	0	0	0	0	0	1	0	1
Mercer	0	0	0	0	0	1	0	1
Mineral	0	0	0	0	0	0	0	0
Mingo	0	0	0	0	0	2	0	2
Monongalia	0	0	0	0	0	0	0	0
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	0	0	0
Ohio	0	0	1	0	0	1	0	2
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	0	0	0
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0
Putnam	0	0	0	0	0	1	0	1
Raleigh	0	0	0	0	0	0	0	0
Randolph	0	0	0	0	0	0	0	0
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	0	0	0
Summers	0	0	0	0	0	0	0	0
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0
Tyler	0	0	0	0	0	0	0	0

County	Lifeline Category of Critical Facilities							
	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health & Medical	Safety & Security	Transportation	Total in the 0.2% Annual Chance Floodplain
Upshur	0	0	0	0	0	0	0	0
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0	0
Total	**5**	**0**	**2**	**0**	**3**	**44**	**2**	**56**

Source: West Virginia Emergency Management Division; FEMA 2022

Table 5.5-12. Critical Facilities Exposure and Potential Losses by Lifeline Category to the 1 Percent Annual Chance Floodplain

Lifeline Category	Total Replacement Cost Value (RCV)	West Virginia State 1% Annual Chance Floodplain	
		Estimated Total Damage	Percent of Total Building and Contents RCV
Communications	$10,240,007	$0	0.00%
Energy	$0	$0	0.00%
Food, Water, Shelter	$2,384,067	$0	0.00%
Hazardous Materials	$0	$0	0.00%
Health and Medical	$200,276,228	$52,556	0.03%
Safety and Security	$946,402,599	$5,008,277	0.53%
Transportation	$44,654,481	$0	0.00%
Total	**$1,203,957,382**	**$5,060,833**	**0.42%**

Source: Source: WV Emergency Management Division; FEMA 2022; FAST v1.0

POPULATION

Over 81,000 residents statewide reside in the 1 percent annual chance floodplain and just under 118,000 reside in the 0.2 percent annual chance floodplain; refer to Table 5.5-13. These residents may be displaced by the flooding of their homes, requiring them to seek temporary shelter with friends and family or in emergency shelters. Kanawha County has the greatest number of people (13,316) located in the 1 percent floodplain and the greatest number of people (36,945) located in the 0.2 percent floodplain. This analysis does not include the number of tourists and visitors in the state; therefore, this estimate may be underestimating exposure and vulnerability.

While all people located in SFHA are considered exposed and potentially vulnerable, populations considered most vulnerable include the elderly (persons over the age of 65) and individuals living below the U.S. Census poverty threshold. Kanawha County has the largest highly vulnerable population (3,539) exposed to the 1 percent floodplain and the largest highly vulnerable population (11,549) exposed to the 0.2 percent floodplain.

Table 5.5-13. 2020 U.S. Census Population Located in the 1 Percent and 0.2 Percent Annual Chance Floodplain by County

County	Population Located within the 1% Annual Chance Floodplain			Population Located within the 0.2% Annual Chance Floodplain		
	Total Population	Highly Vulnerable Population	% Population Highly Vulnerable	Total Population	Highly Vulnerable Population	% Population Highly Vulnerable
Barbour	62	442	14.0%	76	486	15.7%
Berkeley	334	4,064	8.2%	482	4,598	10.5%
Boone	89	1,632	5.5%	89	1,632	5.5%
Braxton	83	290	28.6%	83	290	28.6%
Brooke	19	1,296	1.5%	61	1,507	4.1%
Cabell	871	4,639	18.8%	975	6,489	15.0%
Calhoun	0	349	0.0%	0	349	0.0%
Clay	116	245	47.5%	117	246	47.8%
Doddridge	0	617	0.0%	0	617	0.0%
Fayette	196	691	28.4%	214	1,024	20.9%
Gilmer	191	531	36.0%	262	673	39.0%
Grant	139	231	59.9%	139	232	59.8%
Greenbrier	899	1,771	50.8%	1,104	1,996	55.3%
Hampshire	296	951	31.1%	311	990	31.4%
Hancock	74	526	14.1%	115	683	16.8%
Hardy	0	265	0.0%	0	265	0.0%
Harrison	359	2,700	13.3%	501	3,678	13.6%
Jackson	0	1,767	0.0%	0	1,852	0.0%
Jefferson	80	2,562	3.1%	84	2,662	3.2%
Kanawha	3,539	13,316	26.6%	11,549	36,945	31.3%
Lewis	70	721	9.7%	97	851	11.4%
Lincoln	269	945	28.5%	280	986	28.4%
Logan	1,443	2,062	70.0%	1,600	2,351	68.1%
Marion	24	1,238	2.0%	26	1,399	1.9%
Marshall	661	1,934	34.2%	753	2,138	35.2%
Mason	0	2,500	0.0%	0	3,260	0.0%
McDowell	171	228	75.3%	184	246	74.6%
Mercer	650	1,516	42.9%	769	1,707	45.0%
Mineral	28	554	5.1%	28	602	4.7%
Mingo	752	1,141	65.9%	1,041	1,528	68.1%
Monongalia	63	1,985	3.2%	90	2,590	3.5%
Monroe	0	316	0.0%	0	317	0.0%
Morgan	0	627	0.0%	0	638	0.0%
Nicholas	0	564	0.0%	0	591	0.0%
Ohio	1,590	5,529	28.8%	1,671	6,223	26.8%
Pendleton	0	218	0.0%	0	218	0.0%
Pleasants	0	301	0.0%	0	316	0.0%
Pocahontas	0	276	0.0%	0	291	0.0%
Preston	56	659	8.5%	56	662	8.5%
Putnam	0	2,683	0.0%	0	4,020	0.0%
Raleigh	997	1,966	50.7%	1,040	2,104	49.4%

County	Population Located within the 1% Annual Chance Floodplain			Population Located within the 0.2% Annual Chance Floodplain		
	Total Population	Highly Vulnerable Population	% Population Highly Vulnerable	Total Population	Highly Vulnerable Population	% Population Highly Vulnerable
Randolph	467	1,409	33.1%	501	1,452	34.5%
Ritchie	0	188	0.0%	0	188	0.0%
Roane	153	401	38.1%	165	414	39.9%
Summers	118	435	27.1%	125	965	13.0%
Taylor	228	575	39.7%	229	583	39.2%
Tucker	0	357	0.0%	0	383	0.0%
Tyler	0	649	0.0%	0	694	0.0%
Upshur	0	1,347	0.0%	0	1,660	0.0%
Wayne	0	1,935	0.0%	0	2,453	0.0%
Webster	0	450	0.0%	0	480	0.0%
Wetzel	0	1,262	0.0%	0	1,344	0.0%
Wirt	0	367	0.0%	0	367	0.0%
Wood	546	4,838	11.3%	851	6,093	14.0%
Wyoming	55	331	16.7%	59	352	16.7%
Total	**15,688**	**81,392**	**19.3%**	**25,727**	**117,680**	**21.9%**

Source: Source: CDC 2020; FEMA 2022

Impacts on Socially Vulnerable Populations

Socially vulnerable populations are most 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 evacuate.

The aftermath of flooding events presents numerous threats to public health and safety, including unsafe food; contaminated drinking and washing water and poor sanitation; mosquitoes and animals; mold and mildew; carbon monoxide poisoning; and mental stress and fatigue. Current loss estimation models such as Hazus are not equipped to measure public health impacts. The best preparation for these effects includes awareness that they can occur, education of the public on prevention, and planning to deal with them during responses to flooding events.

Over 117,000 residents statewide reside in the 1 percent annual chance floodplain; nearly 26,000 of those residents are considered socially vulnerable populations. These residents may be displaced by the flooding of their homes, requiring them to seek temporary shelter with friends and family or in emergency shelters. This analysis does not include the number of tourists and visitors in the state; therefore, this estimate may be underestimating exposure and vulnerability.

Future Changes That May Impact State Vulnerability

Understanding future changes that may impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors in examining potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including impacts of future conditions

Potential or Projected Development

Each county participates in the NFIP and has flood damage prevention regulations in place that regulate how development can occur in mapped SFHAs. Future development in these areas will require adherence to flood damage prevention standards. If new development occurs in areas that currently support natural and beneficial floodplain functions, such as in conservation areas, impacts to flooding may be seen throughout the associated locations.

Projected Changes in Population

West Virginia is losing population faster than recent forecasts, which do not account for county-by-county increases. According to population projections in 2022 from the West Virginia University (WVU) Bureau of Business and Economic Research, West Virginia's population was projected to fall from 1,793,716 in 2020 to 1,705,509 in 2040 (West Virginia University 2022). As of July 1, 2019, according to estimates by the U.S. Census Bureau, West Virginia's total population is 1,792,147, representing a 3.3 percent decline since 2010 (approximately 60,487 fewer residents). West Virginia lost population both naturally, with 19,000 more deaths than births, and through migration, with 27,000 more people leaving the state than moving in (WVDOT 2020). Refer to Section 3 (County Profile), which includes a discussion on population trends for the County.

The overall anticipated decrease in population for West Virginia will potentially lower the threat of the flood hazard and its impact on life, but it will not eliminate the hazard. As the population leaves the state, the buildings and structures once resided in will remain standing, leaving the structural risk to the flood hazard the same as before. The groups most vulnerable to the hazard will remain the same, as will the geographic and topographic areas most vulnerable.

Other Factors of Change

Changing rain patterns are certain to alter flood dynamics in the state. Most studies project that the State will see an increase in average annual temperatures and precipitation. It is anticipated that the state will continue to experience direct and indirect impacts of flooding events annually that may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents, and inconveniences.

5.5.3 Consequence Analysis

Impacts to the Public

The most at-risk populations include those who live within the FEMA-defined SFHA; however, it is also recognized that the flood hazard is not limited to just that area. Impacts to the public include potential for injury or loss of life, and destruction and/or loss of land and property due to flood. Loss of property can leave people homeless and with a hefty list of assets that need to be replaced, and some of these may be out-of-pocket costs. In general, floods and their aftermath present numerous threats to public health and safety, including:

- **Vehicles in floodwaters** — Floodwaters can carry large amounts of debris, potentially increasing the damage caused by the floodwaters.
- **Unsafe food** — Floodwaters can contain disease-causing bacteria, dirt, oil, human and animal waste, and farm and industrial chemicals. Their contact with food items, including food crops in agricultural lands, can make that food unsafe to eat.
- **Contaminated drinking and washing water and poor sanitation** — Flooding impairs clean water sources with pollutants; pollutants also infiltrate into the groundwater contaminating potable water. Flooded wastewater treatment plants and private sewage disposal systems can be overloaded, resulting in backflows of raw sewage becoming a cause of disease.
- **Mosquitoes and animals** — Floods provide new breeding grounds for mosquitoes in wet areas and stagnant pools; deceased animals can carry viruses and diseases if not disposed of timely and properly.
- **Mold and mildew**—Excessive exposure to mold and mildew can cause flood victims, especially those with allergies and asthma, to contract upper respiratory diseases, triggering cold-like symptoms. Infants, children, elderly people, and pregnant women are considered most vulnerable to mold-induced health problems.
- **Carbon monoxide poisoning** — In the event of power outages, the use of alternative fuels in enclosed or partially enclosed spaces can lead to carbon monoxide poisoning.
- **Hazards when reentering and cleaning flooded homes and buildings** — Flooded buildings can pose significant health and physical hazards to people entering them, including live electrical wires, gas leaks, flood debris, and hazardous materials.
- **Mental stress and fatigue** — People who live through a devastating flood can experience long-term psychological impact (National Geographic 2022) (Centers for Disease Control and Prevention [CDC] 2022) (WHO 2020).

Impacts to Responders

In the aftermath of a flood, workers may be involved in a variety of response and recovery operations. Emergency response to floods may involve several first response organizations, ranging from local police, fire and EMS departments, public service workers, specialty response task forces, and sometimes federal agencies. Assessments must be done to determine the current needs of the situation, including evacuation, search and rescue, distribution of resources, relocation of displaced individuals, firefighting, and utility repairs. Emergency responders can be exposed to the dangers from floods, including after-effects from debris and contaminated waters.

Floods may immobilize a region and shut down transportation which, in turn, stops the flow of supplies and disrupts the distribution of medical and emergency services and goods. Floods can quickly engulf buildings, knock down trees, and submerge additional infrastructure, making it difficult for responders to access the incident area. Rural areas may experience isolation for days at a time until first responders can safely access the area.

Impacts to Continuity of Operations

Floods can bring down trees, electrical wires, telephone poles, lines, communication towers; floods can also inundate buildings with water, causing potential mold and mildew issues. Communication and power can be disrupted for days while utility companies work to repair the extensive damage; restoration crews may not be able to clean buildings for several days or weeks following a flood to make the structure is habitable. Floods can obstruct and slow transportation by knocking down trees and utility lines and causing structural collapses in buildings not designed to withstand an influx of water. Floods have the potential to impact airports and roadways, sometimes even closing them completely, stopping the flow of supplies and disrupting continuity of operations in the state and counties.

Impacts to Property, Facilities, and Infrastructure

Economic losses to the State from event-based flooding include but are not limited to general building stock damage, agricultural losses, and business interruption. These losses will negatively affect the tax base. Damage to general building stock can be quantified using Hazus. Other economic components, such as loss of facility use, functional downtime, and social economic factors are less quantifiable. For the purposes of this analysis, the general building stock damage is discussed further.

Low-lying urban areas have the greatest vulnerability to a flood event. To estimate the potential losses by county, the Hazus flood model and default general building stock provided by the model were used. This analysis has been refined since the 2018 SHMP due to the updated and improved flood hazard areas and flood depth grids across the state. Table 5.5-14 summarizes the estimated potential losses to the general building stock by county.

Hazus estimates $27.4 million in statewide potential damages to the general building stock inventory associated with the 1 percent annual chance flood event. Although this loss represents only 0.45 percent of the state's total building replacement cost value, the area flooded comprises some of the most valued in the state. Preston County is estimated to experience the greatest loss: over $14.9 million in building damages (repair or replacement costs), which represents 16.62 percent of the replacement cost value of State facilities in Preston County.

Table 5.5-14. General Building Stock Exposure and Potential Losses to the 1 Percent Annual Chance Floodplain

County	Total Replacement Cost Value (RCV)	West Virginia State 1% Annual Chance Floodplain	
		Estimated Total Damage	Percent of Total Building and Contents Replacement Cost Value
Barbour	$1,226,301	$0	0.00%
Berkeley	$75,495,416	$0	0.00%
Boone	$44,293,611	$4,882,275	11.02%
Braxton	$7,872,767	$0	0.00%
Brooke	$3,180,003	$0	0.00%

County	Total Replacement Cost Value (RCV)	West Virginia State 1% Annual Chance Floodplain	
		Estimated Total Damage	Percent of Total Building and Contents Replacement Cost Value
Cabell	$219,226,653	$5,915,497	2.70%
Calhoun	$378,405	$0	0.00%
Clay	$743,106	$0	0.00%
Doddridge	$75,001,944	$76,866	0.10%
Fayette	$189,552,329	$0	0.00%
Gilmer	$102,229,007	$0	0.00%
Grant	$2,272,485	$0	0.00%
Greenbrier	$114,552,152	$0	0.00%
Hampshire	$81,457,698	$0	0.00%
Hancock	$5,900,061	$0	0.00%
Hardy	$48,772,559	$0	0.00%
Harrison	$92,890,150	$0	0.00%
Jackson	$43,378,014	$0	0.00%
Jefferson	$279,040,412	$0	0.00%
Kanawha	$998,692,998	$1,226,692	0.12%
Lewis	$83,222,741	$0	0.00%
Lincoln	$1,631,008	$0	0.00%
Logan	$90,013,247	$13,237	0.01%
Marion	$269,370,410	$0	0.00%
Marshall	$83,738,272	$0	0.00%
Mason	$75,424,570	$0	0.00%
McDowell	$2,430,014	$23,641	0.97%
Mercer	$343,799,147	$0	0.00%
Mineral	$138,244,637	$10,118	0.01%
Mingo	$23,756,135	$0	0.00%
Monongalia	$1,605,027,842	$0	0.00%
Monroe	$1,463,850	$0	0.00%
Morgan	$93,738,803	$3,041	0.00%
Nicholas	$9,785,397	$0	0.00%
Ohio	$28,660,306	$0	0.00%
Pendleton	$1,191,904	$0	0.00%
Pleasants	$31,131,899	$0	0.00%
Pocahontas	$36,280,530	$0	0.00%
Preston	$89,928,281	$14,947,847	16.62%
Putnam	$91,192,117	$0	0.00%
Raleigh	$162,946,727	$1	0.00%
Randolph	$133,481,150	$0	0.00%
Ritchie	$9,535,900	$154,799	1.62%
Roane	$2,591,249	$0	0.00%
Summers	$61,399,017	$0	0.00%
Taylor	$35,811,537	$0	0.00%
Tucker	$22,322,036	$32,790	0.15%
Tyler	$1,640,214	$0	0.00%
Upshur	$23,678,716	$0	0.00%

County	Total Replacement Cost Value (RCV)	West Virginia State 1% Annual Chance Floodplain	
		Estimated Total Damage	Percent of Total Building and Contents Replacement Cost Value
Wayne	$13,977,493	$23,611	0.17%
Webster	$2,930,121	$0	0.00%
Wetzel	$1,260,909	$0	0.00%
Wirt	$138,503	$0	0.00%
Wood	$145,288,298	$85,424	0.06%
Wyoming	$801,905	$51,172	6.38%
WV State (Total)	$6,103,990,956	**$27,447,011**	**0.45%**

Source: WV Emergency Management Division; FEMA 2022; FAST v1.0

The NFIP data is also a useful tool to determine areas vulnerable to flood. Table 5.5-15 through Table 5.5-17 summarize the NFIP policies, coverage, loss, and payments in the State. Currently, Kanawha County has the highest number of policies in force (1,740) and the highest amount of total coverage ($301,441,600). Meanwhile, the Wirt County has the lowest number of policies in force (26) and the lowest amount of total coverage ($3,340,000). Between November 2018 and June 30, 2022, the State has 8 records of financial loss due to flood, with 60 of those records being closed with payment losses, and 9 closed without payment losses; 10 records remain open. The total amount of payments was recorded at $1,956,983 (FEMA 2022).

Table 5.5-15. Policy Information for the State of West Virginia by County

County	Policies in Force	Total Coverage	Total Written Premium + FPF
Barbour	70	$10,510,000	$92,534
Berkeley	160	$35,268,000	$161,311
Boone	257	$38,972,000	$335,812
Braxton	52	$6,180,000	$39,885
Brooke	175	$20,196,000	$235,961
Cabell	429	$77,438,600	$476,843
Calhoun	45	$5,095,000	$54,716
Clay	72	$13,933,000	$97,886
Doddridge	41	$4,990,000	$42,434
Fayette	134	$25,048,000	$139,911
Gilmer	74	$14,714,000	$119,882
Grant	76	$19,558,000	$102,944
Greenbrier	398	$82,027,000	$522,148
Hampshire	128	$22,876,000	$156,993
Hancock	97	$17,244,000	$133,101
Hardy	108	$27,284,000	$118,468
Harrison	251	$44,885,000	$351,560
Jackson	119	$24,358,000	$126,329
Jefferson	197	$48,513,000	$234,349
Kanawha	1,740	$301,441,600	$2,309,796
Lewis	102	$19,062,000	$191,607
Lincoln	139	$24,205,000	$148,989
Logan	368	$53,194,000	$431,184
Marion	204	$36,606,000	$258,633

County	Policies in Force	Total Coverage	Total Written Premium + FPF
Marshall	181	$25,567,000	$234,750
Mason	125	$19,122,000	$105,875
McDowell	149	$22,451,000	$196,541
Mercer	189	$42,625,000	$257,164
Mineral	156	$24,206,000	$224,121
Mingo	308	$56,785,400	$289,641
Monongalia	200	$54,921,000	$304,180
Monroe	34	$4,514,000	$32,244
Morgan	111	$24,908,000	$131,550
Nicholas	91	$12,963,000	$150,353
Ohio	495	$69,531,000	$905,250
Pendleton	82	$14,881,000	$82,950
Pleasants	36	$7,201,000	$32,551
Pocahontas	193	$34,899,000	$282,257
Preston	78	$16,733,000	$113,340
Putnam	363	$83,881,000	$366,282
Raleigh	141	$23,781,000	$165,175
Randolph	196	$31,073,000	$202,417
Ritchie	41	$6,411,000	$40,644
Roane	110	$16,175,000	$116,701
Summers	126	$17,908,000	$103,794
Taylor	40	$7,084,000	$43,715
Tucker	118	$21,286,000	$182,201
Tyler	39	$5,147,000	$34,614
Upshur	150	$23,537,000	$161,324
Wayne	215	$32,730,000	$255,778
Webster	97	$15,043,000	$130,242
Wetzel	172	$19,570,000	$222,022
Wirt	26	$3,340,000	$19,133
Wood	326	$63,400,000	$376,518
Wyoming	268	$45,620,000	$318,059
Total	**10,292**	**$1,820,891,600**	**$12,964,622**

Source: FEMA 2023
Notes: All data shown is current as of March 31, 2023.
FPF Federal Policy Fee

Table 5.5-16. Policy Statistics for the State of West Virginia by Rated Flood Zone

Rated Flood Zone	Building Only			Contents Only			Building and C	
	Policies in Force	Premium + FPF	Coverage	Policies in Force	Premium + FPF	Coverage	Policies in Force	Premium + FPF
All A Zones	4,750	$5,603,615	$523,766,400	56	$164,525	$11,436,100	1,992	$4,604,476
D Zone	1	$1,454	$51,800	0	$0	$0	1	$785
X Zone	191	$267,255	$23,382,400	37	$26,304	$4,531,800	2,368	$1,825,033
Unknown or Invalid	391	$537,204	$48,082,100	9	$9,257	$780,100	378	$577,148
Total	**5,333**	**$6,409,528**	**$595,282,700**	**102**	**$200,086**	**$16,748,000**	**4,739**	**$7,007,442**

Source: FEMA 2023
Notes: All data shown is current as of June 30, 2022.
FPF Federal Policy Fee
The rated flood zones represents a grouping of flood zones into categories. A includes all policies with an A zone, A01-A30, AH, AHB, AO, AOB, A0B, ARA, or A99 zone. D zone includes only D zones, All V Zone includes V, VE, and V01-V30 zones, X Zone includes B, C, and Z zones, EMG includes a zone and an emergency program indicator, and Zone Unknown or Invalid includes all other records, due to invalid or blank flood zones.

Table 5.5-17. Loss Statistics for the State of West Virginia by Flood Zone Group

Flood Zone Group	Single Family		2-4 Family		Other Residential		Non-Residential Small Business		Non-Residential Non- Small Business	
	Losses	Payments	Losses	Payments	Losses	Payments	Losses	Payments	Losses	Payments
A	5,609	$55,063,931	164	$1,662,680	70	$1,071,733	2	$60,272	1,307	$31,669,521
AE	8,061	$92,850,553	470	$5,087,296	132	$3,612,807	17	$1,173,690	1,498	$44,203,983
AO	0	$0	0	$0	0	$0	0	$0	1	$0
BLANK	834	$5,776,004	13	$116,259	3	$27,193	0	$0	69	$1,308,684
D	105	$316,647	7	$19,054	0	$0	0	$0	31	$197,992
EMG	3,011	$14,858,464	65	$215,279	47	$260,392	0	$0	616	$5,435,226
VE	1	$1,000	0	$0	0	$0	0	$0	0	$0
X	3,797	$47,263,852	107	$926,346	53	$1,013,734	4	$92,785	550	$13,029,520
Total	**21,418**	**$215,130,451**	**826**	**$8,026,914**	**305**	**$5,985,858**	**23**	**$1,326,747**	**4,072**	**$95,844,925**

Source: FEMA 2023
Notes: All data shown is current as of June 30, 2022.
FPF Federal Policy Fee
The flood zone group combines flood zones into categories. "AE" includes AE and zones A01 through A30, "AH" includes AH and AHB zones, "AO" in A00 zones, "AR" includes AR, ARE, ARH, ARA, and ARO zones, "A", "A99","D", and "V" zones each represent those specific flood zones, "VE" inclu

VE zones, "X" includes B, C, and X zones, "EMG" includes all policies without a valid flood zone but which have an emergency program indicator, remaining policies without a valid flood zone.

The occupancy/business group filter and header combines the occupancy type and small business code fields. "Single Family" includes all losses wit "Two-to-Four Family" includes all losses with an occupancy type of 2. "Other Residential" includes all losses with an occupancy type of 3. "Non-R includes all losses with an occupancy type of 4 and a small business value of Y. "Non-Residential Non-Small Business" includes all losses with an oc other small business values. "Non-Residential Business" includes all losses with an occupancy type of 6. "Unknown" includes all other losses occupancy type.

Impacts to the Environment

The loss of natural resources statewide is difficult to quantify. Environmental resources are valuable assets to the environment and overall economy in the state. Damage to natural floodplain function would increase future flood risk as floodplains provide a buffer and protect from flood impacts. Flooding has a range of impacts on the environment, including the following:

- Wildlife habitats can be destroyed
- Contaminated floodwater can pollute rivers and habitats.
- Silt and sediment can destroy crops and vegetation.
- River banks and natural levees can be eliminated as rivers reach bank full capacity.
- Rivers can be widened, and deposition can increase downstream.
- Trees can be uprooted by high-velocity water flow.
- Plants may die due to the soil being overly saturated (National Geographic 2022).

Septic tanks, cesspools, and other sewage disposal systems (OSDS) as well as other hazard materials/waste storage and disposal sites could be impacted by the inundation of water, which would oversaturate soils.

Impacts to the Economic Condition of the State

Flood events can have major economic impacts on a community from the initial loss of structures as well as the subsequent loss of revenue from destroyed businesses. Floods do not only damage assets; they also suspend economic activity. Floods have the capability to shut down facilities, cut off power, or interrupt water supplies. Supply chain sales and distribution may be disrupted; staff may be prevented from getting to work. Losses from business interruption can approach, or even exceed, those from damage to property and assets (MarshMcLennan 2021).

In the most serious events, suspension of business activity can lead to bankruptcies among small and medium-sized enterprises with low levels of working capital and no business interruption coverage. In the United States, between 40 percent and 60 percent of small businesses shut down by disasters remain closed indefinitely (MarshMcLennan 2021).

Floods not only have the potential to change the landscape of areas that draw in tourists but also to drive people away. Tourists and outdoors enthusiasts tend to avoid State and National Parks when heavy rains are present, and this can have a widespread impact on other industries as well. In this way, floods, and its precursors, can also negatively affect hospitality, restaurant, and other industries present in these key locations (Southon and van der Merwe 2018).

Impacts to Public Confidence in State Governance

The public confidence in state governance primarily depends on how effective the State has been in the past at preparing and responding to flood events. Public confidence also depends on the size of the event and the preparation the State takes for each potential event. In general, if the State is transparent in sharing relevant information with the public regarding flood events and demonstrates its reliability to the public through availability of programs and services relevant to floods, then the public will remain confident in the State’s governance (Chew, et al. 2021).

5.6 Hazardous Materials

2023 SHMP Update Changes

- The hazard profile was reorganized and significantly enhanced to include detailed descriptions of the following: hazard definition, location, extent, previous occurrences, and probability of future occurrences (including how future conditions may impact the hazard).
- Hazardous materials incidents that occurred in the State of West Virginia (the State) from January 1, 2018, through December 31, 2022, were researched for this 2023 HMP.
- Information was updated regarding the current population affected by hazardous materials.
- State asset exposure to hazardous materials was analyzed, and local vulnerabilities were assessed.
- The profile and vulnerability assessment have been updated to include the most up-to-date information on the numbers of hazardous materials facilities and Superfund sites.
- A discussion of future changes that may impact the State's vulnerability has been added.

5.6.1 Hazard Profile

This section provides general information on the hazardous materials hazard.

Hazard Description

Key Terms

***Hazardous Materials**: Any substance or material that can pose an unreasonable risk to health, safety, and property (Federal Aviation Administration 2023)*

Hazardous materials are ubiquitous in modern society and may be found at all production, consumption, and disposal stages. Federal and State laws permit the intentional release of some hazardous materials into the environment, typically in quantities, in a form, and/or in locations such that the risk to human health and the environment is thought to be acceptable. However, sometimes releases are unintentional, resulting from leaks, accidents, or natural hazards (FEMA 2019). Many hazardous substances are commonly used chemicals that are harmless in their normal uses but are quite dangerous if released in concentration. The U.S. Environmental Protection Agency (U.S. EPA) designates more than 1,300 substances as hazardous and subject to the reporting requirements under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Emergency Planning and Community Right-to-Know Act (EPCRA), and/or Clean Air Act (CAA). This number does not include all hazardous chemicals for which material safety data sheets are required (U.S. EPA 2015). Because relevant legislation uses the term "hazardous substance," but the emergency management and response community typically use the term "hazardous materials," for the purpose of this hazard profile, "hazardous materials" is used to include "hazardous substances."

Hazardous waste is waste that is dangerous or potentially harmful to our health or the environment. The wastes can be liquid, solid, gas, or sludge. Examples of potentially hazardous wastes are discarded commercial products, such as cleaning fluids or pesticides, or the by-products of manufacturing processes (West Virginia Department of Environmental Protection 2022).

Oil releases are a subset of hazardous materials that can occur naturally or unnaturally through oil seeps on land or underwater. Oil spills can result from the release of crude oil from offshore oil platforms, drilling rigs, wells, pipelines, tank trucks, and marine tank vessels (tankers). Refined petroleum products such as gasoline, diesel, and heavier fuels such as bunker fuel used by cargo ships are also sources of potential oil spill releases. According to the National Oceanic and Atmospheric Administration (NOAA), oil spills can be caused by people making mistakes or being careless, by equipment breaking down, by natural disasters, and by deliberate acts of terrorism, vandals, or illegal dumpers (NOAA 2016).

Hazardous substances, as defined by the CERCLA (commonly known as Superfund), include materials and wastes that are considered severely harmful to human health and the environment. According to CERCLA, the definition of a hazardous substance includes the following (U.S. EPA 2023):

- Any element, compound, mixture, solution, or substance designated as hazardous under Section 102 of CERCLA.
- Any hazardous substance designated under Section 311(b)(2)(a) of the Clean Water Act (CWA) or any toxic pollutant listed under Section 307(a) of the CWA. There are over 400 substances designated as either hazardous or toxic under the CWA.
- Any hazardous waste having the characteristics identified or listed under Section 3001 of the Resource Conservation and Recovery Act (RCRA).
- Any hazardous air pollutant listed under Section 112 of the CAA, as amended. There are over 200 substances listed as hazardous air pollutants under the CAA.
- Any imminently hazardous chemical substance or mixture which the U.S. EPA Administrator has "taken action under" Section 7 of the Toxic Substances Control Act (TSCA) (U.S. EPA 2023).

The EPCRA, also known as Title III of the Superfund Amendment and Reauthorization Act (SARA Title III), was passed by Congress in 1986 (NIH n.d.). The EPCRA establishes requirements for federal, State, and local governments, Indian tribes, and industry regarding emergency planning and "Community Right-to-Know" reporting on hazardous and toxic chemicals. The Community Right-to-Know provisions help increase the public's knowledge and access to information on chemicals at individual facilities, their uses, and releases into the environment. States and communities, working with facilities, can use the information to improve chemical safety and protect public health and the environment. There are four key provisions to the EPCRA, which include:

- ***Emergency planning*** – Local governments are required to prepare chemical emergency response plans and to review plans at least annually. State governments are required to oversee and coordinate local planning efforts. Facilities that maintain Extremely Hazardous Substances (EHS) on-site in quantities greater than corresponding threshold planning quantities (TPQs) must also cooperate in preparing emergency plans.
- ***Emergency release notification*** – Facilities must immediately report accidental releases of EHSs and other hazardous substances, as defined under CERCLA. Any release of these substances in quantities greater than their corresponding reportable quantities must be reported to State and local officials.

- ***Hazardous chemical storage reporting requirements*** – Facilities handling or storing any hazardous chemicals, as defined under Occupational Safety and Health Administration (OSHA), must submit Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) to State and local officials and fire departments. Facilities must also submit an inventory form for these chemicals to State and local officials and local fire departments.
- ***Toxic chemical release inventory (TRI)*** – Facilities must complete and submit a toxic chemical release inventory form (Form R) each year. Form R must be submitted for each of the over 600 TRI chemicals that are manufactured or other used above the applicable threshold quantities (NIH n.d.).

The U.S. EPA chooses to specifically list substances as hazardous and extremely hazardous rather than providing objective definitions. Hazardous substances, as listed, are generally materials that, if released into the environment, tend to persist for long periods and pose long-term health hazards for living organisms. Extremely hazardous substances, while also generally toxic materials, represent acute health hazards that, when released, are immediately dangerous to the lives of humans and animals and cause serious damage to the environment. When facilities have these materials in quantities at or above the TPQ, they must submit "Tier II" information to appropriate State and/or local agencies to facilitate emergency planning (NIH n.d.).

The United States Department of Transportation (U.S. DOT) regulations define hazardous materials as a substance or material that the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce and has designated as hazardous under Section 5103 of federal hazardous materials transportation law (U.S. Code Title 49.B.I.A.105.A n.d.). The term includes hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, materials designated as hazardous in the Hazardous Materials Table (U.S. Code Title 49.B.I.C.172 n.d.), and materials that meet the defining criteria for hazard classes and divisions. When a substance meets the U.S. DOT definition of a hazardous material, it must be transported in accordance with safety regulations providing for appropriate packaging, communication of hazards, and proper shipping controls. According to the National Fire Protection Association (NFPA), the U.S. DOT categorizes hazardous materials into the following nine classes based on chemical characteristics producing the risk (NFPA 2022):

- Class 1: Explosives
- Class 2: Gases
- Class 3: Flammable liquids
- Class 4: Flammable solids
- Class 5: Oxidizers and organic pesticides
- Class 6: Poisons and etiologic materials
- Class 7: Radioactive materials
- Class 8: Corrosives
- Class 9: Miscellaneous

During the past two decades, increasing attention has been given to hazardous materials releases resulting from natural disasters. The term "natech" (an abbreviation for "natural disaster that triggers a technological accident") is generally used to refer to such releases. As pointed out by hazmat specialists (Cruz and Suarez-Paba 2019), natechs are of particular concern because:

- They may simultaneously affect many industrial facilities, overwhelming the capacity for response.
- Mitigation measures may fail (e.g., an outer containment system constructed to contain a release from within may itself be damaged so badly that it allows the hazardous material to escape).
- There may be cascading disasters, resulting in a “domino effect” (e.g., a fire in one facility may cause an explosion in a neighboring facility, which in turn damages a third facility, and so on).
- Response personnel typically focus on search and rescue first and give attention to the presence of hazardous materials only secondarily, if at all.
- Response may be hindered by a disaster’s impact on the physical environment (e.g., roadways may be cut or blocked; power lines and communication towers may be toppled).
- Determining the appropriate response may be difficult (e.g., it may not be obvious whether, following an earthquake, people should shelter in place for protection against a chemical release or be evacuated to avoid being harmed by aftershocks) (Krausmann, Girgin and Necci 2019).

This hazard profile addresses the State’s vulnerability to hazardous materials releases from fixed facilities and during transportation by road, rail, or pipeline.

LOCATION

In-Transit and Fixed Facilities with Hazardous Materials

Hazardous materials are widely stored and transported throughout the State. An event involving hazardous materials release can occur anywhere. However, for the purpose of this hazard profile, the State examines its vulnerability within certain distances of fixed facilities and transportation routes. For releases from road, rail, and pipeline transportation, the State uses a buffer of ½ to define the vulnerable area. For releases from fixed facilities that do not store EHS, the State also uses a ½ mile buffer. The State uses a radius of 1 mile around fixed facilities that do store EHS. The State recognizes that the U.S. EPA guidance (U.S. EPA, FEMA, U.S. DOT 1987) on calculating the vulnerability radius around fixed facilities reflects a 10-mile radius around some facilities. However, the radius around each specific facility was not available for this SHMP update.

Table 5.6-1 shows the area of the State and each county that is vulnerable to hazardous materials releases. West Virginia has 2,621,023 acres of land located within ½ mile of pipelines, 3,331,943 acres within ½ mile of rail lines, 2,158,396 acres within ½ mile of major roadways, 678,002 acres within the vulnerability radii of fixed facilities that store EHS, and 1,663,118 acres within ½ mile of fixed facilities that do not store EHS. Kanawha County has the most land of any county in each of these hazard areas, with 214,163 acres within ½ mile of pipelines, 262,080 acres within ½ mile of rail lines, 109,832 acres within ½ mile of a major roadway, 59,096 acres within the vulnerability radii around fixed facilities with EHS, and 141,795 acres within ½ mile of fixed facilities that do not store EHS.

Figure 5.6-1 shows the buffers around pipelines. Figure 5.6-2 shows the buffer around rail lines. Figure 5.6-3 shows the buffer around major roadways. Figure 5.6-4 shows the vulnerable areas around fixed facilities. Each figure also highlights socially vulnerable populations within the State.

Table 5.6-1: Total Acres of Land Area Located in the Hazmat Area by County

County	Total Acres of Land Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Hazmat Hazard							
		Total Acres Located Within ½ Mile of Pipelines	Percent of Total	Total Acres Located Within ½ Mile of Rail Lines	Percent of Total	Total Acres Within ½ Mile of Major Roadways	Percent of Total	Total Acres Within 1 Mile of Facilities With EHS	Percent of Total
Barbour	218,598	49,009	22.4%	44,594	20.4%	44,570	20.4%	4,014	1.8%
Berkeley	205,141	0	0.0%	159,239	77.6%	26,339	12.8%	26,748	13.0%
Boone	321,687	51,429	16.0%	128,147	39.8%	34,455	10.7%	3,842	1.2%
Braxton	328,023	51,155	15.6%	57,061	17.4%	39,006	11.9%	4,015	1.2%
Brooke	59,321	29,433	49.6%	35,646	60.1%	17,463	29.4%	40,976	69.1%
Cabell	184,109	51,996	28.2%	104,048	56.5%	47,909	26.0%	13,386	7.3%
Calhoun	179,487	33,827	18.8%	0	0.0%	9,007	5.0%	12,487	7.0%
Clay	219,951	36,053	16.4%	0	0.0%	6,066	2.8%	0	0.0%
Doddridge	205,051	128,786	62.8%	0	0.0%	12,115	5.9%	2,117	1.0%
Fayette	427,276	61	0.0%	201,760	47.2%	70,164	16.4%	14,550	3.4%
Gilmer	217,274	43,147	19.9%	3,855	1.8%	16,178	7.4%	2,008	0.9%
Grant	305,479	7,233	2.4%	35,933	11.8%	34,011	11.1%	2,004	0.7%
Greenbrier	654,360	1,609	0.2%	124,222	19.0%	79,696	12.2%	12,716	1.9%
Hampshire	412,248	2,270	0.6%	54,931	13.3%	33,268	8.1%	8,133	2.0%
Hancock	56,222	10,810	19.2%	32,289	57.4%	14,137	25.1%	8,813	15.7%
Hardy	373,689	28,467	7.6%	39,245	10.5%	52,249	14.0%	2,000	0.5%
Harrison	266,023	109,372	41.1%	57,120	21.5%	46,020	17.3%	27,120	10.2%
Jackson	300,968	74,957	24.9%	27,127	9.0%	49,896	16.6%	3,466	1.2%
Jefferson	134,920	0	0.0%	82,092	60.8%	10,293	7.6%	9,206	6.8%
Kanawha	582,312	214,163	36.8%	262,080	45.0%	109,832	18.9%	59,096	10.1%
Lewis	246,359	65,305	26.5%	9,999	4.1%	46,663	18.9%	5,316	2.2%
Lincoln	280,594	83,361	29.7%	39,800	14.2%	43,699	15.6%	5,209	1.9%
Logan	291,325	40,230	13.8%	106,428	36.5%	45,827	15.7%	11,478	3.9%
Marion	199,006	165,861	83.3%	44,625	22.4%	36,657	18.4%	26,662	13.4%
Marshall	199,304	159,269	79.9%	43,621	21.9%	34,308	17.2%	48,829	24.5%

County	Total Acres of Land Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Hazmat Hazard							
		Total Acres Located Within ½ Mile of Pipelines	Percent of Total	Total Acres Located Within ½ Mile of Rail Lines	Percent of Total	Total Acres Within ½ Mile of Major Roadways	Percent of Total	Total Acres Within 1 Mile of Facilities With EHS	Percent of Total
Mason	284,059	16,317	5.7%	108,301	38.1%	67,249	23.7%	8,449	3.0%
McDowell	342,174	21,348	6.2%	134,423	39.3%	37,051	10.8%	6,904	2.0%
Mercer	268,828	10,356	3.9%	89,851	33.4%	70,378	26.2%	20,182	7.5%
Mineral	210,134	7,548	3.6%	31,067	14.8%	16,479	7.8%	6,633	3.2%
Mingo	270,756	48,562	17.9%	115,860	42.8%	64,221	23.7%	9,644	3.6%
Monongalia	232,200	78,878	34.0%	113,501	48.9%	64,867	27.9%	29,591	12.7%
Monroe	302,704	21,901	7.2%	9,892	3.3%	41,484	13.7%	8,054	2.7%
Morgan	146,880	0	0.0%	69,864	47.6%	14,630	10.0%	4,707	3.2%
Nicholas	415,482	27,359	6.6%	35,877	8.6%	29,350	7.1%	8,026	1.9%
Ohio	69,666	25,224	36.2%	115	0.2%	21,701	31.1%	42,170	60.5%
Pendleton	446,485	14,637	3.3%	0	0.0%	50,436	11.3%	7,094	1.6%
Pleasants	85,837	9,147	10.7%	20,650	24.1%	9,940	11.6%	4,232	4.9%
Pocahontas	601,520	0	0.0%	27,258	4.5%	51,593	8.6%	0	0.0%
Preston	415,612	60,370	14.5%	36,536	8.8%	70,425	16.9%	12,079	2.9%
Putnam	223,706	40,999	18.3%	56,257	25.1%	61,362	27.4%	16,399	7.3%
Raleigh	388,484	47,981	12.4%	138,096	35.5%	74,265	19.1%	16,207	4.2%
Randolph	664,970	50,816	7.6%	62,792	9.4%	69,920	10.5%	2,830	0.4%
Ritchie	290,396	60,586	20.9%	0	0.0%	13,637	4.7%	2,092	0.7%
Roane	309,410	53,219	17.2%	0	0.0%	36,385	11.8%	18,846	6.1%
Summers	233,898	20,961	9.0%	84,897	36.3%	23,966	10.2%	6,636	2.8%
Taylor	110,892	19,565	17.6%	55,926	50.4%	28,545	25.7%	3,776	3.4%
Tucker	265,897	30,535	11.5%	578	0.2%	65,541	24.6%	1,999	0.8%
Tyler	166,857	73,355	44.0%	14,248	8.5%	7,519	4.5%	7,681	4.6%
Upshur	226,613	52,533	23.2%	66,478	29.3%	15,235	6.7%	9,169	4.0%
Wayne	325,702	84,760	26.0%	107,232	32.9%	76,248	23.4%	11,462	3.5%
Webster	355,637	0	0.0%	30,588	8.6%	0	0.0%	2,008	0.6%

County	Total Acres of Land Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Hazmat Hazard							
		Total Acres Located Within ½ Mile of Pipelines	Percent of Total	Total Acres Located Within ½ Mile of Rail Lines	Percent of Total	Total Acres Within ½ Mile of Major Roadways	Percent of Total	Total Acres Within 1 Mile of Facilities With EHS	Percent of Total
Wetzel	231,289	195,299	84.4%	49,464	21.4%	33,560	14.5%	25,289	10.9%
Wirt	150,356	4,878	3.2%	0	0.0%	0	0.0%	2,007	1.3%
Wood	241,020	43,178	17.9%	64,242	26.7%	38,152	15.8%	21,613	9.0%
Wyoming	320,602	62,908	19.6%	114,087	35.6%	44,428	13.9%	8,034	2.5%
Total	**15,466,796**	**2,621,023**	**16.9%**	**3,331,943**	**21.5%**	**2,158,396**	**14.0%**	**678,002**	**4.4%**

Source: USGS 2022; West Virginia University Geographic Information Systems (GIS) Technical Center (WVU GISTC) 2022
Note: The acreage in this table excludes waterbody areas.

Figure 5.6-1. Areas within 1/2 Mile of Pipelines

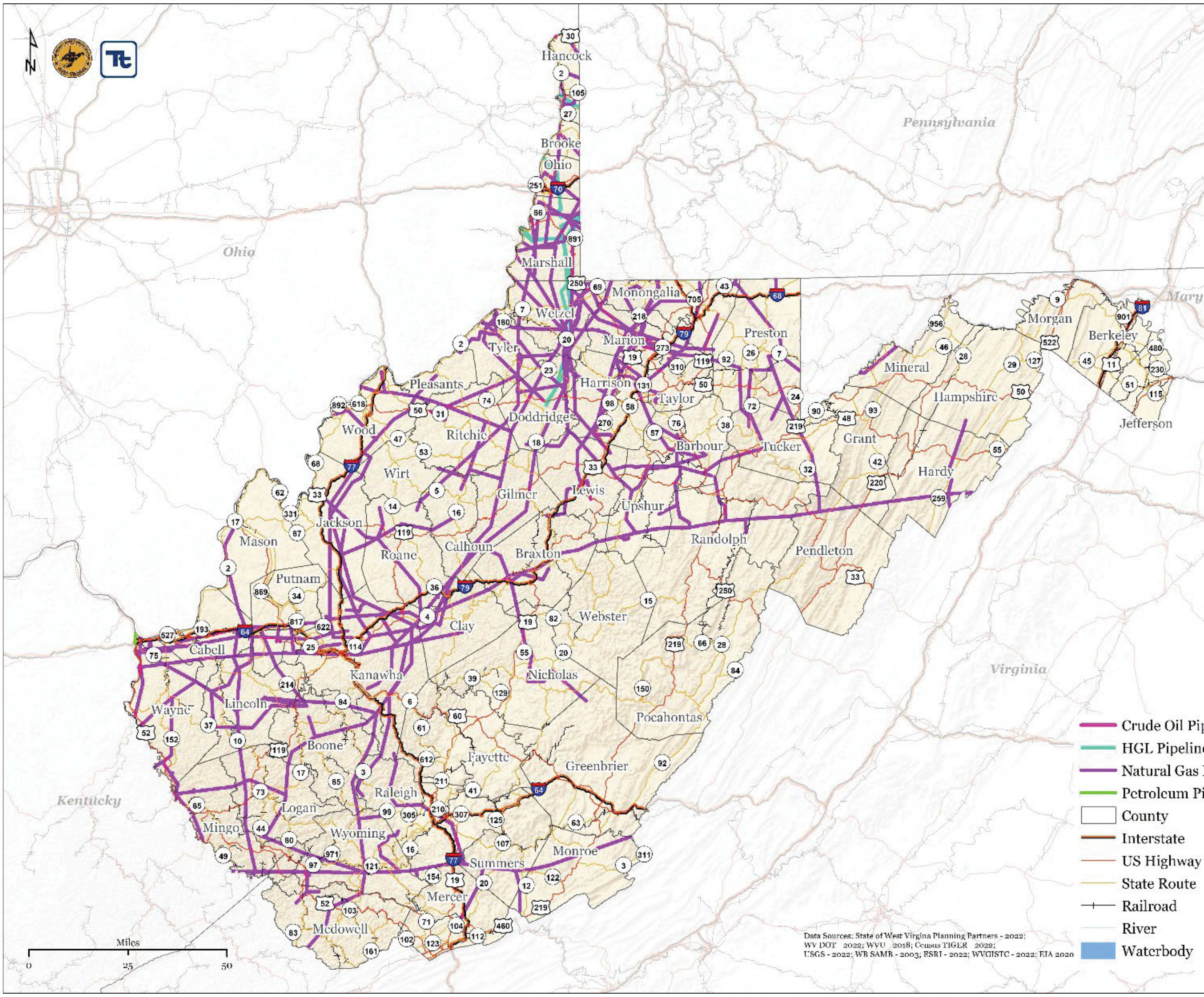


Figure 5.6-2. Areas within 1/2 Mile of Rail Lines

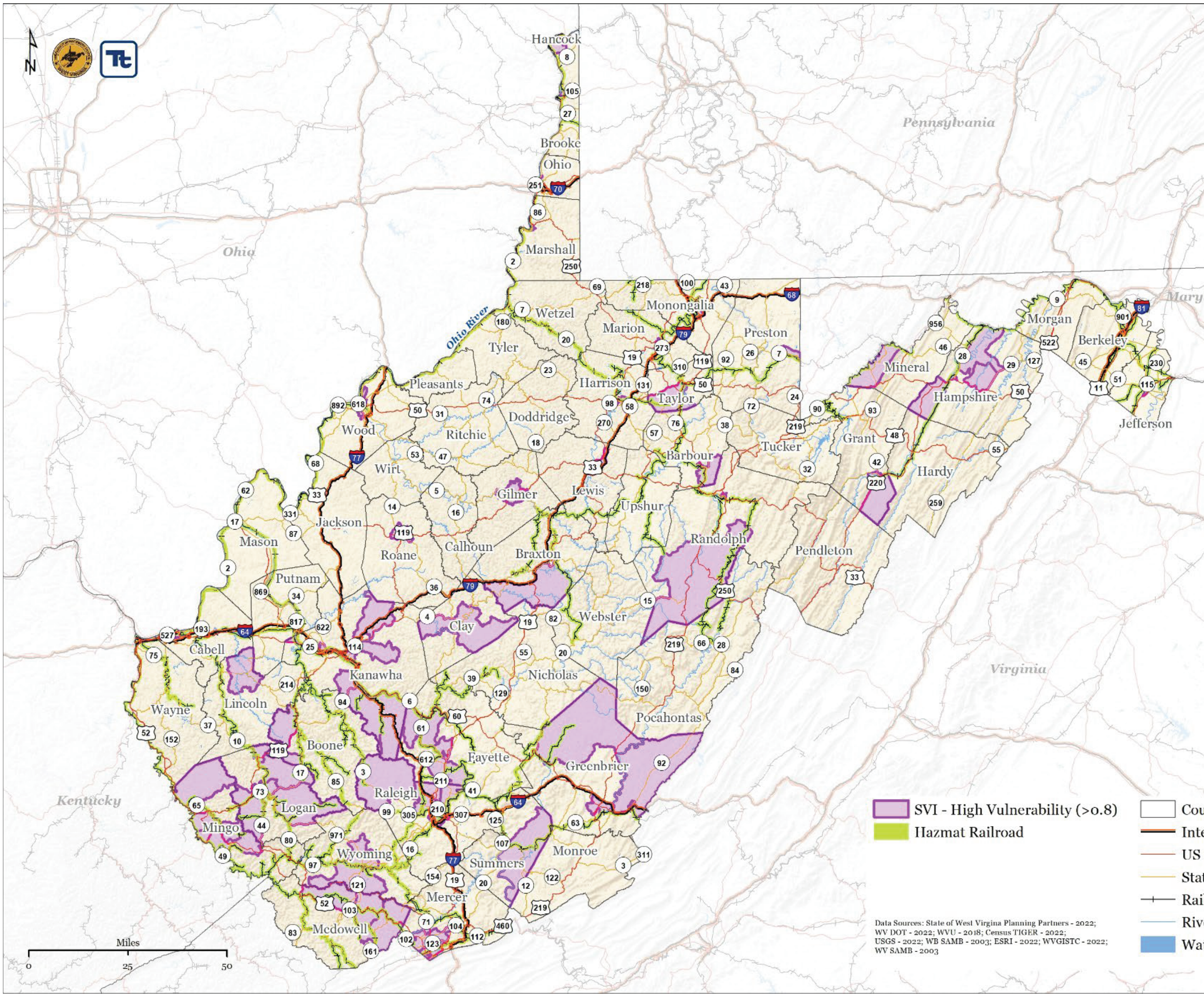


Figure 5.6-3. Areas within 1/2 Mile of Major Roadways

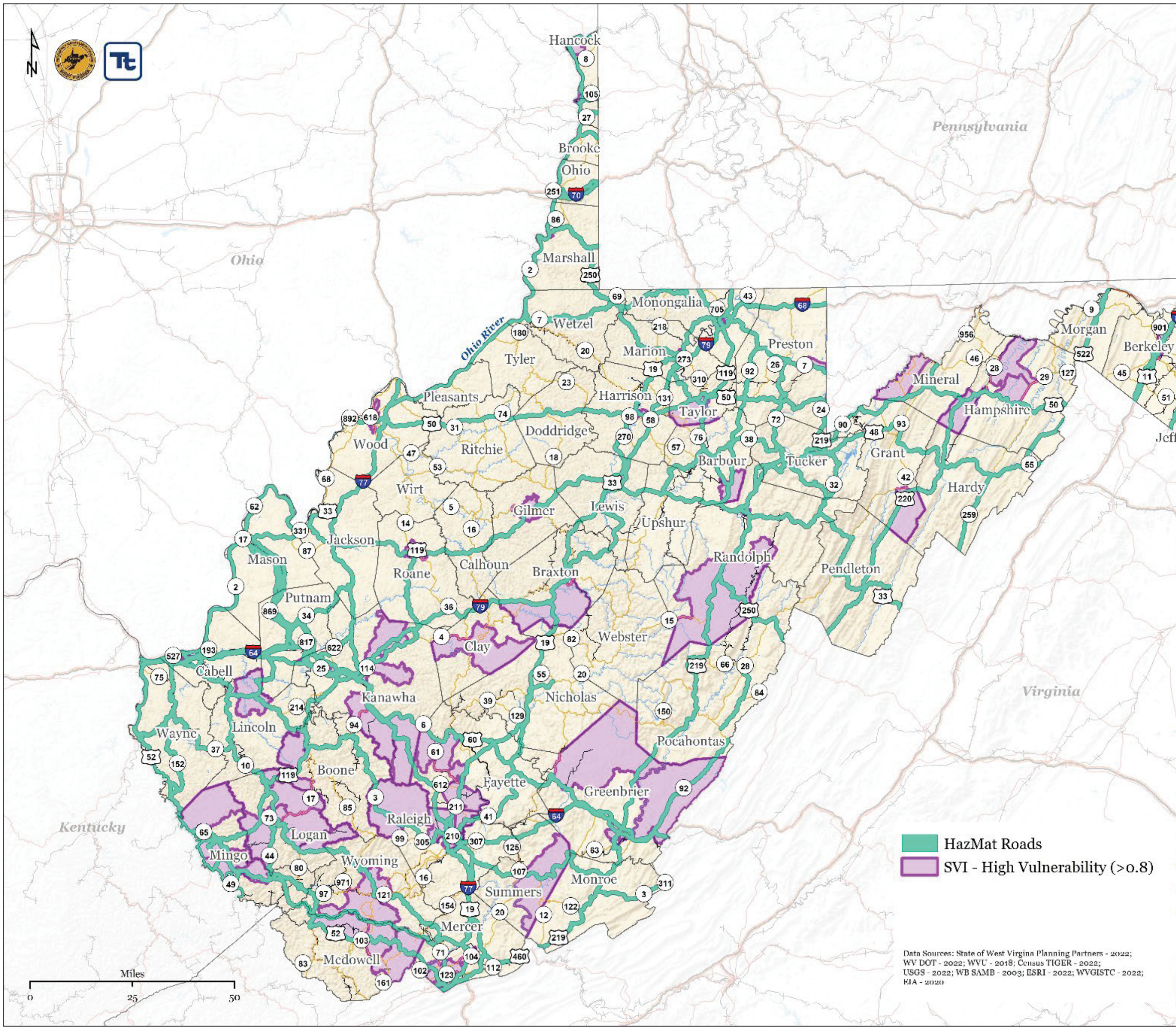
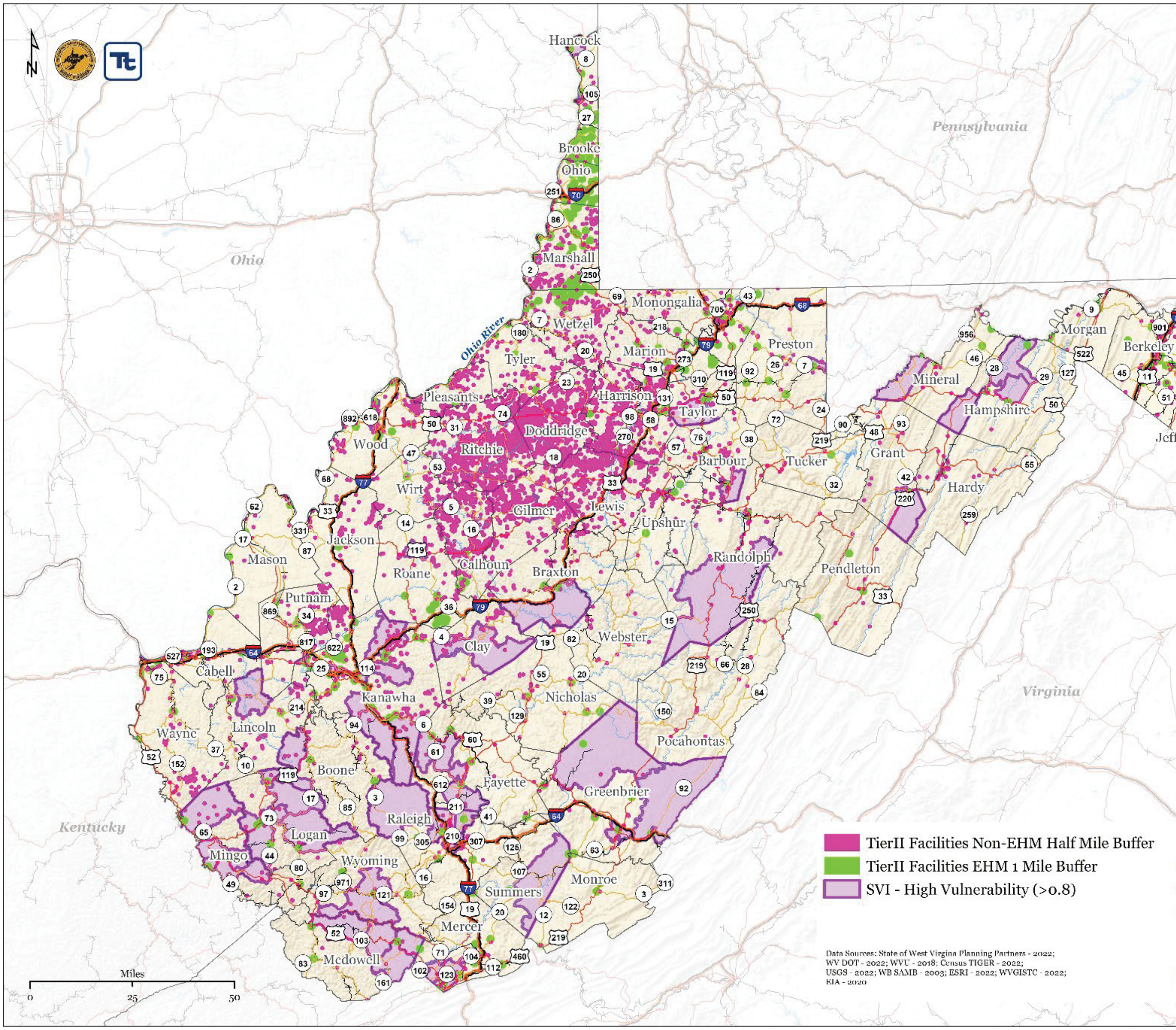


Figure 5.6-4. Areas Vulnerable to Releases from Fixed Facilities



Superfund Sites

In response to concerns regarding health and environmental risks, Congress established the Superfund program in 1980 to clean up sites in which hazardous materials were released and ultimately abandoned (U.S. EPA 2023). The Superfund program is locally administered by the U.S. EPA in cooperation with the West Virginia Department of Environmental Protection (WVDEP 2023).

Federal regulations, including CERCLA and the SARA, require that a National Priorities List (NPL) of sites throughout the United States be maintained and revised at least annually (SARA amended CERCLA on October 17, 1986). The NPL is a list of sites of national priority among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is intended primarily to guide the U.S. EPA in determining which sites warrant further investigation. As of May 21, 2023, there are 14 active NPL (Superfund) sites in West Virginia (U.S. EPA 2023). See Table 5.6-2 for more information.

Superfund sites increase the State's and communities' risk to impacts from other hazards, such as flooding, that can cause the migration or spread of hazardous materials throughout the environment, adversely impacting both public and environmental health and adding significant complications to recovery efforts following a disaster.

Table 5.6-2: Superfund National Priorities List

County	City	Site Name	Listing Date
Brooke	Follansbee	Follansbee	January 2004
Fayette	Minden	Shaffer Equipment/Arbuckle Creek Area	May 2019
Harrison	Clarksburg	North 25th Street Glass and Zinc	September 2016
Jackson	Ravenswood	Ravenswood PCE Ground Water Plume	September 2004
Jefferson	Leetown	Leetown Pesticide	August 1996
Marion	Fairmont	Big John Salvage - Hoult Road	July 2000
Marion	Fairmont	Sharon Steel Corp (Fairmont Coke Works)	December 1996
Marshall	Moundsville	Hanlin-Allied-Olin	July 1999
Mason	Point Pleasant	West Virginia Ordnance (USARMY)	September 1983
Mineral	Mineral County	Allegany Ballistics Laboratory (USNAVY)	May 1994
Monongalia	Morgantown	Ordnance Works Disposal Areas	August 2018
Putnam	Nitro	Fike Chemical, Inc.	September 1983
Wetzel	Paden City	Paden City Groundwater	March 2022
Wood	Vienna	Vienna Tetrachloroethene	October 1999

Source: U.S. EPA 2023

Extent

Hazardous materials vary greatly in the types of health risks they pose to humans. Emergency responders contend with the following potential health risks from hazardous materials: thermal, radiological, asphyxiation, chemical, etiological, or mechanical (TRACEM) (FEMA 2019).

- Thermal harm results from exposure to temperature extremes. Thermal injuries can be external (from contacting or being in close proximity to, a fire or other heat source) or internal (from inhaling fumes or heated air). Thermal injuries can also include frostbite from contact with low-temperature hazardous materials.

- Radiological harm, perhaps the most misunderstood type of harm in the TRACEM model, results from exposure to radioactive materials. The most harmful types of radiation cannot be seen, felt, or smelled. Special detection devices are required to monitor and measure levels of radiation, and these devices are becoming more available to emergency responders.
- Asphyxiation results from exposure to materials that reduce oxygen to levels that may cause suffocation. Asphyxiation typically occurs in confined spaces or with extremely concentrated forms of simple asphyxiants. Asphyxiants displace so much oxygen from the ambient atmosphere that the lungs cannot supply enough to fully oxygenate the tissues, and the victim slowly suffocates. Many asphyxiants (e.g., carbon dioxide, methane) are odorless and tasteless (unless odorants are added), so that individuals could become unconscious without realizing an asphyxiant gas is present.
- Chemical harm results from exposure to chemicals, including poisons and corrosives. Injuries and illness vary by material. Chemical agents are classified according to the potential severity of their effects.
- Etiological (or biological) harm results from exposure to biological materials, including bacteria, viruses, and toxins. Symptoms of etiological harm are often delayed because the pathogens often require time to multiply sufficiently to cause illness in the person carrying the pathogen.
- Mechanical harm results from exposure to, or contact with, fragmentation or debris scattered because of a pressure release, explosion, or boiling liquid expanding vapor explosion (BLEVE). Certain, predictable reactions occur during and immediately after an explosion, routinely injuring or killing anyone in proximity. The degree of harm is closely related to the size of the explosion and proximity to the device (FEMA 2019).

The extent of a hazardous substance release will depend on whether it is from a fixed or in-transit (mobile) source, the volume of substance released, duration of the release, the toxicity and properties of the substance, and the environmental conditions (for example, wind and precipitation, terrain, etc.). Hazardous substance releases can contaminate air, water, and soils, possibly resulting in death and/or injuries. Dispersion can take place rapidly when the hazardous substance is transported by water and wind. While often accidental, releases can occur as a result of human carelessness, intentional acts, or natural hazards. When caused by natural hazards, these incidents are known as secondary events. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas (FEMA 2019).

With a hazardous substance release, whether accidental or intentional, several potentially exacerbating or mitigating circumstances will affect its severity of impact. Mitigating conditions are precautionary measures taken in advance to reduce the impact a release has on the surrounding environment. Primary and secondary containment or shielding by sheltering-in-place measures protects people and property from the harmful effects of a hazardous substance release. Exacerbating conditions, characteristics that can enhance or magnify the effects of a hazardous substance release, include the following (FEMA 2019):

- Weather conditions, which affect how the hazard occurs and develops (such as wind speed and direction)
- Micro-meteorological effects of buildings and terrain, which alters the dispersion of hazardous substances in compliance with applicable codes (such as building or fire codes)
- Mechanical failures (such as fire protection and containment features), which can substantially increase the damage to the facility itself and to surrounding buildings

- Land use, population and building density will be factors contributing to the extent of exposure and impacts incurred.

Warning Time

Hazardous materials incidents can occur suddenly without any warning (such as an explosion) or may develop slowly (such as a leaking container). Facilities that store EHS are required to notify local officials when an incident occurs. Local emergency responders and emergency management officials determine the need to evacuate the public or whether to advise people to shelter in place. Similar to on-site hazardous substances incidents, the amount of warning time for incidents associated with hazardous substances in-transit varies based on the nature and scope of the incident. If an explosion or hazardous materials release does not occur immediately following an accident, there may be time for warning adjacent neighborhoods and enough time to facilitate appropriate protective actions.

PREVIOUS OCCURRENCES AND LOSSES

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1954 and 2022, FEMA has included the State in one hazardous material-related disaster (DR) or emergency (EM) declaration, as shown in Table 5.6-3.

Table 5.6-3. FEMA Disaster Declarations for Hazardous Materials (1954 to 2022)

Date(s) of Event	Incident	Federal Designation	Counties Affected
January 9-20, 2014	Chemical Spill	EM-3366-WV	Boone, Cabell, Clay, Jackson, Kanawha, Lincoln, Logan, Putnam, Roane

Source: FEMA 2022

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2018 and 2022, West Virginia was not included in any hazardous materials-related agricultural disaster declarations.

Previous Events

Information on previous occurrences of hazardous materials releases comes from a variety of sources. For example, the U.S. DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) reported 285 hazardous materials incidents occurred in the State from 2018–2022 (U.S. DOT 2023). For this SHMP update, major events that occurred in the State from 2018–2022 are listed in Table 5.6-4. Not all incidents that occurred are reflected in the table.

Table 5.6-4. Hazardous Material Incidents from 2018 to 2022

Date of Incident	County	City	Impacts
June 6, 2018	Greenbrier	Lewisburg	A truck ran off the roadway along I-64 West at mile 171 and overturned, spilling approximately 6,500 gallons of petroleum product. WVDOH and WVDEP responded. No injuries or fatalities were reported. A contractor excavated 800 tons of contaminated soil that was disposed of in the Greenbrier County Landfill. $336,670 in damages were reported.
July 24, 2018	Kanawha	Belle	A forklift operator lost control of a load of petroleum distillate. 275 gallons were released onto the trailer floor and leaked onto the asphalt and concrete below. A contractor cleaned up the spill. $6,500 in damages were reported.
February 8, 2019	Morgan	Berkeley Springs	A propane truck rolled onto its side, releasing propane vapor for approximately 30 minutes. Remaining product was pumped into another vehicle. $5,000 in damages were reported.
February 26, 2019	Kanawha	Charleston	A package of organic compounds spilled in a trailer and leaked onto 20 more packages. No injuries, fatalities, or damages were reported.
August 10, 2019	Ohio	Valley Grove	200 gallons of diesel fuel were released when the driver of a tank trailer struck a parked trailer. A clean-up contractor was dispatched and conducted remediation at the site. $30,550 in damages were reported.
January 5, 2020	Wetzel	Proctor	3,600 gallons of toluene diisocyanate were released onto the roadway and migrated into a nearby creek. A clean-up contractor was dispatched to complete clean-up and site remediation. $32,800 of damages were reported.
August 24, 2020	Hancock	Newell	500 gallons of flammable liquids were released from a truck onto the roadway. A contractor cleaned affected areas. $25,000 in damages were reported.
April 16, 2021	Wood	Rockport	A tractor-trailer rolled over on I-77, spilling nearly 40,000 pounds of extremely hazardous substance. A contractor excavated affected soil. $10,000 in damages were reported.
November 4, 2021	Wyoming	Maben	$87,350 of damages occurred due to a 35-gallon diesel fuel spill. No other details were provided.
November 11, 2021	Cabell, Wayne	Huntington	270 gallons of corrosive liquids were spilled over the span of 30 miles from a leaking trailer. It was determined that the spilled material was not recoverable due to heavy rain.
July 19, 2022	Kanawha	Charleston	750 gallons of flammable liquids were spilled inside a trailer, with approximately 350 gallons having spilled outside the trailer. $65,000 in damages were reported.
August 25, 2022	Fayette	Pax	A tractor-trailer accident spilled an unidentified quantity of alkyl dimethylamine on the West Virginia Turnpike near mile 62.5.

Source: U.S. DOT 2023; Jordan 2022

Probability of Future Hazard Events

Overall Probability

There has been one federal declaration for hazardous material incidents in the State. All events reported earlier in this section that occurred between 2018 and 2022 were used to calculate the probability of future occurrences. Based on the PHMSA and other sources, the State experienced 285 hazardous material incidents between 2018 and 2022. Therefore, there is a 100 percent chance of a hazardous material incident occurring in any given year in the State. However, as was the case for historical events in the State, the magnitude of the incidents expected to occur will vary widely from very minor releases to the potential for major events in which thousands of gallons of hazardous materials may be released.

Table 5.6-5. Probability of Future Hazardous Materials Events in West Virginia

Hazard Type	Number Of Occurrences Between 2018 And 2022	Percent Chance of Occurrence in Any Given Year
Hazardous Materials	285	100%

Source: U.S. DOT 2023

Projected Future Conditions

In February 2022, the U.S. Government Accountability Office (GAO) found that nearly one-third of all hazardous materials facilities across the country are located in areas vulnerable to hazards that may become more vulnerable due to changing hazard conditions. Further, the U.S. EPA does not consistently assess how these facilities are managing risks from natural hazards (U.S. GAO 2022). GAO maintains an interactive map displaying vulnerable hazardous materials facilities, where it appears that several facilities in West Virginia are subject to moderate to high flood risk.

Future conditions may increase the frequency and intensity of specific natural hazards, putting hazardous materials facilities at greater risk of damage and releasing chemicals into surrounding communities.

5.6.2 Vulnerability Assessment

Overall, it is difficult to quantify potential losses due to hazardous material incidents because of the many variables that must be considered, including but not limited to the specific hazardous substance, quantity, location, time of day, meteorological conditions, surrounding environment, and emergency response and clean-up capabilities. Potential impacts may be local, regional, or statewide depending on the magnitude of the event and level of service disruptions. A qualitative assessment is discussed below.

State Assets

Potential losses to State buildings caused by a hazardous materials release are difficult to monetize. The degree of damage to the asset depends on the scale of the incident. Generally speaking, all State buildings are potentially vulnerable to a hazardous materials release. State facilities near Tier II facilities, NPL sites, or transportation corridors that permit the transport of hazardous materials have an increased risk of exposure. Depending upon the incident, State employees may need to evacuate the building if exposure may impact human health. This may result in loss of productivity that can be measured by days and dollar equivalency. In terms of building-related and property damage, damage may include but not be limited to damage to heating, ventilation, and air conditioning (HVAC) systems due to the corrosive effects of some chemicals; and/or contaminated soil, groundwater, and nearby waterbodies.

All State roads that permit the transport of hazardous materials are potentially at risk of an incident. Quick response minimizes the volume and concentration of hazardous materials that disperse through air, water, and soil. Hazardous material releases may lead to road closures until response and clean-up efforts are completed. This may impact access to communities, commuting to work, and impact the ability to deliver goods and services efficiently.

Table 5.6-6 and Table 5.6-7 show the number of State facilities that are located within ½ mile of a pipeline by county as well as agency. The State has 214 facilities located in this hazard area with a replacement cost value of $2.6 billion. Kanawha County has the most State facilities (88) impacted by this hazard, but Monongalia County has the highest replacement cost ($1.6 billion). The Division of Highways has the most facilities (27) impacted by this hazard, while West Virginia University has the highest replacement cost value ($1.5 billion).

Table 5.6-6: State Facilities Located in the Pipeline Hazard Area by County

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Barbour	2	$40,000	$5,000	$45,000
Berkeley	0	$0	$0	$0
Boone	0	$0	$0	$0
Braxton	9	$3,269,653	$646,100	$3,915,753
Brooke	2	$0	$60,000	$60,000
Cabell	12	$43,790,840	$3,791,300	$47,582,140
Calhoun	0	$0	$0	$0
Clay	0	$0	$0	$0
Doddridge	3	$31,854,101	$6,980,500	$38,834,601
Fayette	0	$0	$0	$0
Gilmer	1	$0	$0	$0
Grant	0	$0	$0	$0
Greenbrier	0	$0	$0	$0
Hampshire	0	$0	$0	$0
Hancock	2	$0	$1,550,000	$1,550,000
Hardy	0	$0	$0	$0
Harrison	3	$515,000	$3,123,000	$3,638,000
Jackson	1	$10,430,053	$2,239,600	$12,669,653
Jefferson	0	$0	$0	$0
Kanawha	88	$349,014,033	$128,597,577	$477,611,610
Lewis	0	$0	$0	$0
Lincoln	4	$800,000	$381,000	$1,181,000
Logan	0	$0	$0	$0
Marion	13	$238,364,751	$17,211,800	$255,576,551
Marshall	10	$75,062,761	$3,935,974	$78,998,735
Mason	7	$2,225,000	$356,050	$2,581,050
McDowell	0	$0	$0	$0
Mercer	0	$0	$0	$0
Mineral	0	$0	$0	$0
Mingo	7	$0	$835,300	$835,300
Monongalia	16	$1,387,674,322	$173,440,604	$1,561,114,926

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Monroe	0	$0	$0	$0
Morgan	0	$0	$0	$0
Nicholas	0	$0	$0	$0
Ohio	5	$0	$1,268,759	$1,268,759
Pendleton	0	$0	$0	$0
Pleasants	0	$0	$0	$0
Pocahontas	0	$0	$0	$0
Preston	0	$0	$0	$0
Putnam	9	$13,750,100	$2,896,500	$16,646,600
Raleigh	6	$6,425,500	$3,130,000	$9,555,500
Randolph	1	$5,000	$15,000	$20,000
Ritchie	3	$8,289,491	$1,026,400	$9,315,891
Roane	0	$0	$0	$0
Summers	1	$51,485,058	$4,025,000	$55,510,058
Taylor	0	$0	$0	$0
Tucker	1	$0	$52,300	$52,300
Tyler	1	$1,000,000	$100,000	$1,100,000
Upshur	2	$0	$115,000	$115,000
Wayne	3	$10,324,150	$1,897,564	$12,221,714
Webster	0	$0	$0	$0
Wetzel	1	$0	$0	$0
Wirt	0	$0	$0	$0
Wood	0	$0	$0	$0
Wyoming	1	$0	$113,400	$113,400
Total (WV State)	**214**	**$2,234,319,813**	**$357,793,728**	**$2,592,113,541**

Source: WVBRIM 2022

Table 5.6-7: State Facilities Located in the Pipeline Hazard Area by Agency

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Adjutant General's Office State of West Virginia	1	$295,000	$93,000	$388,000
Administration, Secretary of Department of Administration	0	$0	$0	$0
Agriculture, Department of State of West Virginia	0	$0	$0	$0
Air and Environmental Quality Boards State of West Virginia	0	$0	$0	$0
Alcohol Beverage Control Administration State of West Virginia	0	$0	$0	$0
Architects, Board of State of West Virginia	1	$0	$17,000	$17,000
Armory Board State of West Virginia	7	$40,919,815	$4,535,064	$45,454,879

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Arts, Culture & History, Department of State of West Virginia	1	$7,062,890	$212,200	$7,275,090
Attorney General, Office of The State of West Virginia	0	$0	$0	$0
Aviation, Division of	0	$0	$0	$0
Bar, State State of West Virginia	1	$1,230,000	$250,000	$1,480,000
Barbers & Cosmetologists, Board of State of West Virginia	1	$0	$100,000	$100,000
Blue Ridge Community & Technical College	0	$0	$0	$0
Bluefield State College	0	$0	$0	$0
Board of Treasury Investments	0	$0	$0	$0
Bridgevalley Community & Tech College	1	$15,000,000	$19,050,000	$34,050,000
Cedar Lakes Conference Center State of West Virginia	1	$10,430,053	$2,239,600	$12,669,653
Chiropractic Examiners Board State of West Virginia	0	$0	$0	$0
Commission For National and Community Service, WV	1	$0	$80,000	$80,000
Concord University	0	$0	$0	$0
Conservation Agency, West Virginia State of West Virginia	4	$0	$749,400	$749,400
Consolidated Public Retirement Board Department of Administration	0	$0	$0	$0
Consumer Advocate, Division of WV Public Service Commission	1	$0	$150,000	$150,000
Corrections, Division of State of West Virginia	5	$97,041,081	$9,831,274	$106,872,355
Courthouse Facilities Improvement Authority	0	$0	$0	$0
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	0	$0	$0	$0
Dietitians, Board of Licensed	0	$0	$0	$0
Eastern Panhandle Instructional Coop	0	$0	$0	$0
Eastern WV Community & Tech. College	0	$0	$0	$0
Economic Development Authority State of West Virginia	1	$750,000	$100,000	$850,000
Economic Development, WV Dept of	1	$0	$3,000,000	$3,000,000
Education, Department of State of West Virginia	10	$0	$1,070,000	$1,070,000
Educational Broadcasting Authority State of West Virginia	0	$0	$0	$0
Enterprise Resource Planning Board, WV	1	$0	$2,000,000	$2,000,000
Environmental Protection, Division of State of West Virginia	5	$11,500	$2,260,660	$2,272,160
Ethics Commission, West Virginia Department of Administration	1	$65,000	$65,000	$130,000
Examiners In Counseling, Board of State of West Virginia	1	$0	$6,000	$6,000
Fairmont State University	1	$211,509,751	$13,786,800	$225,296,551
Fire Commission State of West Virginia	0	$0	$0	$0
Fleet Management Office, Dept of Admin State of West Virginia	0	$0	$0	$0
Forestry, Division of State of West Virginia	3	$0	$680,000	$680,000

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
General Services Division Department of Administration	3	$20,202,522	$1,000,000	$21,202,522
Geological and Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	0	$0	$0	$0
Governor, Office of The State of West Virginia	0	$0	$0	$0
Health & Human Resources, Department of State of West Virginia	21	$102,260,000	$37,070,000	$139,330,000
Higher Education Policy Commission, WV	7	$79,270,000	$19,725,000	$98,995,000
Highways, Division of State of West Virginia	27	$43,975,783	$6,744,236	$50,720,019
Homeland Security & Emergency Management Division	0	$0	$0	$0
Insurance Commissioner, Office of The State of West Virginia	0	$0	$0	$0
Investment Management Board, WV State of West Virginia	1	$0	$2,500,000	$2,500,000
Joint Committee on Government & Finance State of West Virginia	0	$0	$0	$0
Justice & Community Services, Div. of	0	$0	$0	$0
Juvenile Services, Division of	5	$7,504,700	$659,800	$8,164,500
Labor, Division of State of West Virginia	0	$0	$0	$0
Land Division/Dept of Agriculture State of West Virginia	0	$0	$0	$0
Landscape Architects, Board of State of West Virginia	1	$0	$2,500	$2,500
Library Commission State of West Virginia	0	$0	$0	$0
Lottery Commission State of West Virginia	2	$46,200,000	$10,000,000	$56,200,000
Marshall University	0	$0	$0	$0
Military Affairs, Secretary of and Public Safety	0	$0	$0	$0
Miner's Health Safety, Division of and Training, State of West Virginia	0	$0	$0	$0
Motor Vehicles, Division of State of West Virginia	4	$0	$1,048,000	$1,048,000
Mountain State Esc	1	$1,000,000	$250,000	$1,250,000
Mountwest Community & Technical College	0	$0	$0	$0
National Coal Heritage Area Authority	0	$0	$0	$0
Natural Resources, Division of State of West Virginia	5	$2,000,000	$595,000	$2,595,000
New River Community & Technical College	0	$0	$0	$0
Northern Community & Tech College, WV College Square	0	$0	$0	$0
Occupational Therapy Board State of West Virginia	1	$0	$10,000	$10,000
Office of Technology/Is&C Department of Administration	1	$0	$400,000	$400,000
Osteopathic Medicine, WV Board of State of West Virginia	1	$0	$25,000	$25,000
Osteopathic Medicine, WV School of	0	$0	$0	$0
Parks, West Virginia State C\O Division of Natural Resources	7	$59,999,549	$5,071,400	$65,070,949
Pharmacy, Board of State of West Virginia	0	$0	$0	$0
Physical Therapy, Board of State of West Virginia	0	$0	$0	$0
Pierpont Community and Technical College	2	$400,000	$3,100,000	$3,500,000

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Practical Nurses, Board of State of West Virginia	0	$0	$0	$0
Prosecuting Attorneys Institute, WV	1	$0	$121,000	$121,000
Psychologists Examiners, Board of State of West Virginia	0	$0	$0	$0
Public Service Commission State of West Virginia	2	$14,844,069	$3,365,000	$18,209,069
Purchasing, Division of Department of Administration	1	$155,000	$750,000	$905,000
Rail Authority State of West Virginia	0	$0	$0	$0
Real Estate Commission State of West Virginia	1	$0	$150,000	$150,000
Regional Jail & Corr. Fac. Authority State of West Virginia	1	$28,640,000	$1,232,000	$29,872,000
Registered Nurses, Board of State of West Virginia	1	$0	$250,000	$250,000
Rehabilitation Services Division of Commerce	7	$0	$4,086,299	$4,086,299
Respiratory Care, WV Board of	0	$0	$0	$0
School Building Authority, West Virginia	0	$0	$0	$0
Schools For The Deaf and The Blind State of West Virginia	0	$0	$0	$0
Senior Services, Bureau of State of West Virginia	1	$0	$150,000	$150,000
Shepherd University	0	$0	$0	$0
Southern Educational Services Coop	0	$0	$0	$0
Southern WV Community & Tech College	0	$0	$0	$0
Speech Pathology & Audiology Examiners West Virginia Board of	0	$0	$0	$0
State Police, West Virginia Dept of Military Affairs & Public Safety	14	$23,061,623	$11,268,600	$34,330,223
Supreme Court of Appeals State of West Virginia	14	$0	$1,227,400	$1,227,400
Tax Appeals, WV Office of	1	$0	$130,000	$130,000
Tax Department State of West Virginia	2	$0	$5,050,000	$5,050,000
Treasurer of State State of West Virginia	2	$0	$711,000	$711,000
University Physicians and Surgeons	7	$13,530,000	$3,180,000	$16,710,000
Unknown	12	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	3	$10,419,640	$1,393,300	$11,812,940
Veterinary Medicine, Board of State of West Virginia	0	$0	$0	$0
Water Development Authority State of West Virginia	1	$6,500,000	$1,000,000	$7,500,000
West Liberty University	0	$0	$0	$0
West Virginia Parkways Authority	2	$6,425,500	$2,870,000	$9,295,500
West Virginia State University - Institute	0	$0	$0	$0
West Virginia State University - Malden	0	$0	$0	$0
West Virginia University	1	$1,364,812,628	$170,618,604	$1,535,431,232
West Virginia University Arthurdale	0	$0	$0	$0
West Virginia University At Parkersburg	0	$0	$0	$0
West Virginia University Beckley	0	$0	$0	$0
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	1	$14,207	$777,591	$791,798
West Virginia University Fort Ashby	0	$0	$0	$0
West Virginia University Granville	1	$18,789,502	$986,000	$19,775,502
West Virginia University Jacksons Mill	0	$0	$0	$0
West Virginia University Kearneysville	0	$0	$0	$0

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
West Virginia University Keyser	0	$0	$0	$0
West Virginia University Montgomery	0	$0	$0	$0
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	0	$0	$0	$0
West Virginia University Wardensville	0	$0	$0	$0
West Virginia University Weston	0	$0	$0	$0
Workforce West Virginia	0	$0	$0	$0
WV Public Employees Grievance Board	0	$0	$0	$0
WVsom Clinic Inc Dba Robert C Byrd Clinic	0	$0	$0	$0
Total (WV State)	**214**	**$2,234,319,813**	**$357,793,728**	**$2,592,113,541**

Source: WVBRIM 2022

Table 5.6-8 and Table 5.6-9 show the number of State facilities that are located within ½ mile of a rail line by county as well as agency. The State has 500 facilities located in this hazard area with a replacement cost value of $3.8 billion. Kanawha County has the most State facilities (163) impacted by this hazard, but Monongalia County has the highest replacement cost ($1.6 billion). The Department of Health and Human Resources has the most facilities (57) impacted by this hazard, while West Virginia University has the highest replacement cost value ($1.5 billion).

Table 5.6-8: State Facilities Located in the Rail Line Hazard Area by County

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Barbour	7	$0	$1,168,389	$1,168,389
Berkeley	34	$27,519,308	$12,905,120	$40,424,428
Boone	10	$16,905,900	$2,952,700	$19,858,600
Braxton	3	$755,000	$220,000	$975,000
Brooke	1	$0	$0	$0
Cabell	28	$158,070,028	$10,121,683	$168,191,711
Calhoun	0	$0	$0	$0
Clay	0	$0	$0	$0
Doddridge	0	$0	$0	$0
Fayette	6	$44,454,142	$5,790,000	$50,244,142
Gilmer	0	$0	$0	$0
Grant	3	$423,675	$846,800	$1,270,475
Greenbrier	4	$60,000	$125,000	$185,000
Hampshire	3	$6,175,924	$160,000	$6,335,924
Hancock	6	$650,000	$1,640,000	$2,290,000
Hardy	9	$3,408,434	$4,342,000	$7,750,434
Harrison	18	$13,096,296	$6,549,682	$19,645,978
Jackson	3	$25,773,856	$2,065,000	$27,838,856
Jefferson	8	$246,743,250	$27,814,895	$274,558,145

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Kanawha	163	$709,998,329	$211,934,296	$921,932,625
Lewis	0	$0	$0	$0
Lincoln	0	$0	$0	$0
Logan	16	$27,166,000	$6,798,100	$33,964,100
Marion	13	$11,729,271	$1,321,300	$13,050,571
Marshall	9	$47,197,174	$2,068,804	$49,265,978
Mason	17	$63,877,708	$8,503,850	$72,381,558
McDowell	11	$1,125,000	$995,000	$2,120,000
Mercer	4	$122,335,739	$20,665,400	$143,001,139
Mineral	4	$119,654,403	$7,000,839	$126,655,242
Mingo	11	$15,995,822	$4,415,300	$20,411,122
Monongalia	13	$1,385,694,322	$173,247,604	$1,558,941,926
Monroe	0	$0	$0	$0
Morgan	1	$0	$125,000	$125,000
Nicholas	0	$0	$0	$0
Ohio	0	$0	$0	$0
Pendleton	0	$0	$0	$0
Pleasants	6	$28,974,523	$2,157,372	$31,131,895
Pocahontas	1	$6,333,200	$1,181,000	$7,514,200
Preston	2	$25,548,000	$360,000	$25,908,000
Putnam	18	$48,723,773	$25,829,725	$74,553,498
Raleigh	5	$10,600,500	$3,420,000	$14,020,500
Randolph	8	$42,901,784	$4,460,000	$47,361,784
Ritchie	0	$0	$0	$0
Roane	0	$0	$0	$0
Summers	4	$151,200	$251,300	$402,500
Taylor	3	$0	$554,000	$554,000
Tucker	0	$0	$0	$0
Tyler	1	$0	$10,000	$10,000
Upshur	8	$19,372,708	$4,061,000	$23,433,708
Wayne	7	$727,769	$871,000	$1,598,769
Webster	0	$0	$0	$0
Wetzel	6	$760,000	$500,900	$1,260,900
Wirt	0	$0	$0	$0
Wood	23	$27,439,387	$6,440,282	$33,879,669
Wyoming	3	$11,500	$190,400	$201,900
Total	**500**	**$3,260,353,925**	**$564,063,741**	**$3,824,417,666**

Source: WVBRIM 2022

Table 5.6-9: State Facilities Located in the Rail Line Hazard Area by Agency

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Adjutant General's Office State of West Virginia	0	$0	$0	$0
Administration, Secretary of Department of Administration	1	$0	$112,000	$112,000
Agriculture, Department of State of West Virginia	4	$1,384,053	$1,020,000	$2,404,053
Air and Environmental Quality Boards State of West Virginia	1	$0	$60,000	$60,000
Alcohol Beverage Control Administration State of West Virginia	1	$8,398,535	$5,375,000	$13,773,535
Architects, Board of State of West Virginia	1	$0	$17,000	$17,000
Armory Board State of West Virginia	21	$126,306,240	$30,097,000	$156,403,240
Arts, Culture & History, Department of State of West Virginia	2	$7,062,890	$212,200	$7,275,090
Attorney General, Office of The State of West Virginia	1	$0	$40,000	$40,000
Aviation, Division of	0	$0	$0	$0
Bar, State State of West Virginia	0	$0	$0	$0
Barbers & Cosmetologists, Board of State of West Virginia	1	$0	$100,000	$100,000
Blue Ridge Community & Technical College	2	$0	$6,872,720	$6,872,720
Bluefield State College	1	$121,244,089	$20,360,000	$141,604,089
Board of Treasury Investments	1	$0	$70,000	$70,000
Bridgevalley Community & Tech College	2	$44,146,767	$21,740,000	$65,886,767
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	1	$0	$100,000	$100,000
Commission For National and Community Service, WV	1	$0	$80,000	$80,000
Concord University	0	$0	$0	$0
Conservation Agency, West Virginia State of West Virginia	4	$0	$33,200	$33,200
Consolidated Public Retirement Board Department of Administration	1	$0	$1,500,000	$1,500,000
Consumer Advocate, Division of WV Public Service Commission	1	$0	$150,000	$150,000
Corrections, Division of State of West Virginia	10	$109,933,215	$11,577,776	$121,510,991
Courthouse Facilities Improvement Authority	1	$300,000	$200,000	$500,000
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	2	$0	$0	$0
Dietitians, Board of Licensed	1	$0	$20,000	$20,000
Eastern Panhandle Instructional Coop	8	$800,000	$1,690,000	$2,490,000
Eastern WV Community & Tech. College	2	$1,923,675	$766,000	$2,689,675
Economic Development Authority State of West Virginia	0	$0	$0	$0
Economic Development, WV Dept of	0	$0	$0	$0
Education, Department of State of West Virginia	17	$22,307,648	$5,274,200	$27,581,848
Educational Broadcasting Authority State of West Virginia	0	$0	$0	$0
Enterprise Resource Planning Board, WV	1	$0	$2,000,000	$2,000,000

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Environmental Protection, Division of State of West Virginia	8	$14,000	$1,390,812	$1,404,812
Ethics Commission, West Virginia Department of Administration	1	$65,000	$65,000	$130,000
Examiners In Counseling, Board of State of West Virginia	1	$0	$6,000	$6,000
Fairmont State University	0	$0	$0	$0
Fire Commission State of West Virginia	1	$0	$500,000	$500,000
Fleet Management Office, Dept of Admin State of West Virginia	1	$0	$50,000	$50,000
Forestry, Division of State of West Virginia	4	$307,488	$550,300	$857,788
General Services Division Department of Administration	14	$241,162,952	$21,828,174	$262,991,126
Geological and Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	0	$0	$0	$0
Governor, Office of The State of West Virginia	1	$0	$2,000,000	$2,000,000
Health & Human Resources, Department of State of West Virginia	57	$197,046,661	$55,987,500	$253,034,161
Higher Education Policy Commission, WV	9	$83,870,000	$21,767,246	$105,637,246
Highways, Division of State of West Virginia	50	$80,946,183	$15,871,036	$96,817,219
Homeland Security & Emergency Management Division	0	$0	$0	$0
Insurance Commissioner, Office of The State of West Virginia	2	$0	$1,270,000	$1,270,000
Investment Management Board, WV State of West Virginia	1	$0	$2,500,000	$2,500,000
Joint Committee on Government & Finance State of West Virginia	0	$0	$0	$0
Justice & Community Services, Div. of	1	$0	$750,000	$750,000
Juvenile Services, Division of	13	$7,504,700	$1,829,800	$9,334,500
Labor, Division of State of West Virginia	1	$0	$975,000	$975,000
Land Division/Dept of Agriculture State of West Virginia	0	$0	$0	$0
Landscape Architects, Board of State of West Virginia	1	$0	$2,500	$2,500
Library Commission State of West Virginia	1	$0	$166,959	$166,959
Lottery Commission State of West Virginia	2	$46,200,000	$10,000,000	$56,200,000
Marshall University	1	$78,454,356	$4,269,858	$82,724,214
Military Affairs, Secretary of and Public Safety	1	$0	$350,000	$350,000
Miner's Health Safety, Division of and Training, State of West Virginia	3	$0	$75,000	$75,000
Motor Vehicles, Division of State of West Virginia	12	$1,000,000	$6,069,000	$7,069,000
Mountain State Esc	1	$1,000,000	$250,000	$1,250,000
Mountwest Community & Technical College	0	$0	$0	$0
National Coal Heritage Area Authority	2	$2,000,000	$350,000	$2,350,000
Natural Resources, Division of State of West Virginia	10	$9,030,000	$3,005,000	$12,035,000
New River Community & Technical College	0	$0	$0	$0
Northern Community & Tech College, WV College Square	0	$0	$0	$0
Occupational Therapy Board State of West Virginia	0	$0	$0	$0

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Office of Technology/Is&C Department of Administration	5	$0	$22,382,000	$22,382,000
Osteopathic Medicine, WV Board of State of West Virginia	1	$0	$25,000	$25,000
Osteopathic Medicine, WV School of	6	$0	$64,225	$64,225
Parks, West Virginia State C\O Division of Natural Resources	11	$24,695,181	$4,985,682	$29,680,863
Pharmacy, Board of State of West Virginia	1	$850,000	$80,000	$930,000
Physical Therapy, Board of State of West Virginia	1	$0	$80,000	$80,000
Pierpont Community and Technical College	2	$9,616,296	$700,000	$10,316,296
Practical Nurses, Board of State of West Virginia	1	$0	$60,000	$60,000
Prosecuting Attorneys Institute, WV	1	$0	$121,000	$121,000
Psychologists Examiners, Board of State of West Virginia	1	$0	$45,000	$45,000
Public Service Commission State of West Virginia	2	$14,844,069	$3,365,000	$18,209,069
Purchasing, Division of Department of Administration	2	$155,000	$1,196,000	$1,351,000
Rail Authority State of West Virginia	1	$524,381	$2,827,000	$3,351,381
Real Estate Commission State of West Virginia	1	$0	$150,000	$150,000
Regional Jail & Corr. Fac. Authority State of West Virginia	2	$50,640,000	$2,056,000	$52,696,000
Registered Nurses, Board of State of West Virginia	1	$0	$250,000	$250,000
Rehabilitation Services Division of Commerce	13	$0	$7,546,924	$7,546,924
Respiratory Care, WV Board of	1	$0	$100,000	$100,000
School Building Authority, West Virginia	1	$500,000	$300,000	$800,000
Schools For The Deaf and The Blind State of West Virginia	0	$0	$0	$0
Senior Services, Bureau of State of West Virginia	1	$0	$150,000	$150,000
Shepherd University	1	$246,443,250	$27,131,195	$273,574,445
Southern Educational Services Coop	0	$0	$0	$0
Southern WV Community & Tech College	1	$15,882,800	$3,515,000	$19,397,800
Speech Pathology & Audiology Examiners West Virginia Board of	1	$0	$20,000	$20,000
State Police, West Virginia Dept of Military Affairs & Public Safety	37	$35,864,791	$13,930,600	$49,795,391
Supreme Court of Appeals State of West Virginia	44	$0	$4,785,300	$4,785,300
Tax Appeals, WV Office of	1	$0	$130,000	$130,000
Tax Department State of West Virginia	5	$0	$5,340,000	$5,340,000
Treasurer of State State of West Virginia	4	$0	$1,876,000	$1,876,000
University Physicians and Surgeons	8	$530,000	$1,015,000	$1,545,000
Unknown	29	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	7	$10,419,640	$1,429,300	$11,848,940
Veterinary Medicine, Board of State of West Virginia	0	$0	$0	$0
Water Development Authority State of West Virginia	1	$6,500,000	$1,000,000	$7,500,000
West Liberty University	0	$0	$0	$0
West Virginia Parkways Authority	5	$10,734,000	$6,470,000	$17,204,000
West Virginia State University - Institute	1	$130,503,950	$9,519,200	$140,023,150
West Virginia State University - Malden	1	$1,114,000	$115,000	$1,229,000

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
West Virginia University	1	$1,364,812,628	$170,618,604	$1,535,431,232
West Virginia University Arthurdale	0	$0	$0	$0
West Virginia University At Parkersburg	0	$0	$0	$0
West Virginia University Beckley	0	$0	$0	$0
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	1	$14,207	$777,591	$791,798
West Virginia University Fort Ashby	0	$0	$0	$0
West Virginia University Granville	1	$18,789,502	$986,000	$19,775,502
West Virginia University Jacksons Mill	0	$0	$0	$0
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	1	$119,654,403	$6,972,839	$126,627,242
West Virginia University Montgomery	1	$4,857,375	$0	$4,857,375
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	0	$0	$0	$0
West Virginia University Wardensville	0	$0	$0	$0
West Virginia University Weston	0	$0	$0	$0
Workforce West Virginia	5	$0	$317,000	$317,000
WV Public Employees Grievance Board	1	$0	$285,000	$285,000
WVsom Clinic Inc Dba Robert C Byrd Clinic	0	$0	$0	$0
Total (WV State)	**500**	**$3,260,353,925**	**$564,063,741**	**$3,824,417,666**

Source: WVBRIM 2022

Table 5.6-10 and Table 5.6-11 show the number of State facilities that are located within ½ mile of major roadways by county as well as agency. The State has 827 facilities located in this hazard area with a replacement cost value of $4.8 billion. Kanawha County has the most State facilities (183) impacted by this hazard, but Monongalia County has the highest replacement cost ($1.6 billion). The Division of Highways has the most facilities (105) impacted by this hazard, while West Virginia University has the highest replacement cost value ($1.5 billion).

Table 5.6-10: State Facilities Located in the Major Roadway Hazard Area by County

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Barbour	8	$40,000	$931,289	$971,289
Berkeley	27	$22,324,660	$11,697,392	$34,022,052
Boone	8	$19,955,900	$3,638,700	$23,594,600
Braxton	4	$750,000	$360,000	$1,110,000
Brooke	3	$2,900,000	$85,000	$2,985,000
Cabell	35	$157,346,692	$10,439,683	$167,786,375
Calhoun	0	$0	$0	$0
Clay	0	$0	$0	$0
Doddridge	9	$34,570,334	$1,659,000	$36,229,334
Fayette	17	$45,742,063	$8,149,200	$53,891,263
Gilmer	3	$88,806,230	$12,320,500	$101,126,730
Grant	2	$0	$110,800	$110,800

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Greenbrier	26	$91,878,077	$16,983,045	$108,861,122
Hampshire	13	$51,732,644	$6,344,846	$58,077,490
Hancock	7	$661,500	$1,665,100	$2,326,600
Hardy	14	$35,915,524	$4,951,035	$40,866,559
Harrison	32	$59,641,712	$28,244,182	$87,885,894
Jackson	8	$26,973,856	$3,734,500	$30,708,356
Jefferson	1	$0	$275,000	$275,000
Kanawha	183	$727,085,454	$222,177,658	$949,263,112
Lewis	15	$60,094,272	$5,063,110	$65,157,382
Lincoln	7	$825,000	$806,000	$1,631,000
Logan	20	$27,166,000	$7,794,417	$34,960,417
Marion	23	$225,207,022	$16,460,858	$241,667,880
Marshall	9	$47,197,174	$2,068,804	$49,265,978
Mason	19	$66,160,708	$9,258,850	$75,419,558
McDowell	11	$1,125,000	$995,000	$2,120,000
Mercer	24	$141,218,789	$26,864,535	$168,083,324
Mineral	11	$125,084,763	$8,915,339	$134,000,102
Mingo	11	$15,995,822	$4,415,300	$20,411,122
Monongalia	26	$1,403,786,789	$176,426,031	$1,580,212,820
Monroe	5	$652,903	$439,427	$1,092,330
Morgan	23	$79,299,467	$12,994,309	$92,293,776
Nicholas	10	$7,669,634	$1,320,500	$8,990,134
Ohio	23	$16,293,184	$7,504,209	$23,797,393
Pendleton	4	$900,000	$166,900	$1,066,900
Pleasants	6	$28,974,523	$2,157,372	$31,131,895
Pocahontas	3	$316,399	$116,500	$432,899
Preston	21	$67,502,734	$7,605,169	$75,107,903
Putnam	25	$62,473,873	$28,718,225	$91,192,098
Raleigh	37	$123,974,745	$23,973,688	$147,948,433
Randolph	26	$117,387,933	$15,978,196	$133,366,129
Ritchie	0	$0	$0	$0
Roane	9	$1,625,400	$965,840	$2,591,240
Summers	0	$0	$0	$0
Taylor	6	$24,092,343	$4,622,700	$28,715,043
Tucker	6	$17,575,145	$2,123,600	$19,698,745
Tyler	1	$0	$10,000	$10,000
Upshur	5	$2,000	$367,000	$369,000
Wayne	7	$727,769	$871,000	$1,598,769

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Webster	0	$0	$0	$0
Wetzel	7	$760,000	$500,900	$1,260,900
Wirt	0	$0	$0	$0
Wood	23	$56,764,157	$12,626,882	$69,391,039
Wyoming	4	$191,500	$97,000	$288,500
Total	**827**	**$4,087,369,694**	**$715,994,591**	**$4,803,364,285**

Source: WVBRIM 2022

Table 5.6-11: State Facilities Located in the Major Roadway Hazard Area by Agency

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Adjutant General's Office State of West Virginia	2	$100,000	$70,000	$170,000
Administration, Secretary of Department of Administration	1	$0	$112,000	$112,000
Agriculture, Department of State of West Virginia	5	$2,584,053	$2,225,000	$4,809,053
Air and Environmental Quality Boards State of West Virginia	1	$0	$60,000	$60,000
Alcohol Beverage Control Administration State of West Virginia	1	$8,398,535	$5,375,000	$13,773,535
Architects, Board of State of West Virginia	1	$0	$17,000	$17,000
Armory Board State of West Virginia	41	$189,611,055	$44,335,000	$233,946,055
Arts, Culture & History, Department of State of West Virginia	3	$7,067,274	$214,200	$7,281,474
Attorney General, Office of The State of West Virginia	1	$0	$40,000	$40,000
Aviation, Division of	1	$2,000,000	$250,000	$2,250,000
Bar, State State of West Virginia	1	$1,230,000	$250,000	$1,480,000
Barbers & Cosmetologists, Board of State of West Virginia	1	$0	$100,000	$100,000
Blue Ridge Community & Technical College	4	$17,395,660	$8,697,301	$26,092,961
Bluefield State College	1	$121,244,089	$20,360,000	$141,604,089
Board of Treasury Investments	1	$0	$70,000	$70,000
Bridgevalley Community & Tech College	2	$44,146,767	$21,740,000	$65,886,767
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	1	$0	$100,000	$100,000
Commission For National and Community Service, WV	1	$0	$80,000	$80,000
Concord University	0	$0	$0	$0
Conservation Agency, West Virginia State of West Virginia	13	$0	$385,545	$385,545
Consolidated Public Retirement Board Department of Administration	1	$0	$1,500,000	$1,500,000
Consumer Advocate, Division of WV Public Service Commission	1	$0	$150,000	$150,000
Corrections, Division of State of West Virginia	22	$211,598,722	$25,755,694	$237,354,416
Courthouse Facilities Improvement Authority	1	$300,000	$200,000	$500,000
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	1	$0	$0	$0

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Dietitians, Board of Licensed	1	$0	$20,000	$20,000
Eastern Panhandle Instructional Coop	7	$300,000	$1,205,000	$1,505,000
Eastern WV Community & Tech. College	4	$9,673,410	$810,000	$10,483,410
Economic Development Authority State of West Virginia	1	$750,000	$100,000	$850,000
Economic Development, WV Dept of	1	$0	$3,000,000	$3,000,000
Education, Department of State of West Virginia	24	$16,904,100	$6,077,780	$22,981,880
Educational Broadcasting Authority State of West Virginia	2	$3,142,000	$1,500,000	$4,642,000
Enterprise Resource Planning Board, WV	1	$0	$2,000,000	$2,000,000
Environmental Protection, Division of State of West Virginia	19	$39,500	$5,401,033	$5,440,533
Ethics Commission, West Virginia Department of Administration	1	$65,000	$65,000	$130,000
Examiners In Counseling, Board of State of West Virginia	1	$0	$6,000	$6,000
Fairmont State University	1	$211,509,751	$13,786,800	$225,296,551
Fire Commission State of West Virginia	1	$0	$500,000	$500,000
Fleet Management Office, Dept of Admin State of West Virginia	1	$0	$50,000	$50,000
Forestry, Division of State of West Virginia	12	$307,488	$1,260,300	$1,567,788
General Services Division Department of Administration	13	$233,626,223	$21,328,174	$254,954,397
Geological and Economic Survey State of West Virginia	1	$5,104,467	$1,439,002	$6,543,469
Glenville State College	1	$88,806,230	$12,031,000	$100,837,230
Governor, Office of The State of West Virginia	1	$0	$2,000,000	$2,000,000
Health & Human Resources, Department of State of West Virginia	91	$337,863,312	$71,785,052	$409,648,364
Higher Education Policy Commission, WV	9	$83,870,000	$21,767,246	$105,637,246
Highways, Division of State of West Virginia	105	$130,899,095	$26,175,626	$157,074,721
Homeland Security & Emergency Management Division	1	$0	$205,000	$205,000
Insurance Commissioner, Office of The State of West Virginia	4	$0	$1,395,000	$1,395,000
Investment Management Board, WV State of West Virginia	1	$0	$2,500,000	$2,500,000
Joint Committee on Government & Finance State of West Virginia	1	$0	$73,871	$73,871
Justice & Community Services, Div. of	1	$0	$750,000	$750,000
Juvenile Services, Division of	19	$35,624,045	$5,714,100	$41,338,145
Labor, Division of State of West Virginia	1	$0	$975,000	$975,000
Land Division/Dept of Agriculture State of West Virginia	2	$144,407	$5,000	$149,407
Landscape Architects, Board of State of West Virginia	1	$0	$2,500	$2,500
Library Commission State of West Virginia	2	$0	$333,918	$333,918
Lottery Commission State of West Virginia	3	$48,700,000	$13,000,000	$61,700,000
Marshall University	1	$78,454,356	$4,269,858	$82,724,214
Military Affairs, Secretary of and Public Safety	1	$0	$350,000	$350,000
Miner's Health Safety, Division of and Training, State of West Virginia	3	$1,950,000	$1,525,000	$3,475,000

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Motor Vehicles, Division of State of West Virginia	18	$1,000,000	$6,760,710	$7,760,710
Mountain State Esc	1	$1,000,000	$250,000	$1,250,000
Mountwest Community & Technical College	1	$2,813,114	$200,000	$3,013,114
National Coal Heritage Area Authority	1	$0	$100,000	$100,000
Natural Resources, Division of State of West Virginia	9	$6,550,000	$2,774,900	$9,324,900
New River Community & Technical College	4	$12,993,665	$4,230,000	$17,223,665
Northern Community & Tech College, WV College Square	1	$8,900,000	$2,000,000	$10,900,000
Occupational Therapy Board State of West Virginia	0	$0	$0	$0
Office of Technology/Is&C Department of Administration	5	$0	$22,382,000	$22,382,000
Osteopathic Medicine, WV Board of State of West Virginia	1	$0	$25,000	$25,000
Osteopathic Medicine, WV School of	10	$66,788,139	$8,271,623	$75,059,762
Parks, West Virginia State C\O Division of Natural Resources	29	$105,084,045	$17,174,682	$122,258,727
Pharmacy, Board of State of West Virginia	1	$850,000	$80,000	$930,000
Physical Therapy, Board of State of West Virginia	1	$0	$80,000	$80,000
Pierpont Community and Technical College	3	$9,616,296	$3,700,000	$13,316,296
Practical Nurses, Board of State of West Virginia	1	$0	$60,000	$60,000
Prosecuting Attorneys Institute, WV	1	$0	$121,000	$121,000
Psychologists Examiners, Board of State of West Virginia	1	$0	$45,000	$45,000
Public Service Commission State of West Virginia	2	$14,844,069	$3,365,000	$18,209,069
Purchasing, Division of Department of Administration	2	$155,000	$1,196,000	$1,351,000
Rail Authority State of West Virginia	0	$0	$0	$0
Real Estate Commission State of West Virginia	1	$0	$150,000	$150,000
Regional Jail & Corr. Fac. Authority State of West Virginia	3	$82,227,048	$3,438,000	$85,665,048
Registered Nurses, Board of State of West Virginia	1	$0	$250,000	$250,000
Rehabilitation Services Division of Commerce	22	$0	$10,409,024	$10,409,024
Respiratory Care, WV Board of	1	$0	$100,000	$100,000
School Building Authority, West Virginia	1	$500,000	$300,000	$800,000
Schools For The Deaf and The Blind State of West Virginia	1	$50,683,070	$5,064,200	$55,747,270
Senior Services, Bureau of State of West Virginia	2	$0	$155,000	$155,000
Shepherd University	0	$0	$0	$0
Southern Educational Services Coop	1	$500,000	$500,000	$1,000,000
Southern WV Community & Tech College	2	$18,882,800	$4,015,000	$22,897,800
Speech Pathology & Audiology Examiners West Virginia Board of	1	$0	$20,000	$20,000
State Police, West Virginia Dept of Military Affairs & Public Safety	70	$51,068,766	$15,890,600	$66,959,366
Supreme Court of Appeals State of West Virginia	61	$0	$6,027,400	$6,027,400
Tax Appeals, WV Office of	1	$0	$130,000	$130,000
Tax Department State of West Virginia	6	$0	$5,400,000	$5,400,000
Treasurer of State State of West Virginia	3	$0	$1,201,000	$1,201,000
University Physicians and Surgeons	12	$13,530,000	$3,690,000	$17,220,000
Unknown	44	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	14	$36,419,640	$16,490,300	$52,909,940

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Veterinary Medicine, Board of State of West Virginia	1	$0	$25,000	$25,000
Water Development Authority State of West Virginia	1	$6,500,000	$1,000,000	$7,500,000
West Liberty University	1	$2,782,000	$6,000	$2,788,000
West Virginia Parkways Authority	16	$52,904,000	$20,213,500	$73,117,500
West Virginia State University - Institute	1	$130,503,950	$9,519,200	$140,023,150
West Virginia State University - Malden	1	$1,114,000	$115,000	$1,229,000
West Virginia University	1	$1,364,812,628	$170,618,604	$1,535,431,232
West Virginia University Arthurdale	1	$31,259	$43,669	$74,928
West Virginia University At Parkersburg	0	$0	$0	$0
West Virginia University Beckley	1	$280,215	$240,287	$520,502
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	1	$14,207	$777,591	$791,798
West Virginia University Fort Ashby	0	$0	$0	$0
West Virginia University Granville	1	$18,789,502	$986,000	$19,775,502
West Virginia University Jacksons Mill	0	$0	$0	$0
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	1	$119,654,403	$6,972,839	$126,627,242
West Virginia University Montgomery	1	$4,857,375	$0	$4,857,375
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	1	$452,903	$53,427	$506,330
West Virginia University Wardensville	1	$6,858,061	$784,035	$7,642,096
West Virginia University Weston	0	$0	$0	$0
Workforce West Virginia	9	$0	$564,000	$564,000
WV Public Employees Grievance Board	1	$0	$285,000	$285,000
WVsom Clinic Inc Dba Robert C Byrd Clinic	1	$0	$2,250,000	$2,250,000
Total (WV State)	**827**	**$4,087,369,694**	**$715,994,591**	**$4,803,364,285**

Source: WVBRIM 2022

Table 5.6-12 and Table 5.6-13 show the number of State facilities that are located within 1 mile of a facility that stores EHS by county as well as agency. The State has 580 facilities located in this hazard area with a replacement cost value of $4.3 billion. Kanawha County has the most State facilities (137) impacted by this hazard, but Monongalia County has the highest replacement cost ($1.6 billion). The Supreme Court of Appeals has the most facilities (66) impacted by this hazard, while West Virginia University has the highest replacement cost value ($1.5 billion).

Table 5.6-12: State Facilities Located in the EHS Fixed Facility Hazard Area by County

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Barbour	7	$0	$1,168,389	$1,168,389
Berkeley	33	$23,948,308	$13,192,520	$37,140,828
Boone	3	$0	$164,000	$164,000
Braxton	4	$5,000	$232,000	$237,000
Brooke	3	$140,000	$115,000	$255,000
Cabell	29	$187,788,608	$10,743,758	$198,532,366
Calhoun	0	$0	$0	$0

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Clay	0	$0	$0	$0
Doddridge	3	$0	$312,000	$312,000
Fayette	11	$35,239,337	$3,746,700	$38,986,037
Gilmer	3	$88,806,230	$12,320,500	$101,126,730
Grant	3	$0	$380,800	$380,800
Greenbrier	14	$68,106,139	$11,396,798	$79,502,937
Hampshire	13	$56,902,644	$6,093,350	$62,995,994
Hancock	2	$11,500	$25,100	$36,600
Hardy	8	$2,024,381	$3,342,000	$5,366,381
Harrison	27	$56,251,142	$27,889,182	$84,140,324
Jackson	2	$0	$74,500	$74,500
Jefferson	6	$246,443,250	$27,359,895	$273,803,145
Kanawha	137	$705,852,403	$191,109,787	$896,962,190
Lewis	5	$403,000	$215,800	$618,800
Lincoln	0	$0	$0	$0
Logan	9	$18,000,000	$3,037,600	$21,037,600
Marion	21	$223,239,022	$16,362,858	$239,601,880
Marshall	12	$78,685,692	$4,537,974	$83,223,666
Mason	6	$387,595	$588,650	$976,245
McDowell	1	$925,000	$40,000	$965,000
Mercer	18	$165,657,424	$17,317,685	$182,975,109
Mineral	6	$122,401,425	$7,705,839	$130,107,264
Mingo	11	$15,995,822	$4,415,300	$20,411,122
Monongalia	20	$1,388,600,322	$173,635,604	$1,562,235,926
Monroe	5	$652,903	$439,427	$1,092,330
Morgan	9	$4,782,671	$1,440,309	$6,222,980
Nicholas	4	$510,000	$130,000	$640,000
Ohio	21	$15,763,272	$4,533,800	$20,297,072
Pendleton	4	$900,000	$166,900	$1,066,900
Pleasants	3	$130,000	$95,000	$225,000
Pocahontas	0	$0	$0	$0
Preston	6	$7,928,228	$1,613,800	$9,542,028
Putnam	13	$21,457,335	$10,644,225	$32,101,560
Raleigh	26	$90,380,245	$12,003,288	$102,383,533
Randolph	17	$11,878,784	$3,984,080	$15,862,864
Ritchie	0	$0	$0	$0
Roane	4	$0	$350,400	$350,400
Summers	4	$151,200	$251,300	$402,500

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Taylor	4	$102,240	$558,700	$660,940
Tucker	1	$2,151,700	$0	$2,151,700
Tyler	4	$0	$540,210	$540,210
Upshur	2	$0	$115,000	$115,000
Wayne	5	$300,000	$751,000	$1,051,000
Webster	4	$0	$330,000	$330,000
Wetzel	4	$760,000	$125,900	$885,900
Wirt	2	$0	$110,000	$110,000
Wood	19	$27,120,087	$5,909,782	$33,029,869
Wyoming	2	$0	$183,400	$183,400
Total	**580**	**$3,670,782,909**	**$581,800,110**	**$4,252,583,019**

Source: WVBRIM 2022

Table 5.6-13: State Facilities Located in the EHS Fixed Facility Hazard Area by Agency

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Adjutant General's Office State of West Virginia	5	$735,000	$293,000	$1,028,000
Administration, Secretary of Department of Administration	0	$0	$0	$0
Agriculture, Department of State of West Virginia	5	$75,000	$30,000	$105,000
Air and Environmental Quality Boards State of West Virginia	1	$0	$60,000	$60,000
Alcohol Beverage Control Administration State of West Virginia	1	$8,398,535	$5,375,000	$13,773,535
Architects, Board of State of West Virginia	1	$0	$17,000	$17,000
Armory Board State of West Virginia	14	$28,173,472	$4,378,000	$32,551,472
Arts, Culture & History, Department of State of West Virginia	3	$7,067,274	$214,200	$7,281,474
Attorney General, Office of The State of West Virginia	1	$0	$40,000	$40,000
Aviation, Division of	0	$0	$0	$0
Bar, State State of West Virginia	1	$1,230,000	$250,000	$1,480,000
Barbers & Cosmetologists, Board of State of West Virginia	1	$0	$100,000	$100,000
Blue Ridge Community & Technical College	2	$0	$7,360,729	$7,360,729
Bluefield State College	0	$0	$0	$0
Board of Treasury Investments	0	$0	$0	$0
Bridgevalley Community & Tech College	2	$44,146,767	$21,740,000	$65,886,767
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	1	$0	$100,000	$100,000
Commission For National and Community Service, WV	1	$0	$80,000	$80,000
Concord University	1	$158,888,424	$14,040,500	$172,928,924
Conservation Agency, West Virginia State of West Virginia	8	$0	$907,110	$907,110

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Consolidated Public Retirement Board Department of Administration	1	$0	$1,500,000	$1,500,000
Consumer Advocate, Division of WV Public Service Commission	1	$0	$150,000	$150,000
Corrections, Division of State of West Virginia	16	$77,252,240	$4,725,874	$81,978,114
Courthouse Facilities Improvement Authority	1	$300,000	$200,000	$500,000
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	1	$0	$0	$0
Dietitians, Board of Licensed	0	$0	$0	$0
Eastern Panhandle Instructional Coop	9	$1,100,000	$2,025,000	$3,125,000
Eastern WV Community & Tech. College	2	$1,500,000	$70,000	$1,570,000
Economic Development Authority State of West Virginia	1	$750,000	$100,000	$850,000
Economic Development, WV Dept of	1	$0	$3,000,000	$3,000,000
Education, Department of State of West Virginia	19	$5,403,548	$2,613,580	$8,017,128
Educational Broadcasting Authority State of West Virginia	1	$30,000	$0	$30,000
Enterprise Resource Planning Board, WV	1	$0	$2,000,000	$2,000,000
Environmental Protection, Division of State of West Virginia	16	$37,000	$3,027,761	$3,064,761
Ethics Commission, West Virginia Department of Administration	1	$65,000	$65,000	$130,000
Examiners In Counseling, Board of State of West Virginia	1	$0	$6,000	$6,000
Fairmont State University	1	$211,509,751	$13,786,800	$225,296,551
Fire Commission State of West Virginia	1	$0	$500,000	$500,000
Fleet Management Office, Dept of Admin State of West Virginia	0	$0	$0	$0
Forestry, Division of State of West Virginia	5	$15,000	$668,000	$683,000
General Services Division Department of Administration	11	$235,432,105	$21,703,174	$257,135,279
Geological and Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	1	$88,806,230	$12,031,000	$100,837,230
Governor, Office of The State of West Virginia	1	$0	$2,000,000	$2,000,000
Health & Human Resources, Department of State of West Virginia	65	$250,675,474	$57,749,317	$308,424,791
Higher Education Policy Commission, WV	7	$77,270,000	$20,167,246	$97,437,246
Highways, Division of State of West Virginia	47	$84,188,854	$15,336,936	$99,525,790
Homeland Security & Emergency Management Division	0	$0	$0	$0
Insurance Commissioner, Office of The State of West Virginia	3	$0	$145,000	$145,000
Investment Management Board, WV State of West Virginia	1	$0	$2,500,000	$2,500,000
Joint Committee on Government & Finance State of West Virginia	0	$0	$0	$0
Justice & Community Services, Div. of	1	$0	$750,000	$750,000
Juvenile Services, Division of	13	$7,518,350	$1,878,250	$9,396,600
Labor, Division of State of West Virginia	1	$0	$975,000	$975,000

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Land Division/Dept of Agriculture State of West Virginia	1	$129,407	$0	$129,407
Landscape Architects, Board of State of West Virginia	1	$0	$2,500	$2,500
Library Commission State of West Virginia	2	$0	$333,918	$333,918
Lottery Commission State of West Virginia	2	$48,700,000	$11,500,000	$60,200,000
Marshall University	1	$78,454,356	$4,269,858	$82,724,214
Military Affairs, Secretary of and Public Safety	1	$0	$350,000	$350,000
Miner's Health Safety, Division of and Training, State of West Virginia	1	$0	$25,000	$25,000
Motor Vehicles, Division of State of West Virginia	15	$1,000,000	$6,315,710	$7,315,710
Mountain State Esc	1	$1,000,000	$250,000	$1,250,000
Mountwest Community & Technical College	0	$0	$0	$0
National Coal Heritage Area Authority	2	$1,000,000	$200,000	$1,200,000
Natural Resources, Division of State of West Virginia	7	$50,000	$1,586,900	$1,636,900
New River Community & Technical College	2	$1,058,000	$1,030,000	$2,088,000
Northern Community & Tech College, WV College Square	1	$8,900,000	$2,000,000	$10,900,000
Occupational Therapy Board State of West Virginia	1	$0	$10,000	$10,000
Office of Technology/Is&C Department of Administration	4	$0	$21,732,000	$21,732,000
Osteopathic Medicine, WV Board of State of West Virginia	1	$0	$25,000	$25,000
Osteopathic Medicine, WV School of	9	$66,788,139	$8,258,723	$75,046,862
Parks, West Virginia State C\O Division of Natural Resources	11	$17,337,155	$1,845,382	$19,182,537
Pharmacy, Board of State of West Virginia	0	$0	$0	$0
Physical Therapy, Board of State of West Virginia	0	$0	$0	$0
Pierpont Community and Technical College	4	$10,016,296	$3,800,000	$13,816,296
Practical Nurses, Board of State of West Virginia	0	$0	$0	$0
Prosecuting Attorneys Institute, WV	1	$0	$121,000	$121,000
Psychologists Examiners, Board of State of West Virginia	1	$0	$45,000	$45,000
Public Service Commission State of West Virginia	2	$14,844,069	$3,365,000	$18,209,069
Purchasing, Division of Department of Administration	0	$0	$0	$0
Rail Authority State of West Virginia	1	$524,381	$2,827,000	$3,351,381
Real Estate Commission State of West Virginia	1	$0	$150,000	$150,000
Regional Jail & Corr. Fac. Authority State of West Virginia	2	$57,701,000	$2,406,000	$60,107,000
Registered Nurses, Board of State of West Virginia	1	$0	$250,000	$250,000
Rehabilitation Services Division of Commerce	16	$0	$9,438,599	$9,438,599
Respiratory Care, WV Board of	0	$0	$0	$0
School Building Authority, West Virginia	0	$0	$0	$0
Schools For The Deaf and The Blind State of West Virginia	1	$50,683,070	$5,064,200	$55,747,270
Senior Services, Bureau of State of West Virginia	2	$0	$155,000	$155,000
Shepherd University	1	$246,443,250	$27,131,195	$273,574,445
Southern Educational Services Coop	1	$500,000	$500,000	$1,000,000
Southern WV Community & Tech College	1	$15,882,800	$3,515,000	$19,397,800
Speech Pathology & Audiology Examiners West Virginia Board of	0	$0	$0	$0

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
State Police, West Virginia Dept of Military Affairs & Public Safety	42	$18,775,501	$3,067,000	$21,842,501
Supreme Court of Appeals State of West Virginia	66	$0	$5,052,100	$5,052,100
Tax Appeals, WV Office of	1	$0	$130,000	$130,000
Tax Department State of West Virginia	6	$0	$5,400,000	$5,400,000
Treasurer of State State of West Virginia	2	$0	$711,000	$711,000
University Physicians and Surgeons	10	$13,530,000	$3,590,000	$17,120,000
Unknown	38	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	12	$36,419,640	$16,470,300	$52,889,940
Veterinary Medicine, Board of State of West Virginia	0	$0	$0	$0
Water Development Authority State of West Virginia	1	$6,500,000	$1,000,000	$7,500,000
West Liberty University	3	$6,273,888	$531,000	$6,804,888
West Virginia Parkways Authority	7	$27,863,500	$9,145,000	$37,008,500
West Virginia State University - Institute	1	$130,503,950	$9,519,200	$140,023,150
West Virginia State University - Malden	0	$0	$0	$0
West Virginia University	1	$1,364,812,628	$170,618,604	$1,535,431,232
West Virginia University Arthurdale	0	$0	$0	$0
West Virginia University At Parkersburg	0	$0	$0	$0
West Virginia University Beckley	1	$280,215	$240,287	$520,502
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	1	$14,207	$777,591	$791,798
West Virginia University Fort Ashby	1	$2,747,022	$705,000	$3,452,022
West Virginia University Granville	1	$18,789,502	$986,000	$19,775,502
West Virginia University Jacksons Mill	0	$0	$0	$0
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	1	$119,654,403	$6,972,839	$126,627,242
West Virginia University Montgomery	1	$4,857,375	$0	$4,857,375
West Virginia University Reedsville	1	$7,728,228	$1,041,300	$8,769,528
West Virginia University Union	1	$452,903	$53,427	$506,330
West Virginia University Wardensville	0	$0	$0	$0
West Virginia University Weston	0	$0	$0	$0
Workforce West Virginia	5	$0	$377,000	$377,000
WV Public Employees Grievance Board	0	$0	$0	$0
WVsom Clinic Inc Dba Robert C Byrd Clinic	1	$0	$2,250,000	$2,250,000
Total (WV State)	**580**	**$3,670,782,909**	**$581,800,110**	**$4,252,583,019**

Source: WVBRIM 2022

Table 5.6-14 and Table 5.6-15 show the number of State facilities that are located within ½ mile of fixed facilities that do not store EHS by county as well as agency. The State has 682 facilities located in this hazard area with a replacement cost value of $4.3 billion. Kanawha County has the most State facilities (141) impacted by this hazard, but Monongalia County has the highest replacement cost ($1.6 billion). The Division of Highways has the most facilities (103) impacted by this hazard, while West Virginia University has the highest replacement cost value ($1.5 billion).

Table 5.6-14: State Facilities Located in the Non-EHS Fixed Facility Hazard Area by County

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Barbour	6	$40,000	$361,300	$401,300
Berkeley	35	$30,697,808	$16,188,020	$46,885,828
Boone	2	$1,800	$3,000	$4,800
Braxton	9	$2,414,153	$3,218,600	$5,632,753
Brooke	1	$140,000	$55,000	$195,000
Cabell	30	$157,346,692	$9,950,683	$167,297,375
Calhoun	4	$18,400	$360,000	$378,400
Clay	1	$0	$0	$0
Doddridge	10	$66,424,435	$8,477,500	$74,901,935
Fayette	13	$34,392,063	$3,649,200	$38,041,263
Gilmer	3	$88,806,230	$12,320,500	$101,126,730
Grant	5	$423,675	$1,119,800	$1,543,475
Greenbrier	16	$10,754,319	$6,811,345	$17,565,664
Hampshire	10	$56,888,994	$6,004,900	$62,893,894
Hancock	5	$71,500	$1,655,100	$1,726,600
Hardy	14	$36,439,905	$7,778,035	$44,217,940
Harrison	31	$61,757,944	$25,653,682	$87,411,626
Jackson	6	$26,973,856	$3,660,000	$30,633,856
Jefferson	8	$246,743,250	$27,981,195	$274,724,445
Kanawha	141	$556,236,680	$172,124,803	$728,361,483
Lewis	14	$65,761,624	$6,608,083	$72,369,707
Lincoln	5	$800,000	$806,000	$1,606,000
Logan	15	$27,166,000	$7,776,417	$34,942,417
Marion	21	$226,007,022	$16,200,858	$242,207,880
Marshall	6	$43,094,243	$1,441,804	$44,536,047
Mason	0	$0	$0	$0
McDowell	2	$200,000	$180,000	$380,000
Mercer	14	$14,795,400	$4,903,400	$19,698,800
Mineral	5	$125,084,763	$8,265,339	$133,350,102
Mingo	1	$150,000	$50,000	$200,000
Monongalia	28	$1,400,852,820	$176,793,029	$1,577,645,849
Monroe	0	$0	$0	$0
Morgan	9	$5,334,971	$1,233,800	$6,568,771
Nicholas	9	$5,469,634	$1,295,500	$6,765,134
Ohio	16	$12,563,184	$4,926,609	$17,489,793
Pendleton	3	$900,000	$96,900	$996,900
Pleasants	6	$28,974,523	$2,157,372	$31,131,895

County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Pocahontas	3	$0	$75,000	$75,000
Preston	15	$67,948,475	$7,629,500	$75,577,975
Putnam	19	$42,845,227	$18,223,225	$61,068,452
Raleigh	39	$79,252,829	$14,176,263	$93,429,092
Randolph	13	$27,318,784	$4,067,000	$31,385,784
Ritchie	8	$8,289,491	$1,246,400	$9,535,891
Roane	6	$1,505,400	$655,840	$2,161,240
Summers	4	$151,200	$251,300	$402,500
Taylor	1	$981,700	$224,000	$1,205,700
Tucker	2	$129,600	$56,600	$186,200
Tyler	2	$1,000,000	$110,000	$1,110,000
Upshur	8	$19,372,708	$4,061,000	$23,433,708
Wayne	9	$11,051,919	$2,693,564	$13,745,483
Webster	3	$2,093,012	$442,100	$2,535,112
Wetzel	6	$760,000	$125,900	$885,900
Wirt	3	$0	$138,500	$138,500
Wood	34	$101,423,969	$20,573,605	$121,997,574
Wyoming	3	$11,500	$477,000	$488,500
Total	**682**	**$3,697,861,702**	**$615,334,571**	**$4,313,196,273**

Source: WVBRIM 2022

Table 5.6-15: State Facilities Located in the Non-EHS Fixed Facility Hazard Area by Agency

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Adjutant General's Office State of West Virginia	4	$835,000	$308,000	$1,143,000
Administration, Secretary of Department of Administration	0	$0	$0	$0
Agriculture, Department of State of West Virginia	7	$2,584,053	$2,240,000	$4,824,053
Air and Environmental Quality Boards State of West Virginia	1	$0	$60,000	$60,000
Alcohol Beverage Control Administration State of West Virginia	1	$8,398,535	$5,375,000	$13,773,535
Architects, Board of State of West Virginia	1	$0	$17,000	$17,000
Armory Board State of West Virginia	45	$234,639,652	$45,306,064	$279,945,716
Arts, Culture & History, Department of State of West Virginia	2	$7,067,274	$214,200	$7,281,474
Attorney General, Office of The State of West Virginia	1	$0	$40,000	$40,000
Aviation, Division of	0	$0	$0	$0
Bar, State State of West Virginia	0	$0	$0	$0
Barbers & Cosmetologists, Board of State of West Virginia	0	$0	$0	$0
Blue Ridge Community & Technical College	2	$0	$6,872,720	$6,872,720

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Bluefield State College	0	$0	$0	$0
Board of Treasury Investments	0	$0	$0	$0
Bridgevalley Community & Tech College	2	$44,146,767	$21,740,000	$65,886,767
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	1	$0	$100,000	$100,000
Commission For National and Community Service, WV	1	$0	$80,000	$80,000
Concord University	0	$0	$0	$0
Conservation Agency, West Virginia State of West Virginia	11	$0	$855,545	$855,545
Consolidated Public Retirement Board Department of Administration	1	$0	$1,500,000	$1,500,000
Consumer Advocate, Division of WV Public Service Commission	1	$0	$150,000	$150,000
Corrections, Division of State of West Virginia	16	$109,821,437	$11,976,076	$121,797,513
Courthouse Facilities Improvement Authority	0	$0	$0	$0
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	1	$0	$0	$0
Dietitians, Board of Licensed	0	$0	$0	$0
Eastern Panhandle Instructional Coop	9	$1,100,000	$1,800,000	$2,900,000
Eastern WV Community & Tech. College	4	$10,097,085	$1,406,000	$11,503,085
Economic Development Authority State of West Virginia	0	$0	$0	$0
Economic Development, WV Dept of	0	$0	$0	$0
Education, Department of State of West Virginia	20	$5,403,548	$2,596,500	$8,000,048
Educational Broadcasting Authority State of West Virginia	3	$5,168,084	$2,000,000	$7,168,084
Enterprise Resource Planning Board, WV	1	$0	$2,000,000	$2,000,000
Environmental Protection, Division of State of West Virginia	16	$25,500	$3,678,667	$3,704,167
Ethics Commission, West Virginia Department of Administration	1	$65,000	$65,000	$130,000
Examiners In Counseling, Board of State of West Virginia	1	$0	$6,000	$6,000
Fairmont State University	1	$211,509,751	$13,786,800	$225,296,551
Fire Commission State of West Virginia	1	$0	$500,000	$500,000
Fleet Management Office, Dept of Admin State of West Virginia	0	$0	$0	$0
Forestry, Division of State of West Virginia	8	$165,000	$678,000	$843,000
General Services Division Department of Administration	7	$75,761,251	$2,600,000	$78,361,251
Geological and Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	1	$88,806,230	$12,031,000	$100,837,230
Governor, Office of The State of West Virginia	1	$0	$2,000,000	$2,000,000
Health & Human Resources, Department of State of West Virginia	78	$301,314,922	$67,627,552	$368,942,474
Higher Education Policy Commission, WV	8	$79,270,000	$21,267,246	$100,537,246
Highways, Division of State of West Virginia	103	$131,541,678	$25,773,626	$157,315,304
Homeland Security & Emergency Management Division	1	$0	$205,000	$205,000

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Insurance Commissioner, Office of The State of West Virginia	3	$0	$145,000	$145,000
Investment Management Board, WV State of West Virginia	1	$0	$2,500,000	$2,500,000
Joint Committee on Government & Finance State of West Virginia	1	$0	$73,871	$73,871
Justice & Community Services, Div. of	1	$0	$750,000	$750,000
Juvenile Services, Division of	14	$12,567,200	$2,738,300	$15,305,500
Labor, Division of State of West Virginia	0	$0	$0	$0
Land Division/Dept of Agriculture State of West Virginia	1	$129,407	$0	$129,407
Landscape Architects, Board of State of West Virginia	1	$0	$2,500	$2,500
Library Commission State of West Virginia	2	$0	$333,918	$333,918
Lottery Commission State of West Virginia	3	$48,700,000	$13,000,000	$61,700,000
Marshall University	1	$78,454,356	$4,269,858	$82,724,214
Military Affairs, Secretary of and Public Safety	1	$0	$350,000	$350,000
Miner's Health Safety, Division of and Training, State of West Virginia	1	$0	$25,000	$25,000
Motor Vehicles, Division of State of West Virginia	15	$1,000,000	$6,399,000	$7,399,000
Mountain State Esc	0	$0	$0	$0
Mountwest Community & Technical College	1	$2,813,114	$200,000	$3,013,114
National Coal Heritage Area Authority	1	$0	$100,000	$100,000
Natural Resources, Division of State of West Virginia	5	$130,000	$1,281,900	$1,411,900
New River Community & Technical College	2	$2,945,665	$1,200,000	$4,145,665
Northern Community & Tech College, WV College Square	1	$8,900,000	$2,000,000	$10,900,000
Occupational Therapy Board State of West Virginia	1	$0	$10,000	$10,000
Office of Technology/Is&C Department of Administration	2	$0	$2,850,000	$2,850,000
Osteopathic Medicine, WV Board of State of West Virginia	1	$0	$25,000	$25,000
Osteopathic Medicine, WV School of	9	$0	$90,325	$90,325
Parks, West Virginia State C\O Division of Natural Resources	15	$25,605,318	$3,139,982	$28,745,300
Pharmacy, Board of State of West Virginia	0	$0	$0	$0
Physical Therapy, Board of State of West Virginia	0	$0	$0	$0
Pierpont Community and Technical College	3	$10,016,296	$800,000	$10,816,296
Practical Nurses, Board of State of West Virginia	0	$0	$0	$0
Prosecuting Attorneys Institute, WV	1	$0	$121,000	$121,000
Psychologists Examiners, Board of State of West Virginia	1	$0	$45,000	$45,000
Public Service Commission State of West Virginia	2	$14,844,069	$3,365,000	$18,209,069
Purchasing, Division of Department of Administration	1	$155,000	$750,000	$905,000
Rail Authority State of West Virginia	1	$524,381	$2,827,000	$3,351,381
Real Estate Commission State of West Virginia	1	$0	$150,000	$150,000
Regional Jail & Corr. Fac. Authority State of West Virginia	2	$60,227,048	$2,614,000	$62,841,048
Registered Nurses, Board of State of West Virginia	1	$0	$250,000	$250,000
Rehabilitation Services Division of Commerce	18	$0	$10,292,374	$10,292,374
Respiratory Care, WV Board of	0	$0	$0	$0
School Building Authority, West Virginia	0	$0	$0	$0

Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Schools For The Deaf and The Blind State of West Virginia	1	$50,683,070	$5,064,200	$55,747,270
Senior Services, Bureau of State of West Virginia	2	$0	$155,000	$155,000
Shepherd University	1	$246,443,250	$27,131,195	$273,574,445
Southern Educational Services Coop	1	$500,000	$500,000	$1,000,000
Southern WV Community & Tech College	0	$0	$0	$0
Speech Pathology & Audiology Examiners West Virginia Board of	1	$0	$20,000	$20,000
State Police, West Virginia Dept of Military Affairs & Public Safety	53	$48,121,522	$15,628,600	$63,750,122
Supreme Court of Appeals State of West Virginia	55	$0	$5,286,400	$5,286,400
Tax Appeals, WV Office of	1	$0	$130,000	$130,000
Tax Department State of West Virginia	6	$0	$5,400,000	$5,400,000
Treasurer of State State of West Virginia	2	$0	$711,000	$711,000
University Physicians and Surgeons	10	$13,530,000	$3,440,000	$16,970,000
Unknown	28	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	14	$36,419,640	$16,490,300	$52,909,940
Veterinary Medicine, Board of State of West Virginia	0	$0	$0	$0
Water Development Authority State of West Virginia	1	$6,500,000	$1,000,000	$7,500,000
West Liberty University	1	$2,782,000	$6,000	$2,788,000
West Virginia Parkways Authority	11	$15,780,500	$9,780,000	$25,560,500
West Virginia State University - Institute	1	$130,503,950	$9,519,200	$140,023,150
West Virginia State University - Malden	0	$0	$0	$0
West Virginia University	1	$1,364,812,628	$170,618,604	$1,535,431,232
West Virginia University Arthurdale	0	$0	$0	$0
West Virginia University At Parkersburg	1	$51,935,381	$9,834,823	$61,770,204
West Virginia University Beckley	1	$280,215	$240,287	$520,502
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	1	$14,207	$777,591	$791,798
West Virginia University Fort Ashby	0	$0	$0	$0
West Virginia University Granville	0	$0	$0	$0
West Virginia University Jacksons Mill	1	$11,287,734	$3,312,473	$14,600,207
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	1	$119,654,403	$6,972,839	$126,627,242
West Virginia University Montgomery	1	$4,857,375	$0	$4,857,375
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	0	$0	$0	$0
West Virginia University Wardensville	1	$6,858,061	$784,035	$7,642,096
West Virginia University Weston	1	$2,165,145	$75,000	$2,240,145
Workforce West Virginia	6	$0	$367,000	$367,000
WV Public Employees Grievance Board	1	$0	$285,000	$285,000
WVsom Clinic Inc Dba Robert C Byrd Clinic	1	$0	$2,250,000	$2,250,000
Total (WV State)	**682**	**$3,697,861,702**	**$615,334,571**	**$4,313,196,273**

Source: WVBRIM 2022

Damages to transportation infrastructure and their closure is common following a hazardous materials release. Similar to the fixed-site hazardous materials release, the greatest risk to the population and the built environment would be from an explosion from hazardous materials in transport. Proximity, intensity, and the structural integrity of the building itself are all factors in the subsequent vulnerability and expected damage.

Table 5.6-16 shows the mileage of roads affected by each type of hazardous materials release. West Virginia has a total of 510.17 miles located within ½ mile of pipelines, 1,239.60 miles located within ½ mile of rail lines, 566.32 miles within 1 mile of fixed facilities storing EHS, and 800.73 miles located within ½ mile of fixed facilities that do not store EHS.

Table 5.6-16: State Roads Located in Hazmat Buffer Areas

County	State Roads Located Within The Hazmat Pipe 1/2 Mile Buffer Hazard Area	State Roads Located Within The Hazmat Rail 1/2 Mile Buffer Hazard Area	State Roads Located Within The Hazmat Tier II Facility EHM 1 Mile Buffer Hazard Area	State Roads Located Within The Hazmat Tier II Facility Non-EHM 1/2 Mile Buffer Hazard Area
	Mileage of Roadway	Mileage of Roadway	Mileage of Roadway	Mileage of Roadway
Barbour	3.41	2.65	0.64	13.13
Berkeley	0.00	16.08	25.12	20.21
Boone	10.45	70.40	6.65	5.32
Braxton	17.83	21.97	5.12	9.05
Brooke	23.73	14.67	36.17	9.10
Cabell	9.76	28.74	8.88	17.57
Calhoun	7.24	0.00	2.39	24.75
Clay	9.43	0.00	0.00	1.91
Doddridge	18.60	0.00	3.21	33.62
Fayette	0.00	54.33	17.28	8.61
Gilmer	5.83	2.41	1.15	25.37
Grant	1.23	7.25	1.09	5.62
Greenbrier	0.00	16.61	6.35	3.36
Hampshire	0.00	9.16	1.07	4.36
Hancock	7.59	19.64	11.88	8.24
Hardy	2.21	1.73	0.00	5.01
Harrison	12.58	21.49	31.93	39.53
Jackson	4.90	21.79	1.58	8.94
Jefferson	0.00	36.28	9.67	26.07
Kanawha	30.04	61.97	59.38	59.43
Lewis	0.00	0.00	0.00	0.00
Lincoln	19.09	25.36	5.67	14.21
Logan	6.57	78.46	13.30	16.64
Marion	18.41	4.75	6.53	3.33
Marshall	25.90	31.26	19.31	13.19
Mason	12.81	67.35	10.04	10.20
McDowell	12.59	75.20	9.49	15.83
Mercer	2.14	28.02	15.47	11.21
Mineral	10.35	12.45	9.21	8.19
Mingo	2.78	43.28	7.66	0.12
Monongalia	13.71	17.03	15.32	23.60

County	State Roads Located Within The Hazmat Pipe 1/2 Mile Buffer Hazard Area Mileage of Roadway	State Roads Located Within The Hazmat Rail 1/2 Mile Buffer Hazard Area Mileage of Roadway	State Roads Located Within The Hazmat Tier II Facility EHM 1 Mile Buffer Hazard Area Mileage of Roadway	State Roads Located Within The Hazmat Tier II Facility Non-EHM 1/2 Mile Buffer Hazard Area Mileage of Roadway
Monroe	0.38	2.05	5.84	3.80
Morgan	0.00	4.79	4.39	3.32
Nicholas	16.85	18.99	13.06	15.70
Ohio	8.98	0.00	12.14	4.51
Pendleton	1.92	0.00	0.00	1.32
Pleasants	0.00	20.59	6.68	17.55
Pocahontas	0.00	1.07	0.00	6.15
Preston	10.29	15.49	16.61	13.03
Putnam	7.39	48.97	30.92	33.41
Raleigh	13.52	50.28	29.26	22.53
Randolph	2.22	4.97	2.08	4.04
Ritchie	17.84	0.00	2.43	71.74
Roane	5.69	0.00	3.82	5.35
Summers	3.22	38.10	9.47	5.28
Taylor	1.17	8.79	0.00	2.88
Tucker	10.80	0.00	3.60	1.92
Tyler	16.39	14.73	8.57	17.38
Upshur	7.59	4.50	4.18	3.67
Wayne	20.22	29.51	8.24	14.81
Webster	0.00	3.61	5.17	7.02
Wetzel	28.14	48.66	4.94	34.71
Wirt	0.00	0.00	4.43	7.87
Wood	16.42	42.30	34.18	47.77
Wyoming	31.95	91.87	14.76	9.23
Total	**510.17**	**1,239.60**	**566.32**	**800.73**

Source: *WVBRIM 2022*

Critical Facilities and Community Lifelines

Similar to State assets, potential losses to critical facilities caused by a hazardous materials release are difficult to monetize. The degree of damages to the asset depends on the scale of the incident. Critical facilities need to remain in operation before, during, and after disaster events. Loss of use will impact the services they provide to the State which may have public safety and economic implications.

Table 5.6-17 shows critical facilities that are located within ½ mile of pipelines. There are 48 facilities located in this hazard area with Kanawha County having the greatest number (31) of facilities. The safety and security sector owns or leases 42 of the 48 critical facilities located within ½ mile of pipelines.

Table 5.6-17: Critical Facilities Located in the Pipeline Hazard Area by County

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Barbour	0	0	0	0	0	0	0	0
Berkeley	0	0	0	0	0	0	0	0
Boone	0	0	0	0	0	0	0	0
Braxton	0	0	0	0	0	1	0	1
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	3	0	3
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	1	0	1
Fayette	0	0	0	0	0	0	0	0
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	0	0	0	0	0	0
Hampshire	0	0	0	0	0	0	0	0
Hancock	0	0	0	0	0	1	0	1
Hardy	0	0	0	0	0	0	0	0
Harrison	0	0	0	0	0	0	0	0
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	0	0	0	0	0	0
Kanawha	3	0	1	0	0	26	1	31
Lewis	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	0	0	0
Marion	0	0	0	0	0	2	0	2
Marshall	0	0	0	0	0	2	0	2
Mason	0	0	0	0	0	0	0	0
McDowell	0	0	0	0	0	0	0	0
Mercer	0	0	0	0	0	0	0	0
Mineral	0	0	0	0	0	0	0	0
Mingo	0	0	0	0	0	2	0	2
Monongalia	1	0	0	0	0	0	0	1
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	0	0	0
Ohio	0	0	0	0	0	1	0	1
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	0	0	0

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0
Putnam	0	0	0	0	0	2	0	2
Raleigh	0	0	0	0	0	1	0	1
Randolph	0	0	0	0	0	0	0	0
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	0	0	0
Summers	0	0	0	0	0	0	0	0
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0
Tyler	0	0	0	0	0	0	0	0
Upshur	0	0	0	0	0	0	0	0
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0	0
Total	**4**	**0**	**1**	**0**	**0**	**42**	**1**	**48**

Source: WVBRIM 2022

Table 5.6-18 shows critical facilities that are located within ½ mile of rail lines. There are 105 facilities located in this hazard area with Kanawha County having the greatest number (55) of facilities. The safety and security sector owns or leases 79 of the 105 critical facilities located within ½ mile of rail lines.

Table 5.6-18: Critical Facilities Located in the Rail Line Hazard Area by County

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Barbour	0	0	0	0	0	1	0	1
Berkeley	0	0	0	0	0	5	0	5
Boone	0	0	0	0	0	1	0	1
Braxton	0	0	0	0	0	0	0	0
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	5	1	6
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	0	0	0
Fayette	0	0	0	0	0	0	0	0
Gilmer	0	0	0	0	0	0	0	0

County	Communi cations	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	1	0	0	0	0	1
Hampshire	0	0	0	0	0	0	0	0
Hancock	0	0	1	0	0	1	0	2
Hardy	0	0	1	0	0	2	1	4
Harrison	0	0	0	0	1	1	0	2
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	1	0	0	1	0	2
Kanawha	6	0	1	0	4	41	3	55
Lewis	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	2	0	2
Marion	0	0	0	0	1	0	0	1
Marshall	0	0	0	0	0	0	0	0
Mason	0	0	0	0	1	2	0	3
McDowell	0	0	0	0	0	5	0	5
Mercer	0	0	0	0	0	0	0	0
Mineral	0	0	0	0	0	0	0	0
Mingo	0	0	0	0	0	2	0	2
Monongalia	1	0	0	0	0	0	0	1
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	0	0	0
Ohio	0	0	0	0	0	0	0	0
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	1	0	1
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	1	0	0	1
Putnam	0	0	0	0	0	2	0	2
Raleigh	0	0	0	0	0	1	0	1
Randolph	0	0	0	0	0	2	0	2
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	0	0	0
Summers	0	0	0	0	0	1	0	1
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0
Tyler	0	0	0	0	0	0	0	0
Upshur	0	0	0	0	0	0	1	1

County	Communi cations	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	3	0	3
Wyoming	0	0	0	0	0	0	0	0
Total	**7**	**0**	**5**	**0**	**8**	**79**	**6**	**105**

Source: WVBRIM 2022

Table 5.6-19 shows critical facilities that are located within 1/2 mile of major roadways. There are 150 facilities located in this hazard area with Kanawha County having the greatest number (65) of facilities. The safety and security sector owns or leases 120 of the 150 critical facilities located within ½ of major roadways.

Table 5.6-19: Critical Facilities Located in the Major Roadway Hazard Area by County

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Barbour	0	0	0	0	0	1	0	1
Berkeley	0	0	0	0	0	0	0	0
Boone	0	0	0	0	0	1	0	1
Braxton	0	0	0	0	0	1	0	1
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	5	1	6
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	2	0	2
Fayette	0	0	0	0	0	1	0	1
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	1	0	0	3	0	4
Hampshire	0	0	0	0	0	4	0	4
Hancock	0	0	1	0	0	1	0	2
Hardy	0	0	1	0	0	3	0	4
Harrison	0	0	0	0	2	1	0	3
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	0	0	0	0	0	0
Kanawha	6	0	2	0	4	49	4	65
Lewis	0	0	0	0	1	0	0	1
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	4	0	4

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Marion	0	0	0	0	1	4	0	5
Marshall	0	0	0	0	0	0	0	0
Mason	0	0	0	0	1	2	0	3
McDowell	0	0	0	0	0	5	0	5
Mercer	0	0	0	0	0	3	0	3
Mineral	0	0	0	0	0	1	0	1
Mingo	0	0	0	0	0	2	0	2
Monongalia	0	0	0	0	0	3	0	3
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	1	1	2
Ohio	0	0	1	0	0	4	0	5
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	1	0	1
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	1	0	0	1
Putnam	0	0	0	0	0	3	0	3
Raleigh	0	0	0	0	1	5	0	6
Randolph	0	0	0	0	0	3	0	3
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	2	0	2
Summers	0	0	0	0	0	0	0	0
Taylor	0	0	0	0	0	1	0	1
Tucker	0	0	0	0	0	1	0	1
Tyler	0	0	0	0	0	0	0	0
Upshur	0	0	0	0	0	0	1	1
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	3	0	3
Wyoming	0	0	0	0	0	0	0	0
Total	**6**	**0**	**6**	**0**	**11**	**120**	**7**	**150**

Source: WVBRIM 2022

Table 5.6-20 shows critical facilities that are located within 1 mile of fixed facilities that store EHS. There are 108 facilities located in this hazard area with Kanawha County having the greatest number (49) of facilities. The safety and security sector owns or leases 88 of the 108 critical facilities located within 1 mile of fixed facilities with EHS.

Table 5.6-20: Critical Facilities Located in the EHS Hazard Area by County

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Barbour	0	0	0	0	0	1	0	1
Berkeley	0	0	0	0	0	4	0	4
Boone	0	0	0	0	0	0	0	0
Braxton	0	0	0	0	0	1	0	1
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	6	1	7
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	0	0	0
Fayette	0	0	0	0	0	0	0	0
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	1	0	0	0	0	1
Hampshire	0	0	0	0	0	3	0	3
Hancock	0	0	1	0	0	0	0	1
Hardy	0	0	0	0	0	2	1	3
Harrison	0	0	0	0	2	1	0	3
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	1	0	0	0	0	1
Kanawha	4	0	1	0	1	41	2	49
Lewis	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	2	0	2
Marion	0	0	0	0	1	3	0	4
Marshall	0	0	0	0	0	2	0	2
Mason	0	0	0	0	0	1	0	1
McDowell	0	0	0	0	0	0	0	0
Mercer	0	0	0	0	0	2	0	2
Mineral	0	0	0	0	0	0	0	0
Mingo	0	0	0	0	0	2	0	2
Monongalia	1	0	0	0	0	0	0	1
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	0	0	0
Ohio	0	0	1	0	0	3	0	4
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	0	0	0

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0
Putnam	0	0	0	0	0	2	0	2
Raleigh	0	0	0	0	1	5	0	6
Randolph	0	0	0	0	0	1	0	1
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	2	0	2
Summers	0	0	0	0	0	1	0	1
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0
Tyler	0	0	0	0	0	0	0	0
Upshur	0	0	0	0	0	0	0	0
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	1	0	0	1
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	3	0	3
Wyoming	0	0	0	0	0	0	0	0
Total	**5**	**0**	**5**	**0**	**6**	**88**	**4**	**108**

Source: WVBRIM 2022

Table 5.6-21 shows critical facilities that are located within ½ mile of fixed facilities that do not store EHS. There are 116 facilities located in this hazard area with Kanawha County having the greatest number (50) of facilities. The safety and security sector owns or leases 87 of the 116 critical facilities located within ½ mile of fixed facilities without EHS.

Table 5.6-21: Critical Facilities Located in the Non-EHS Fixed Facility Hazard Area by County

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Barbour	0	0	0	0	0	1	0	1
Berkeley	0	0	0	0	0	4	0	4
Boone	0	0	0	0	0	0	0	0
Braxton	0	0	0	0	0	2	0	2
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	4	1	5
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	2	0	2
Fayette	0	0	0	0	0	0	0	0

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	0	0	0	2	0	2
Hampshire	0	0	0	0	0	1	0	1
Hancock	0	0	0	0	0	1	0	1
Hardy	0	0	1	0	0	3	1	5
Harrison	0	0	0	0	2	1	0	3
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	1	0	0	1	0	2
Kanawha	4	0	3	0	3	37	3	50
Lewis	0	0	0	0	1	0	0	1
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	3	0	3
Marion	0	0	0	0	1	2	0	3
Marshall	0	0	0	0	0	0	0	0
Mason	0	0	0	0	0	0	0	0
McDowell	0	0	0	0	0	0	0	0
Mercer	0	0	0	0	0	1	0	1
Mineral	0	0	0	0	0	0	0	0
Mingo	0	0	0	0	0	0	0	0
Monongalia	1	0	0	0	0	1	0	2
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	1	1	2
Ohio	0	0	1	0	0	3	0	4
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	1	0	1
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	1	0	0	1
Putnam	0	0	0	0	0	3	0	3
Raleigh	0	0	0	0	1	6	0	7
Randolph	0	0	0	0	0	0	0	0
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	2	0	2
Summers	0	0	0	0	0	1	0	1
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0
Tyler	0	0	0	0	0	0	0	0

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Upshur	0	0	0	0	0	0	1	1
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	1	0	0	1
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	4	1	5
Wyoming	0	0	0	0	0	0	0	0
Total	**5**	**0**	**6**	**0**	**10**	**87**	**8**	**116**

Source: WVBRIM 2022

Population

Table 5.6-22 shows the total number of people exposed to hazardous materials releases from pipelines, the number of those people identified as “highly vulnerable” in the Centers for Disease Control and Prevention’s (CDC) SVI data, and the percentage of the exposed people who are considered highly vulnerable.

Table 5.6-22: Population Located in the Pipeline Hazard Area by County

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Barbour	4,116	1,174	28.51%
Berkeley	0	0	0.00%
Boone	3,414	286	8.37%
Braxton	1,970	506	25.71%
Brooke	7,450	2,077	27.88%
Cabell	20,289	0	0.00%
Calhoun	844	0	0.00%
Clay	1,108	254	22.93%
Doddridge	3,398	0	0.00%
Fayette	0	0	0.00%
Gilmer	1,465	419	28.62%
Grant	383	306	79.70%
Greenbrier	26	21	80.26%
Hampshire	167	0	0.00%
Hancock	5,562	2,889	51.94%
Hardy	842	0	0.00%
Harrison	13,766	0	0.00%
Jackson	7,110	0	0.00%
Jefferson	0	0	0.00%
Kanawha	56,606	14,010	24.75%
Lewis	3,026	423	13.97%

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Lincoln	5,097	1,462	28.68%
Logan	3,754	2,494	66.45%
Marion	28,187	4,314	15.30%
Marshall	19,074	2,311	12.12%
Mason	1,228	0	0.00%
McDowell	653	395	60.51%
Mercer	3,504	1,909	54.48%
Mineral	372	372	100.00%
Mingo	4,447	2,253	50.67%
Monongalia	35,422	7,899	22.30%
Monroe	938	0	0.00%
Morgan	0	0	0.00%
Nicholas	1,527	0	0.00%
Ohio	13,226	1,148	8.68%
Pendleton	287	0	0.00%
Pleasants	766	0	0.00%
Pocahontas	0	0	0.00%
Preston	2,812	0	0.00%
Putnam	17,429	0	0.00%
Raleigh	12,482	4,998	40.04%
Randolph	3,724	4	0.12%
Ritchie	1,958	0	0.00%
Roane	2,392	549	22.96%
Summers	642	297	46.23%
Taylor	1,499	371	24.72%
Tucker	1,365	0	0.00%
Tyler	3,652	0	0.00%
Upshur	7,038	0	0.00%
Wayne	14,357	0	0.00%
Webster	0	0	0.00%
Wetzel	4,616	0	0.00%
Wirt	295	0	0.00%
Wood	10,796	324	3.00%
Wyoming	3,049	883	28.97%
Total	**338,130**	**54,349**	**16.07%**

Source: CDC 2022

Table 5.6-23 shows the total number of people exposed to hazardous materials releases from rail lines, the number of those people identified as “highly vulnerable” in the CDC’s SVI data, and the percentage of the exposed people who are considered highly vulnerable.

Table 5.6-23: Population Located in the Rail Line Hazard Area by County

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Barbour	3,830	1,580	41.26%
Berkeley	34,676	12,780	36.86%
Boone	7,939	273	3.44%
Braxton	1,699	70	4.11%
Brooke	5,786	1,782	30.79%
Cabell	43,394	15,087	34.77%
Calhoun	0	0	0.00%
Clay	0	0	0.00%
Doddridge	0	0	0.00%
Fayette	8,597	2,610	30.36%
Gilmer	42	0	0.00%
Grant	285	139	48.71%
Greenbrier	4,303	1,744	40.52%
Hampshire	884	411	46.53%
Hancock	3,559	1,745	49.02%
Hardy	1,435	0	0.00%
Harrison	16,664	5,260	31.57%
Jackson	2,756	0	0.00%
Jefferson	17,678	1,278	7.23%
Kanawha	63,414	16,915	26.67%
Lewis	211	0	0.00%
Lincoln	1,705	0	0.00%
Logan	8,515	5,335	62.66%
Marion	13,233	3,330	25.16%
Marshall	5,926	1,420	23.96%
Mason	6,895	0	0.00%
McDowell	3,217	2,057	63.96%
Mercer	10,797	5,964	55.24%
Mineral	1,715	102	5.93%
Mingo	7,179	4,270	59.48%
Monongalia	26,617	7,467	28.05%
Monroe	80	0	0.00%
Morgan	1,589	0	0.00%
Nicholas	814	0	0.00%
Ohio	351	0	0.00%
Pendleton	0	0	0.00%
Pleasants	900	0	0.00%
Pocahontas	279	0	0.00%

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Preston	2,184	661	30.27%
Putnam	15,691	0	0.00%
Raleigh	14,341	8,629	60.17%
Randolph	5,193	2,017	38.83%
Ritchie	0	0	0.00%
Roane	0	0	0.00%
Summers	2,357	628	26.65%
Taylor	4,682	2,881	61.53%
Tucker	1	0	0.00%
Tyler	1,332	0	0.00%
Upshur	5,972	0	0.00%
Wayne	14,081	0	0.00%
Webster	842	0	0.00%
Wetzel	5,817	0	0.00%
Wirt	0	0	0.00%
Wood	15,384	3,950	25.67%
Wyoming	3,554	302	8.49%
Total	**398,396**	**110,687**	**27.78%**

Source: CDC 2022

Table 5.6-24 shows the total number of people exposed to hazardous materials releases from major roadways, the number of those people identified as "highly vulnerable" in the CDC's SVI data, and the percentage of the exposed people who are considered highly vulnerable.

Table 5.6-24: Population Located in the Major Roadway Hazard Area by County

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Barbour	5,748	1,649	28.68%
Berkeley	35,448	13,754	38.80%
Boone	6,490	782	12.05%
Braxton	1,604	529	32.96%
Brooke	9,763	996	10.20%
Cabell	60,639	16,462	27.15%
Calhoun	629	0	0.00%
Clay	139	0	0.00%
Doddridge	1,356	0	0.00%
Fayette	10,749	3,932	36.58%
Gilmer	1,755	851	48.48%
Grant	1,246	569	45.71%
Greenbrier	11,366	7,533	66.28%

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Hampshire	2,418	991	40.97%
Hancock	6,453	2,109	32.68%
Hardy	2,287	0	0.00%
Harrison	26,079	4,350	16.68%
Jackson	7,710	0	0.00%
Jefferson	5,603	331	5.90%
Kanawha	86,520	21,236	24.54%
Lewis	6,146	2,122	34.53%
Lincoln	4,473	953	21.31%
Logan	9,085	5,578	61.40%
Marion	26,768	5,054	18.88%
Marshall	12,983	2,116	16.30%
Mason	10,233	0	0.00%
McDowell	1,443	1,304	90.36%
Mercer	23,710	13,859	58.45%
Mineral	3,951	165	4.18%
Mingo	7,858	4,946	62.95%
Monongalia	51,871	8,535	16.45%
Monroe	1,922	0	0.00%
Morgan	3,069	0	0.00%
Nicholas	3,451	0	0.00%
Ohio	24,736	3,621	14.64%
Pendleton	1,236	0	0.00%
Pleasants	1,023	0	0.00%
Pocahontas	1,488	0	0.00%
Preston	8,540	838	9.81%
Putnam	28,345	0	0.00%
Raleigh	37,856	18,691	49.37%
Randolph	10,279	5,012	48.76%
Ritchie	524	0	0.00%
Roane	4,125	2,428	58.85%
Summers	2,533	740	29.22%
Taylor	7,045	2,400	34.06%
Tucker	3,072	0	0.00%
Tyler	1,398	0	0.00%
Upshur	2,649	0	0.00%
Wayne	16,114	0	0.00%
Webster	0	0	0.00%
Wetzel	6,358	0	0.00%

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Wirt	0	0	0.00%
Wood	15,939	627	3.94%
Wyoming	3,639	554	15.23%
Total	**627,862**	**155,616**	**24.79%**

Source: CDC 2022

Table 5.6-25 shows the total number of people exposed to hazardous materials releases from fixed facilities that do not store EHS, the number of those people identified as "highly vulnerable" in the CDC's SVI data, and the percentage of the exposed people who are considered highly vulnerable.

Table 5.6-25: Population Located in the EHS Fixed Facility Hazard Area by County

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Barbour	1,815	604	33.27%
Berkeley	34,598	13,045	37.71%
Boone	721	0	0.00%
Braxton	239	70	29.28%
Brooke	15,503	850	5.48%
Cabell	40,405	16,115	39.88%
Calhoun	403	0	0.00%
Clay	0	0	0.00%
Doddridge	296	0	0.00%
Fayette	6,727	2,643	39.29%
Gilmer	642	642	100.00%
Grant	194	190	98.26%
Greenbrier	3,775	3,336	88.37%
Hampshire	543	226	41.66%
Hancock	4,464	1,229	27.53%
Hardy	1,060	0	0.00%
Harrison	24,882	5,275	21.20%
Jackson	2,731	0	0.00%
Jefferson	8,044	2,234	27.77%
Kanawha	53,429	10,429	19.52%
Lewis	1,804	699	38.77%
Lincoln	750	0	0.00%
Logan	2,077	1,704	82.08%
Marion	16,320	4,331	26.53%
Marshall	9,697	2,337	24.10%
Mason	2,328	0	0.00%
McDowell	170	88	51.64%
Mercer	14,953	10,025	67.04%
Mineral	1,457	36	2.46%
Mingo	1,911	1,736	90.81%
Monongalia	54,318	9,205	16.95%
Monroe	490	0	0.00%
Morgan	1,494	0	0.00%
Nicholas	2,130	0	0.00%
Ohio	16,601	3,142	18.93%
Pendleton	161	0	0.00%
Pleasants	734	0	0.00%

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Pocahontas	0	0	0.00%
Preston	2,396	464	19.38%
Putnam	10,631	0	0.00%
Raleigh	16,628	6,306	37.92%
Randolph	4,576	3,760	82.16%
Ritchie	212	0	0.00%
Roane	1,915	1,182	61.71%
Summers	1,099	73	6.61%
Taylor	1,153	571	49.48%
Tucker	55	0	0.00%
Tyler	1,152	0	0.00%
Upshur	5,080	0	0.00%
Wayne	6,179	0	0.00%
Webster	243	0	0.00%
Wetzel	2,321	0	0.00%
Wirt	195	0	0.00%
Wood	21,884	8,881	40.58%
Wyoming	451	56	12.47%
Total	**404,036**	**111,484**	**27.59%**

Source: CDC 2022

Table 5.6-26 shows the total number of people exposed to hazardous materials releases from fixed facilities that do not store EHS, the number of those people identified as "highly vulnerable" in the CDC's SVI data, and the percentage of the exposed people who are considered highly vulnerable.

Table 5.6-26: Population Located in the Non-EHS Fixed Facility Hazard Area by County

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Barbour	2,955	810	27.40%
Berkeley	24,284	13,789	56.78%
Boone	614	158	25.76%
Braxton	1,215	38	3.13%
Brooke	4,034	1,817	45.04%
Cabell	35,908	16,416	45.72%
Calhoun	3,610	0	0.00%
Clay	652	146	22.35%
Doddridge	6,386	0	0.00%
Fayette	4,118	2,281	55.39%
Gilmer	3,135	1,151	36.72%
Grant	336	257	76.30%
Greenbrier	2,675	1,746	65.28%
Hampshire	406	118	28.99%
Hancock	3,692	886	24.00%
Hardy	1,781	0	0.00%
Harrison	34,249	5,272	15.39%
Jackson	4,440	0	0.00%
Jefferson	13,123	916	6.98%
Kanawha	49,382	13,325	26.98%
Lewis	6,749	1,399	20.72%
Lincoln	2,123	211	9.94%
Logan	2,425	1,714	70.68%

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Population Highly Vulnerable
Marion	12,254	2,333	19.04%
Marshall	7,116	1,447	20.33%
Mason	1,286	0	0.00%
McDowell	328	236	71.83%
Mercer	8,266	6,631	80.22%
Mineral	2,259	26	1.14%
Mingo	939	746	79.42%
Monongalia	43,020	8,642	20.09%
Monroe	162	0	0.00%
Morgan	979	0	0.00%
Nicholas	1,231	0	0.00%
Ohio	11,108	3,533	31.81%
Pendleton	90	0	0.00%
Pleasants	3,471	0	0.00%
Pocahontas	187	0	0.00%
Preston	1,633	92	5.62%
Putnam	17,224	0	0.00%
Raleigh	15,584	6,597	42.33%
Randolph	5,238	3,459	66.03%
Ritchie	6,183	0	0.00%
Roane	2,399	1,220	50.85%
Summers	691	21	3.02%
Taylor	1,904	576	30.24%
Tucker	267	0	0.00%
Tyler	1,804	0	0.00%
Upshur	5,654	0	0.00%
Wayne	5,977	0	0.00%
Webster	451	0	0.00%
Wetzel	5,046	0	0.00%
Wirt	784	0	0.00%
Wood	28,194	12,019	42.63%
Wyoming	424	147	34.62%
Total	**400,445**	**110,175**	**27.51%**

Source: CDC 2022

Impacts on Socially Vulnerable Populations

Many communities and populations are especially vulnerable to hazmat, including low-income communities, migrant populations, populations whose primary language is not English, indigenous populations, communities of older adults, and those with respiratory and other health concerns. The elderly, persons over the age of 65 (19.9 percent of the population), the young, persons under the age of 5 (5.2 percent of the population), and individuals living below the U.S. Census poverty threshold (16.9 percent of the population) are considered highly vulnerable based on a variety of factors including their physical and financial ability to react or respond during a hazard, as well as the location and construction quality of their housing (U.S. Census Bureau 2023). Children are more susceptible to chemical exposure because they eat, breathe, and drink more relative to their body mass than adults do. Adults with compromised immune systems and pre-existing health conditions may also be more vulnerable to chemical exposures (U.S. EPA n.d.) In addition, members of immigrant communities may not speak English and may also be concerned about impacts to their immigration status and do not seek help. It can take days to translate information into languages other than English, hindering communication about evacuations and health and safety alerts.

Certain populations are more vulnerable than others in the event of a hazardous materials release. In a recent study done by Virginia Tech, researchers used geospatial analysis to identify the year 2021 and year 2051 threats of flood-induced natech disaster and assess its exposure to different coastal populations and ecosystems. Findings reveal that block groups with higher proportions of minorities, people in poverty, and people without a vehicle experience significant exposure to a natech disaster compared to those who are living further away from the TRI and Superfund facilities (Crawford 2022).

Future Changes That May Impact State Vulnerability

Understanding future changes that impact vulnerability in the State can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of future conditions

Potential or Projected Development

Throughout the State, little new development is being conducted in areas that were not already developed. That is, development is occurring to fill in or redevelop areas that are already developed rather than clearing natural land for new structures and infrastructure. As such, projected development is not expected to significantly impact vulnerability to hazardous materials releases.

Projected Changed in Population

As shown in Section 2, the State is experiencing a net loss of population. This could lead to fewer people in areas vulnerable to hazardous materials releases, reducing overall vulnerability of the population to a release. On the other hand, as economic conditions decline in the State, more people may move into areas vulnerable to hazardous materials releases (such as areas immediately surrounding a major chemical facility) to take advantage of lower property values and rent levels. As the population in the State ages, more residents may face challenges quickly evacuating an area in the event of a hazardous materials incident.

Other Factors of Change

The number, types, and quantities of hazardous materials used in, stored in, and/or transported throughout the State may change over time.

5.6.3 Consequence Analysis

Impacts to the Public

Impacts to the public include potential for injury or loss of life and destruction or loss of land and property due to hazardous materials exposure (FEMA 2019). When hazardous substances are released in the air, water, or on land, they may contaminate the environment and pose greater danger to human health. The general population may be exposed to a hazardous materials release through inhalation, ingestion, or dermal exposure. Exposure may be either acute or chronic, depending upon the nature of the substance and extent of release and concentration (FEMA 2019).

Population living and/or working near facilities that produce, store, or transport hazardous substances are at higher risk to exposure. Populations downstream, downwind, and downhill of a released substance are particularly vulnerable. Depending on the type of release and environmental conditions, people may be evacuated as a precaution or instructed to shelter in place. Similarly, populations living and/or working near major transportation routes are more vulnerable to a hazardous materials release because of the potential for chemicals to be transported on these major thoroughfares. Hazardous substances can also be transported via pipeline.

Impacts to Responders

Hazardous materials release leaks are often fast-moving, causing impacts in a short time frame (FEMA 2019). Emergency response to hazardous materials releases will involve several first response organizations, ranging from local police to specific federal agencies. Emergency responders can be exposed to the chemicals themselves, heat, and/or cold during a hazardous materials incident.

Impacts to Continuity of Operations

Releases of hazardous materials can impact the health of individuals who are required to ensure government operations continue and can damage the facilities, equipment, and supplies necessary to continue operations (FEMA 2019). Releases may also disrupt the distribution of gasoline, kerosene, diesel fuel, fuel oils, propane, and other petroleum products. This disruption could cause major problems for organizations and businesses that rely on such supplies as well as impact the average citizen relying on gas to attend work.

Many larger governments and large-scale organizations keep updated continuity of operations plans to guide them in maintaining critical functions in the event of a hazardous materials release. However, smaller governments and businesses may not have such plans. A hazardous materials release would likely halt critical and secondary functioning in these smaller organizations for significant period of time.

Impacts to Property, Facilities, and Infrastructure

Depending on the substance, buildings may be vulnerable to damage in the event of a hazardous materials release. Hazardous material releases can damage and destroy public, commercial, and private property. Losses include both direct and indirect costs. Direct costs can be defined as the cost of materials, property damage, response cost, and remediation/clean-up cost for a specific release. All other costs and losses from hazardous material releases are indirect. These include (1) loss of productivity as a result of damage to land, facilities, or interruption of services, (2) loss of access to recreation lands and facilities, (3) cost of lost human productivity due to injury and death, (4) damages to ecosystems, and (5) the cost of litigation as a consequence of the release.

Additional impacts to property, facilities, and infrastructure are described in the Vulnerability Assessment section above.

Impacts to the Environment

A hazardous substance release, whether fixed-site or in-transit can negatively impact the natural environment (FEMA 2019). Depending on the nature and amount of the substance, the release may contaminate the air, water, or soil, potentially causing concern for direct human and animal exposure, recreational usage, crop irrigation, and fish and wildlife consumption.

Oil spills and other hazardous releases of that caliber can significantly harm wildlife in the area. In addition to the harms posed to these creatures, this contamination can make its way up the food chain, affecting the seafood supply and, in turn, affecting humans. Additionally, open water and wetland environments will also experience significant exposure to hazmat events, which may indicate a loss of ecosystem services. Hazardous material releases could also significantly impact soils, including agricultural lands. Depending on the characteristic of the hazardous material and/or the volume of product involved, the affected area can be as small as several square feet or as large as many square miles that require soil remediation. Such environmental damage can linger for decades and result in extensive remediation costs.

Impacts to the Economic Condition of the State

If a significant hazardous materials release were to occur, not only would life, safety, and building stock be at risk, but the economy of West Virginia would also be affected (FEMA 2019). A significant incident within an urban area may force businesses to close for an extended period of time because of contamination or because of direct damage caused by an explosion. The economic impacts of hazardous materials release include any physical damages caused by the toxic release, as well as the cost of cleaning up releases or resources contaminated by toxic releases. If the incident is large enough in scale, evacuations may be required, disrupting the commerce of the area involved. Exact impacts on the economy are difficult to predict, given the uncertainty of the size and scope of potential incidents.

Hazardous materials incidents can also lead to closures of major transportation routes in the State. Closures of railroads, airports, and highways as a result of these incidents can hinder delivery of goods and services. Potential impacts may be local, regional, or statewide, depending on the magnitude of the event and the extent of disruptions to services.

Impacts to Public Confidence in State Governance

The public confidence in the State's governance would mainly depend on how effective the State has been in the past at preparing and responding to hazardous materials incidents. Public confidence also depends on the size of the hazmat event and the preparation that the State and local governments and response agencies have in place for these events. In general, if the State is transparent in sharing relevant information with the public and proves that they have the capability to protect and assist the residents of West Virginia from hazardous materials and is also able to demonstrate its reliability to the public through availability of programs and services relevant to hazardous materials, then the public will remain confident in the State's governance.

5.7 Landslides

2023 SHMP Update Changes

- The hazard profile was reorganized and significantly enhanced to include detailed descriptions of the following: hazard definition, hazard location, previous hazard occurrences, probability of future occurrences (including how future conditions may impact the hazard), and impact analysis. The profile is then followed by the vulnerability assessment, which summarizes the impacts and losses the landslide hazard can have on state and local assets and population.
- Landslide events, including rockfalls and mudslides, that occurred in the State from January 1, 2018, through December 31, 2022, were researched for the 2023 State Hazard Mitigation Plan (SHMP) Update.
- Landslide susceptibility maps, exposure tables of state buildings, critical facilities, and the population have been added and used to assess exposure in the vulnerability assessment.
- Information was updated regarding the current population affected by landslides.

5.7.1 Hazard Profile

Hazard Description

In West Virginia, the most common geologic hazards are landslides and subsidence. A discussion on landslides is included in this profile. For details on land subsidence, refer to Section 5.13.

Landslides are one of the most common natural hazards in West Virginia, having the potential to damage buildings and roads, disrupt utilities, and cause injuries and deaths (West Virginia Emergency Management Division 2018).

Figure 5.7-1. Yeager Airport Landslide of 2015

Source: Mistich 2015

A landslide, such as the one shown in Figure 5.7-1, consists of mass movements of soil and/or rock down a slope due to gravity and usually water. Slips, slumps, rock falls, slides, flows, and creep are terms used by geologists to identify specific mechanisms and velocities for mass movement. Most slopes in West Virginia are vulnerable, especially after heavy rain or snow melt; the telltale signs are hummocky surfaces, leaning and bent trees or utility poles, many seeps and sag ponds (water-filled depressions), and old or recent landslides where horizontal and vertical movement has occurred (West Virginia Geological and Economic Survey 2020).

The West Virginia GIS Technical Center (WVU GISTC) identifies five different types of landslides, all of which are capable of happening in the state:

- **Slide** – Translational or rotational movement of material downslope. Slides travel at a range of rates, displacing forests and infrastructure as they move. Quite common in West Virginia, large slides are readily identified using LiDAR data.
- **Debris Flow** – Failures saturated with water, where transported material moves downslope as a slurry of rock, soil, and debris. Flows may move quickly and cause loss of property and life far downslope from their source. Debris flows are common in mountainous areas of West Virginia but can be difficult to map using LiDAR data.
- **Lateral Spread** – Lateral movement of rock blocks across relatively shallow slopes. Spreads move slowly compared to most other landslides.
- **Fall** – Free-fall of material from a steep slope or cliff face. Falls often occur with little warning. Most falls are very difficult to map using LiDAR data because they are either promptly mitigated or consist of rock fragments too small to be identified.
- **Undetermined Slope Failure** – A contingency category consisting of slope failures in which available data is insufficient to assign failure material or mode (WVU GISTC 2021).

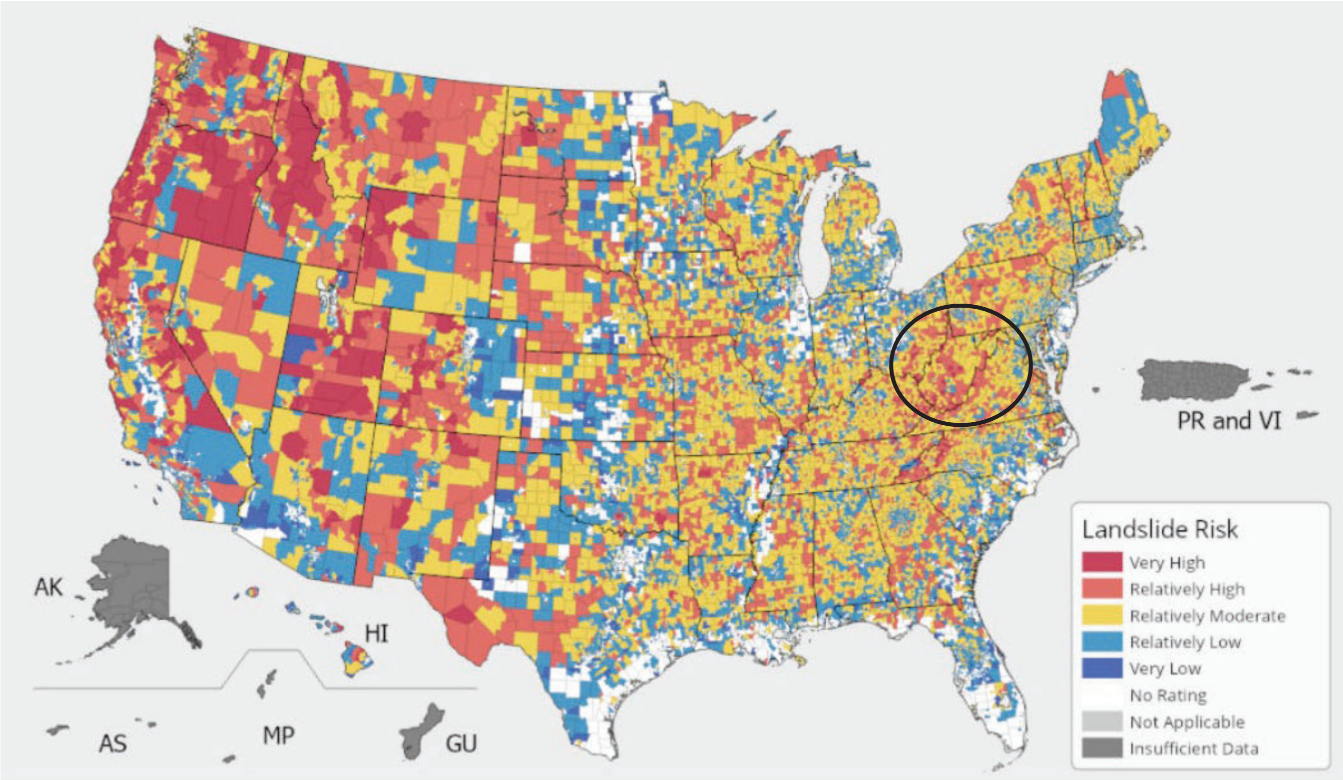
Many factors cause landslides and rockfalls, but the following are prevalent in the State: water changes, seismic activity, mining, and human activity.

- **Water** – Intense rainfall, changes in groundwater level, and water level changes along coastlines, earthen dams, and the banks of lakes, reservoirs, and rivers are the primary triggers of landslides.
- **Seismic Activity** – Earthquakes in landslide-prone areas greatly increase the likelihood that landslides will occur, either due to ground shaking alone or shaking-caused dilation of soil materials.
- **Mining** – Huge amounts of vibrations, including blasting, reach yards under the soil surface, which poses a greater threat to areas that are already at risk for sliding.
- **Human Activity** – Landslides may result directly or indirectly from human activities. Construction activity that undercuts or overloads dangerous slopes or that redirects the flow of surface or groundwater can trigger slope failures (USGS 2004).

LOCATION

Most of West Virginia is susceptible to landslides, especially areas with steep slopes or land degradation. Eastern West Virginia is especially vulnerable due to its mountainous terrain. Landslides may also take place during flooding events, in areas subject to earthquakes, and in areas covered with thick layers of finely grained soil deposits (West Virginia Emergency Management Division 2018). Landslides tend to develop when soil moisture and pressure are at its highest and are most problematic after prolonged wet seasons, specifically in late winter and early spring when soils are saturated (Kite 2021). Figure 5.7-2 displays the Landslides Risk Index for the United States (West Virginia displayed within the black circle). According to the National Risk Index, the majority of the State has a relatively moderate to very high risk to landslides, with a very small portion in the center of the state having relatively low risk.

Figure 5.7-2. National Risk Index, Landslides Risk Index Score



Source: FEMA 2023
Note: West Virginia is located within the black circle.

Due to the state's mountainous terrain and the high average annual precipitation, landslides occur frequently each year. Additionally, as shown in Figure 5.7-3 through Figure 5.7-14, nearly the entire state is located in areas prone to landslides. High susceptibility landslide hazard areas were used to determine risk and impacts to the population and infrastructure. Table 5.7-1 examines the total amount of acres that are located in the high susceptibility landslide hazard area as well as the percentage of land it encompasses broken down by county. Overall, the state has over 685,000 acres (4.4 percent of the State's total land area) of land located within high susceptibility landslide hazard areas. Summers County has the largest amount of land located in the high landslide susceptibility hazard area, with over 10 percent of its total land identified as having high landslide susceptibility.

The USGS divides landslide risk into six categories. These six categories were grouped into the three broader categories to be used for the risk analysis and ranking; geographic extent is based off these groupings. These categories include:

- **High Risk**
  - High susceptibility to land sliding and moderate incidence.
  - High susceptibility to land sliding and low incidence.
  - High landslide incidence (more than 15-percent of the area is involved in land sliding).
- **Moderate Risk**
  - Moderate susceptibility to land sliding and low incidence.
  - Moderate landslide incidence (1.5 – 15-percent of the area is involved in land sliding).
- **Low Risk**
  - Low landslide incidence (less than 1.5-percent of the area is involved in land sliding) (USGS 2022).

Table 5.7-1: Total Acres of Land Area in the Landslide Hazard Area

County	Total Acres of Land Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Landslide Hazard Area	
		Total Acres Located in the High Susceptibility Landslide Hazard Area	Percent of Total
Barbour	218,598	5,708.6	2.6%
Berkeley	205,141	2,461.6	1.2%
Boone	321,687	17,930.8	5.6%
Braxton	328,023	17,769.4	5.4%
Brooke	59,321	634.4	1.1%
Cabell	184,109	8,884.7	4.8%
Calhoun	179,487	3,694.9	2.1%
Clay	219,951	7,347.2	3.3%
Doddridge	205,051	4,407.5	2.1%
Fayette	427,276	29,191.4	6.8%
Gilmer	217,274	6,187.6	2.8%
Grant	305,479	14,309.3	4.7%
Greenbrier	654,360	42,127.3	6.4%
Hampshire	412,248	15,599.2	3.8%
Hancock	56,222	776.5	1.4%
Hardy	373,689	20,415.5	5.5%
Harrison	266,023	8,024.0	3.0%
Jackson	300,968	6,266.5	2.1%
Jefferson	134,920	751.5	0.6%
Kanawha	582,312	34,302.9	5.9%
Lewis	246,359	7,262.9	2.9%
Lincoln	280,594	10,174.5	3.6%
Logan	291,325	22,001.0	7.6%
Marion	199,006	5,042.0	2.5%
Marshall	199,304	2,011.9	1.0%
Mason	284,059	7,077.6	2.5%
McDowell	342,174	10,160.2	3.0%
Mercer	268,828	16,217.1	6.0%
Mineral	210,134	9,263.2	4.4%
Mingo	270,756	21,114.6	7.8%
Monongalia	232,200	5,412.8	2.3%
Monroe	302,704	11,494.9	3.8%
Morgan	146,880	4,849.8	3.3%
Nicholas	415,482	17,113.2	4.1%
Ohio	69,666	599.8	0.9%
Pendleton	446,485	42,013.6	9.4%
Pleasants	85,837	995.6	1.2%
Pocahontas	601,520	37,373.6	6.2%
Preston	415,612	16,915.9	4.1%
Putnam	223,706	11,274.6	5.0%
Raleigh	388,484	26,841.6	6.9%
Randolph	664,970	27,978.6	4.2%
Ritchie	290,396	4,002.4	1.4%
Roane	309,410	11,313.1	3.7%
Summers	233,898	25,083.3	10.7%
Taylor	110,892	3,612.1	3.3%
Tucker	265,897	17,014.7	6.4%
Tyler	166,857	530.8	0.3%
Upshur	226,613	5,287.0	2.3%

County	Total Acres of Land Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Landslide Hazard Area	
		Total Acres Located in the High Susceptibility Landslide Hazard Area	Percent of Total
Wayne	325,702	15,558.6	4.8%
Webster	355,637	24,549.7	6.9%
Wetzel	231,289	1,836.0	0.8%
Wirt	150,356	2,255.3	1.5%
Wood	241,020	3,969.8	1.6%
Wyoming	320,602	10,613.5	3.3%
Total	**15,466,793**	**685,606.1**	**4.4%**

Source: WVU 2020; USGS 2022; WVU GISTC 2022

Figure 5.7-3: Landslide Susceptibility Hazard Area in Region 1

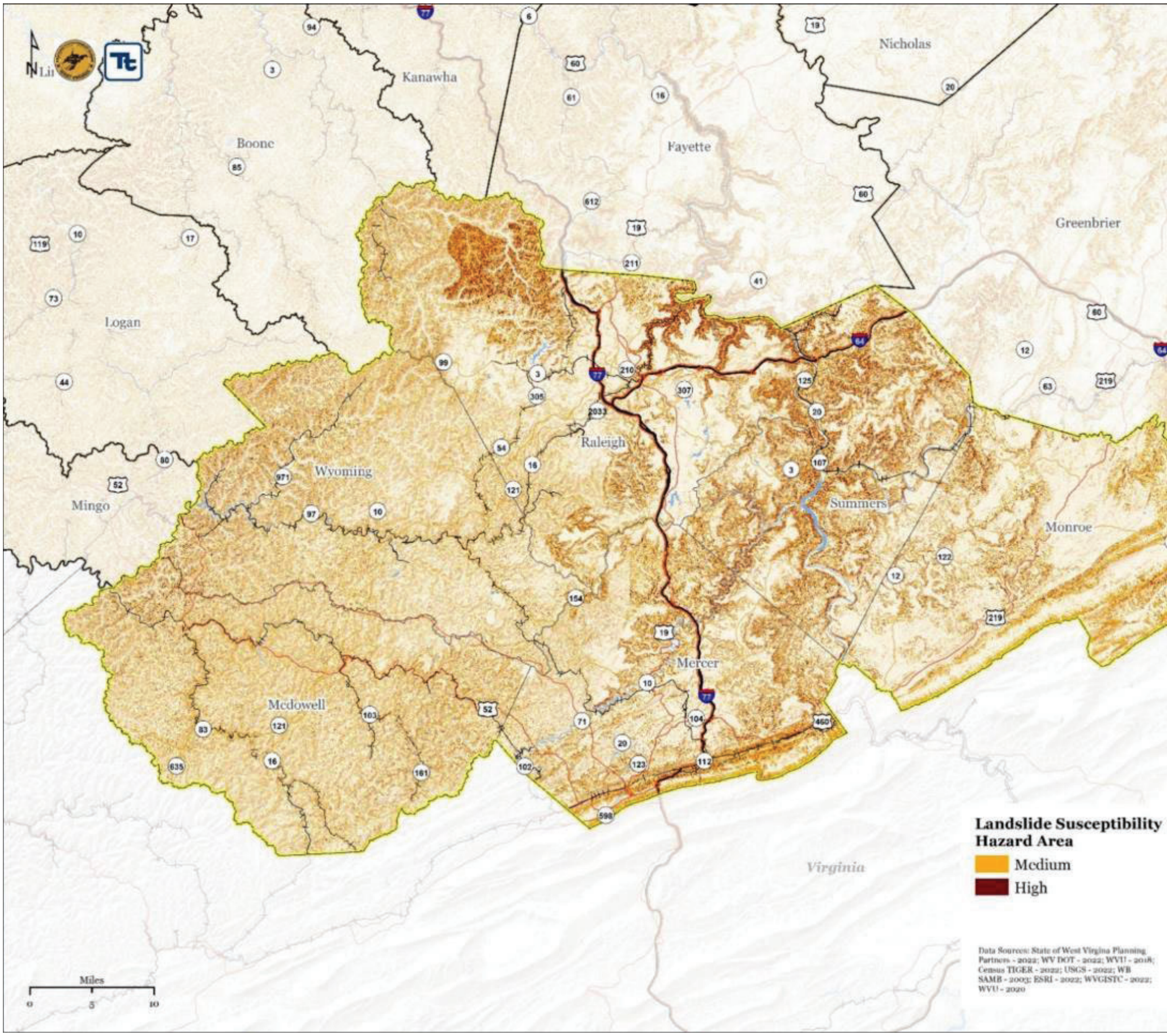


Figure 5.7-4: Landslide Susceptibility Hazard Area in Region 2

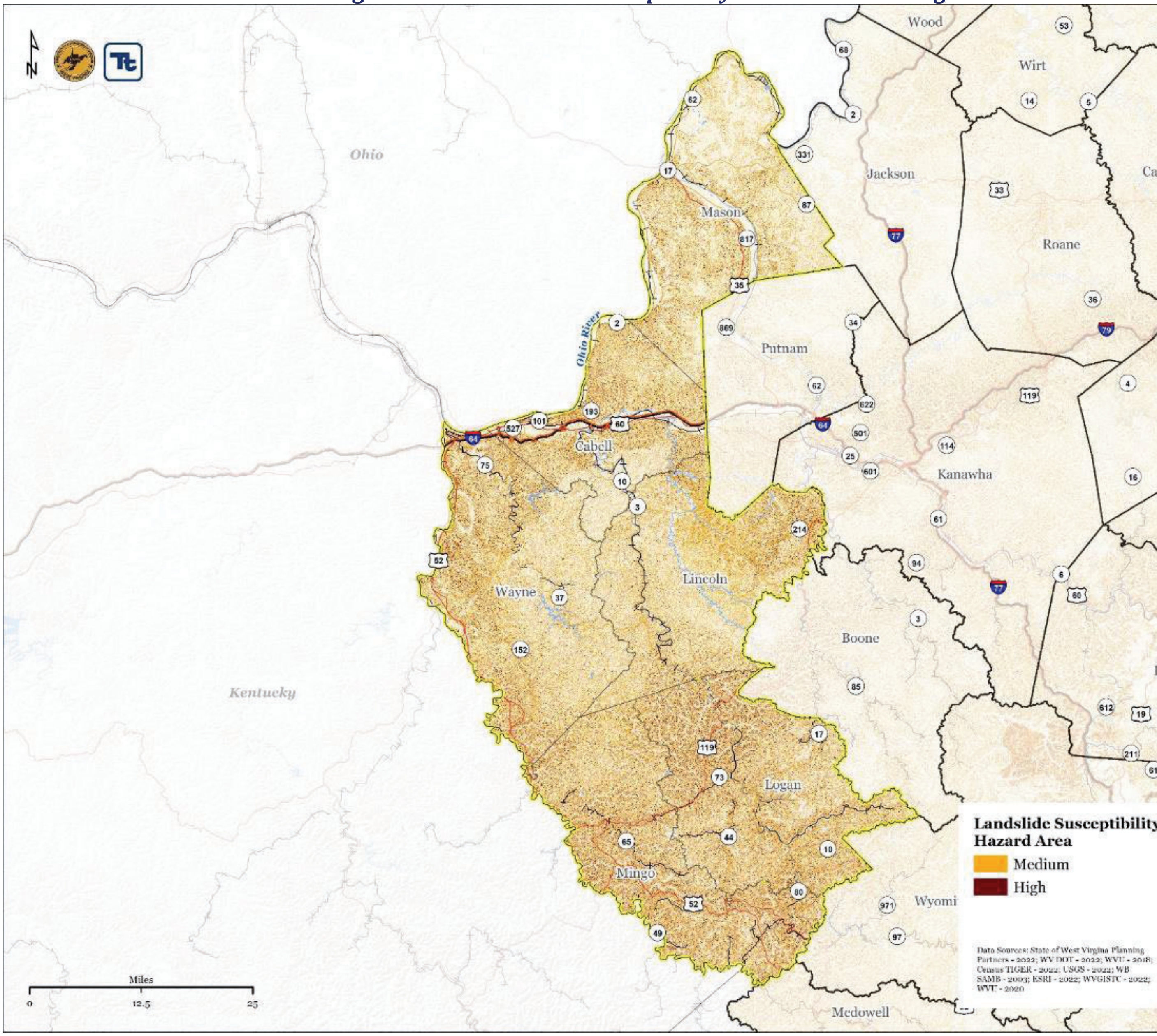


Figure 5.7-5: Landslide Susceptibility Hazard Area in Region 3

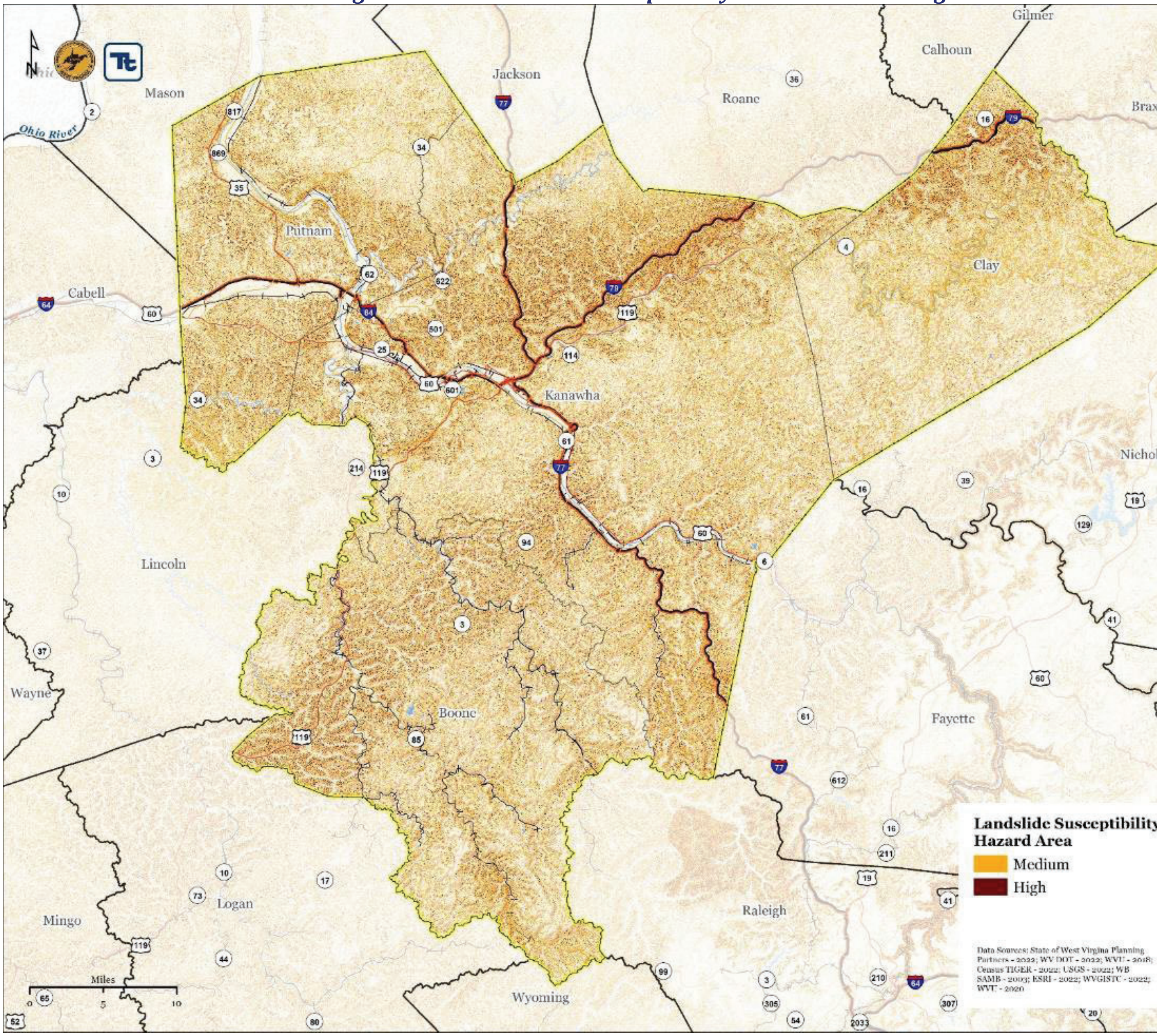


Figure 5.7-6: Landslide Susceptibility Hazard Area in Region 4

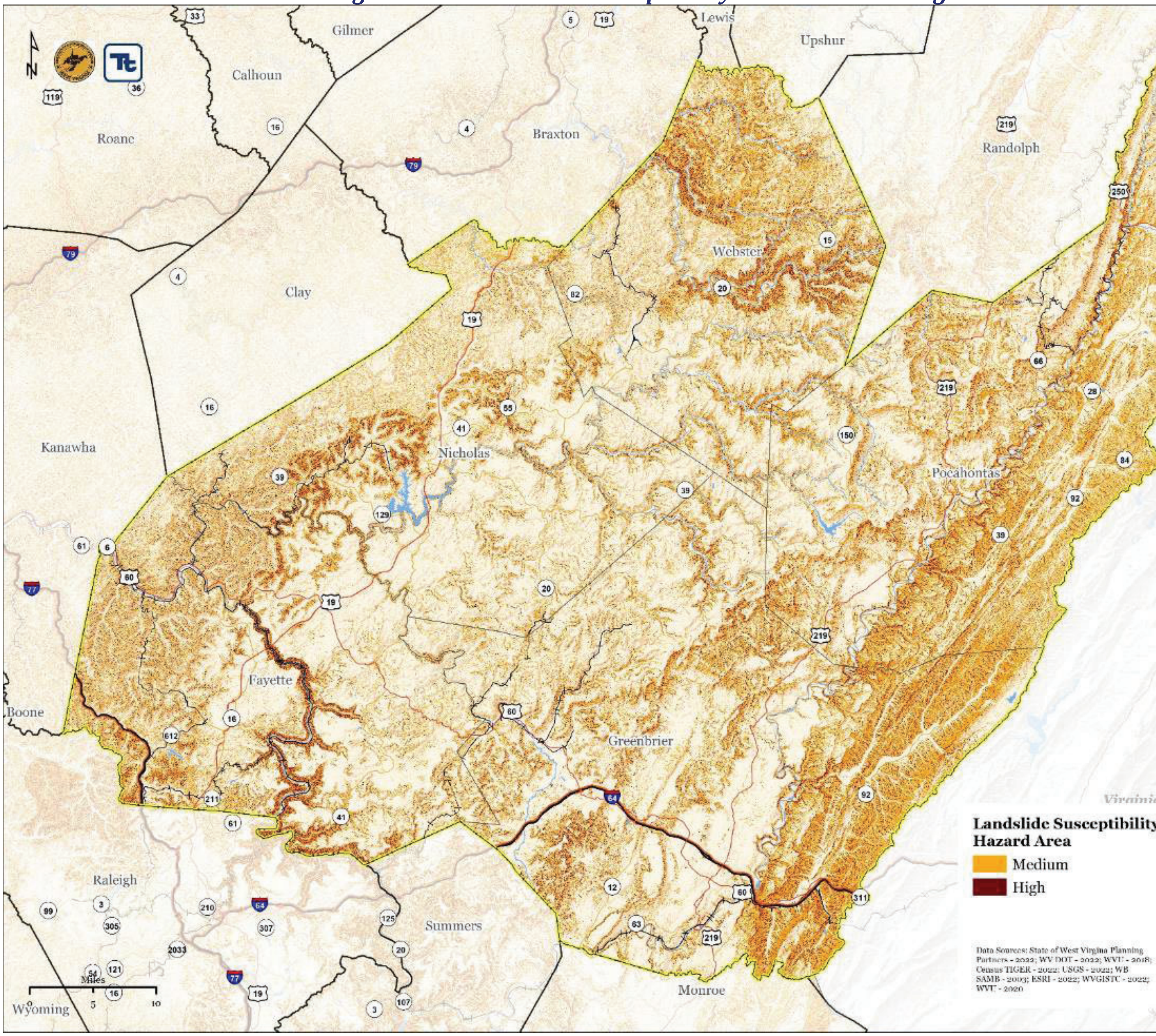


Figure 5.7-7: Landslide Susceptibility Hazard Area in Region 5

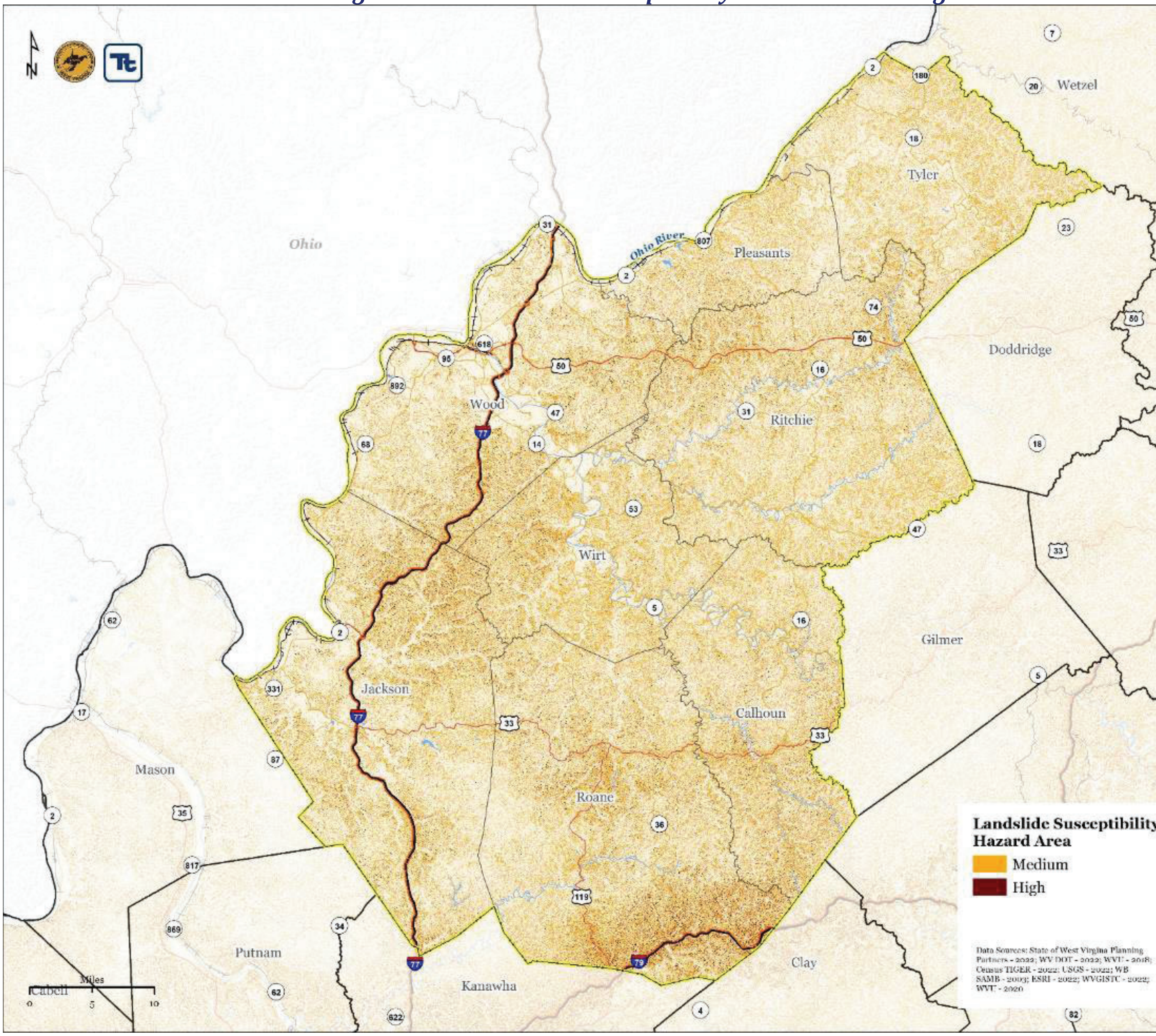


Figure 5.7-8: Landslide Susceptibility Hazard Area in Region 6

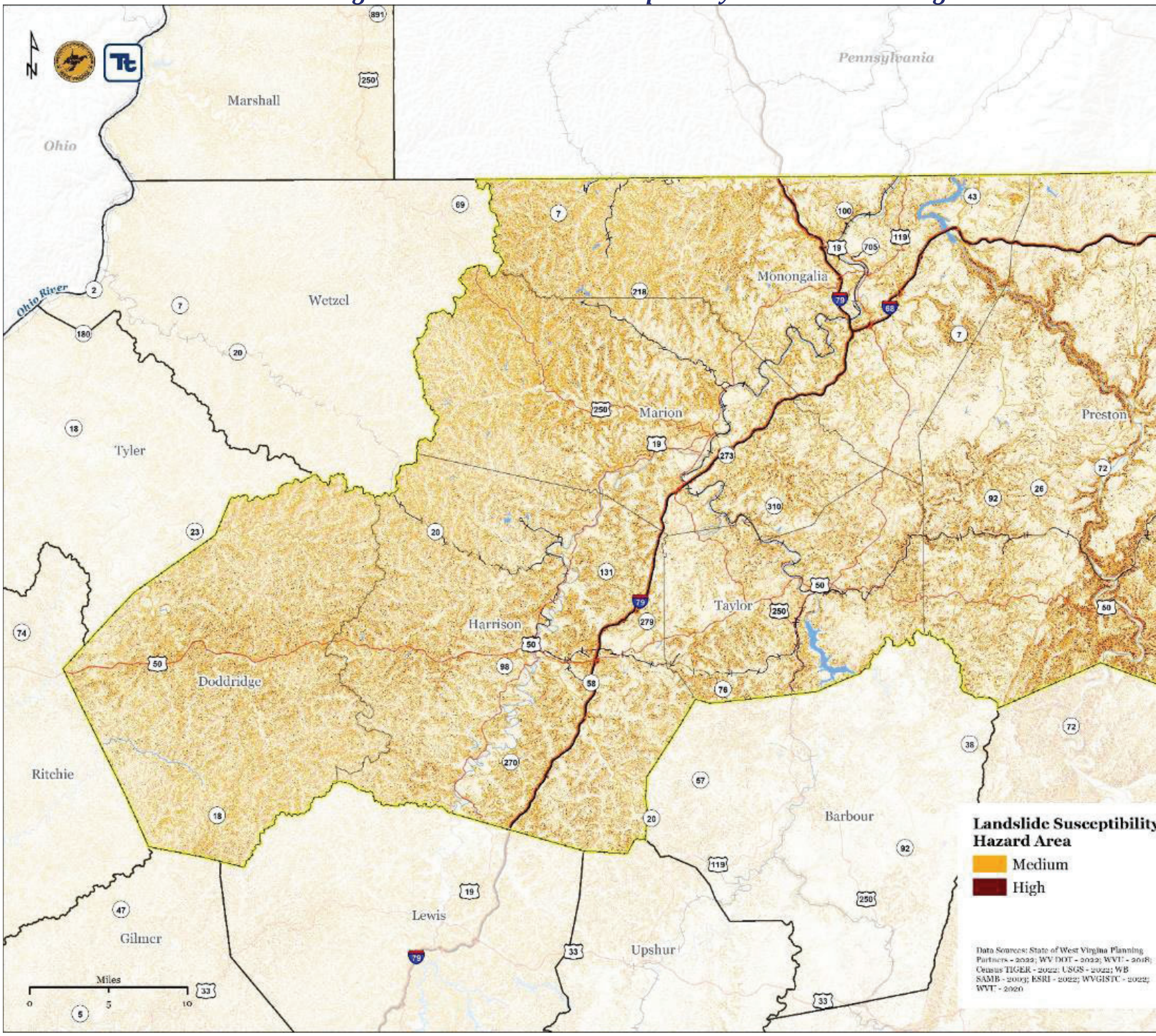


Figure 5.7-9: Landslide Susceptibility Hazard Area in Region 7

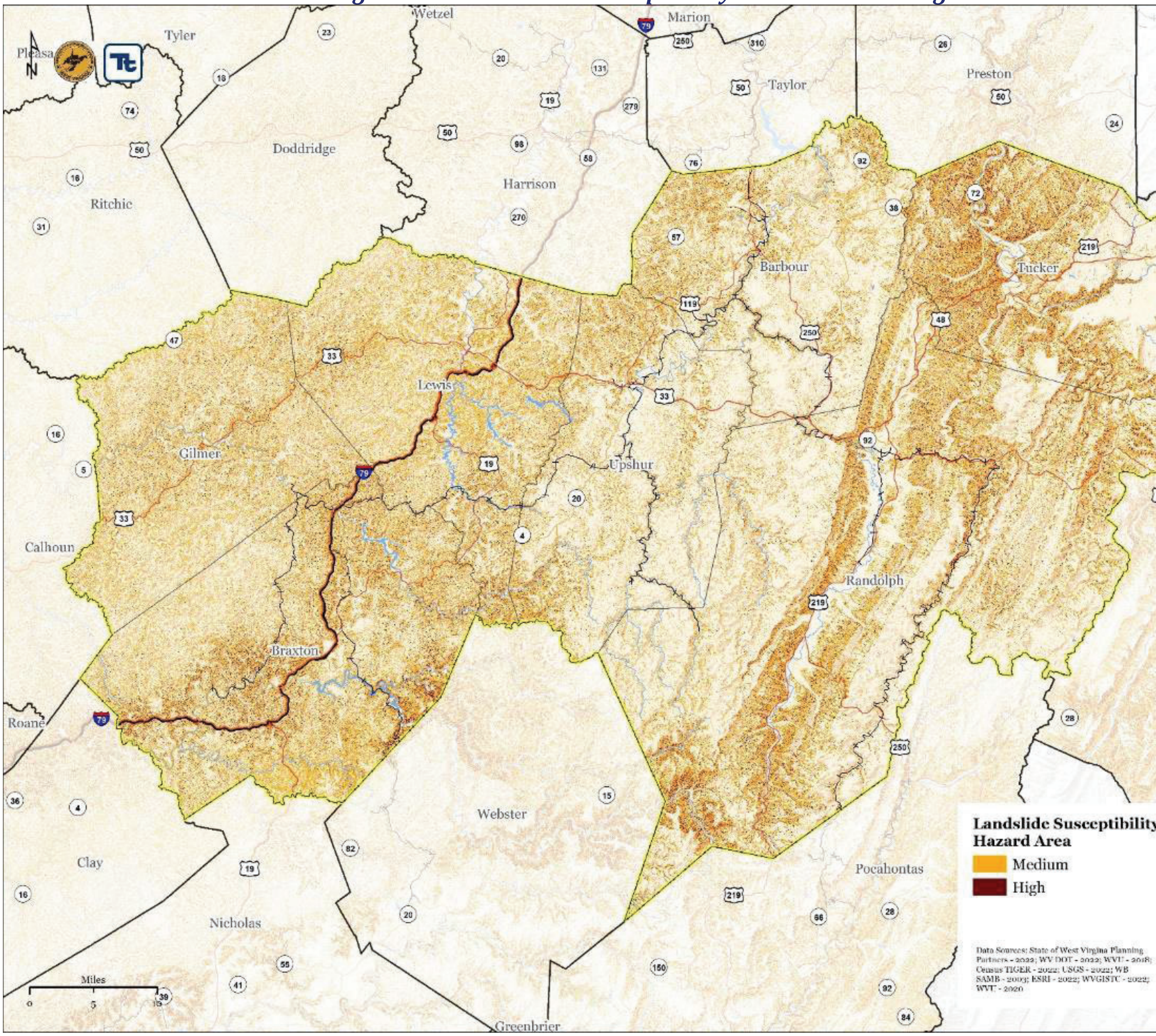


Figure 5.7-10: Landslide Susceptibility Hazard Area in Region 8

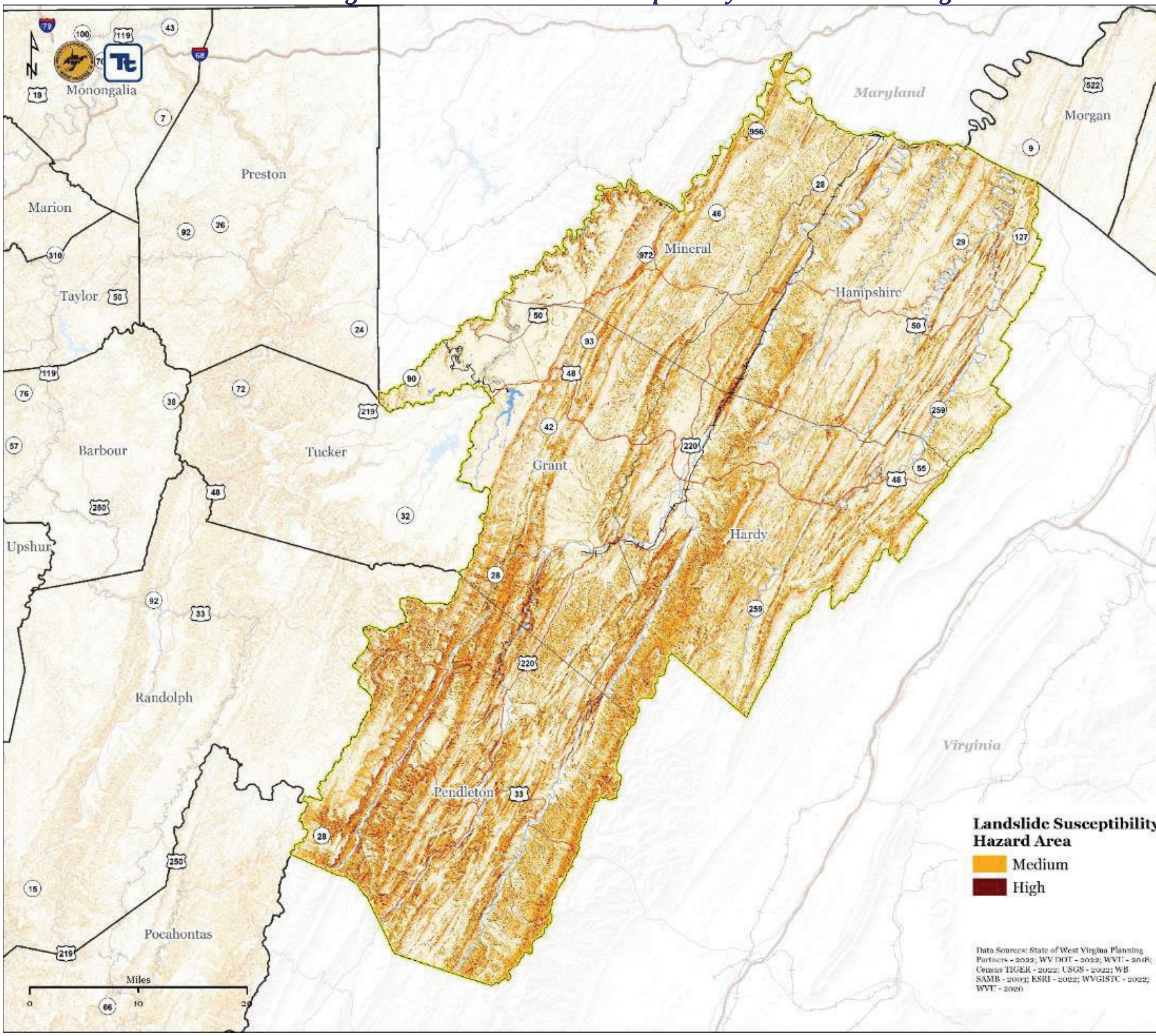


Figure 5.7-11: Landslide Susceptibility Hazard Area in Region 9

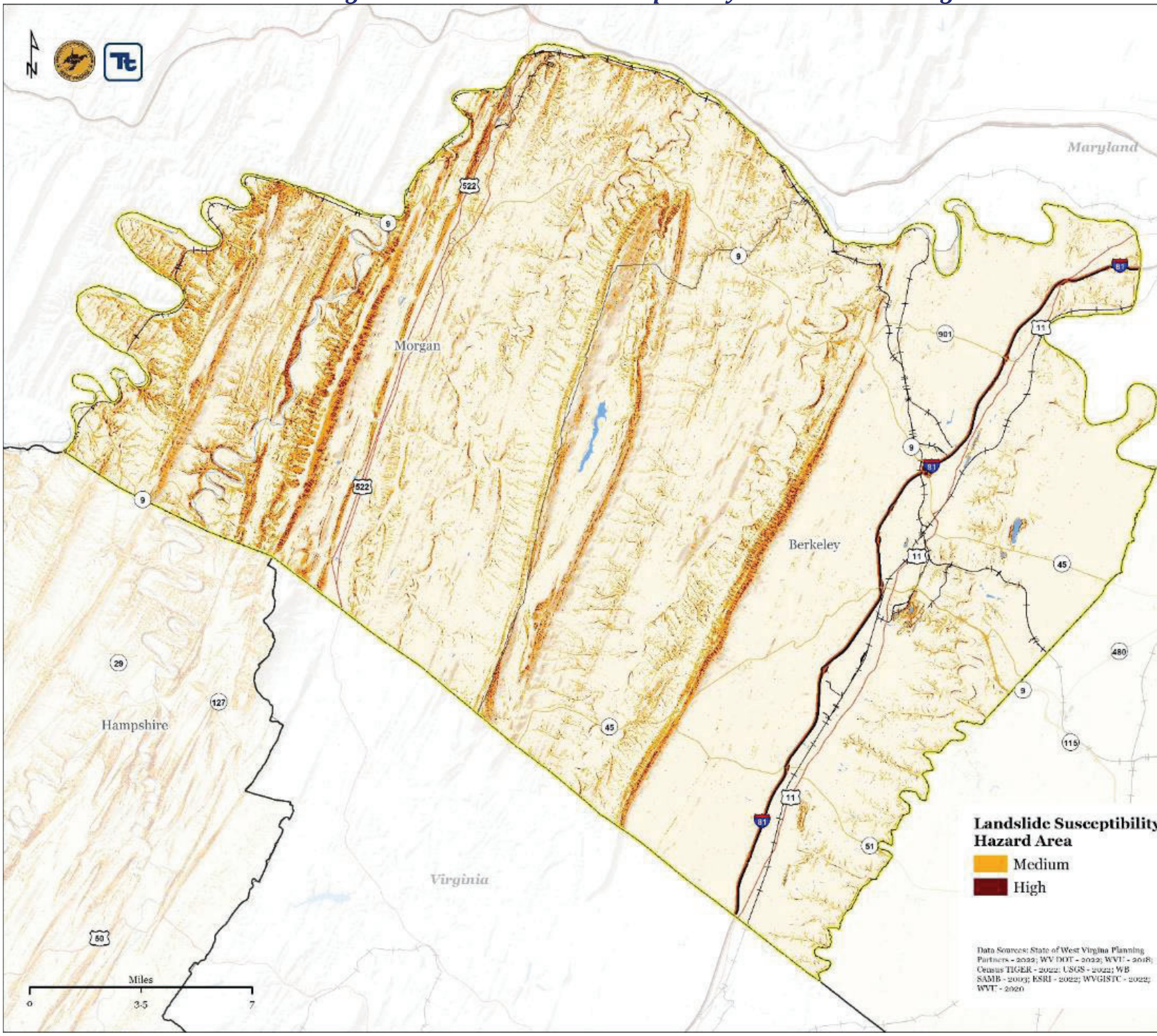


Figure 5.7-12: Landslide Susceptibility Hazard Area in Region 10

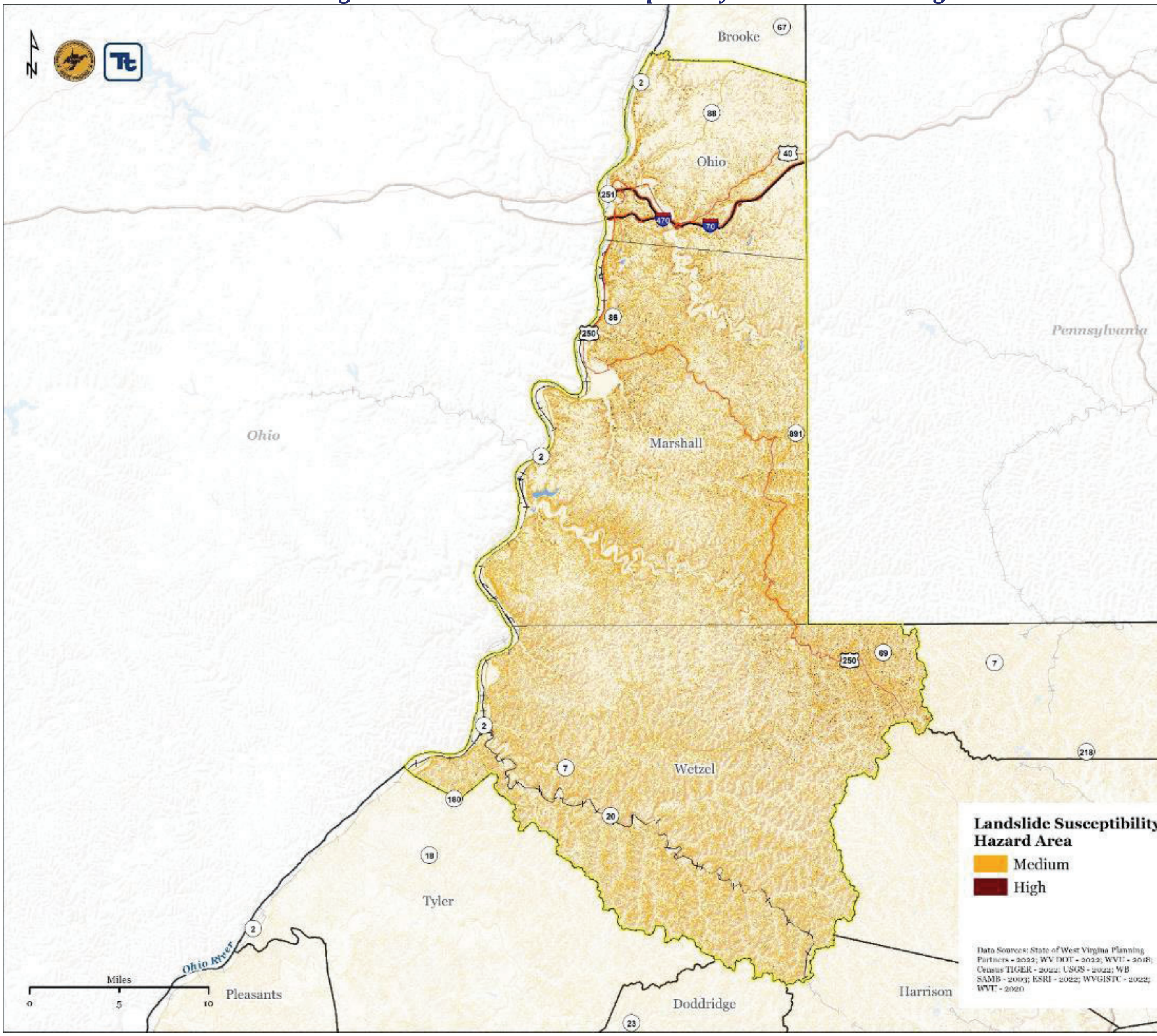


Figure 5.7-13: Landslide Susceptibility Hazard Area in Region 11

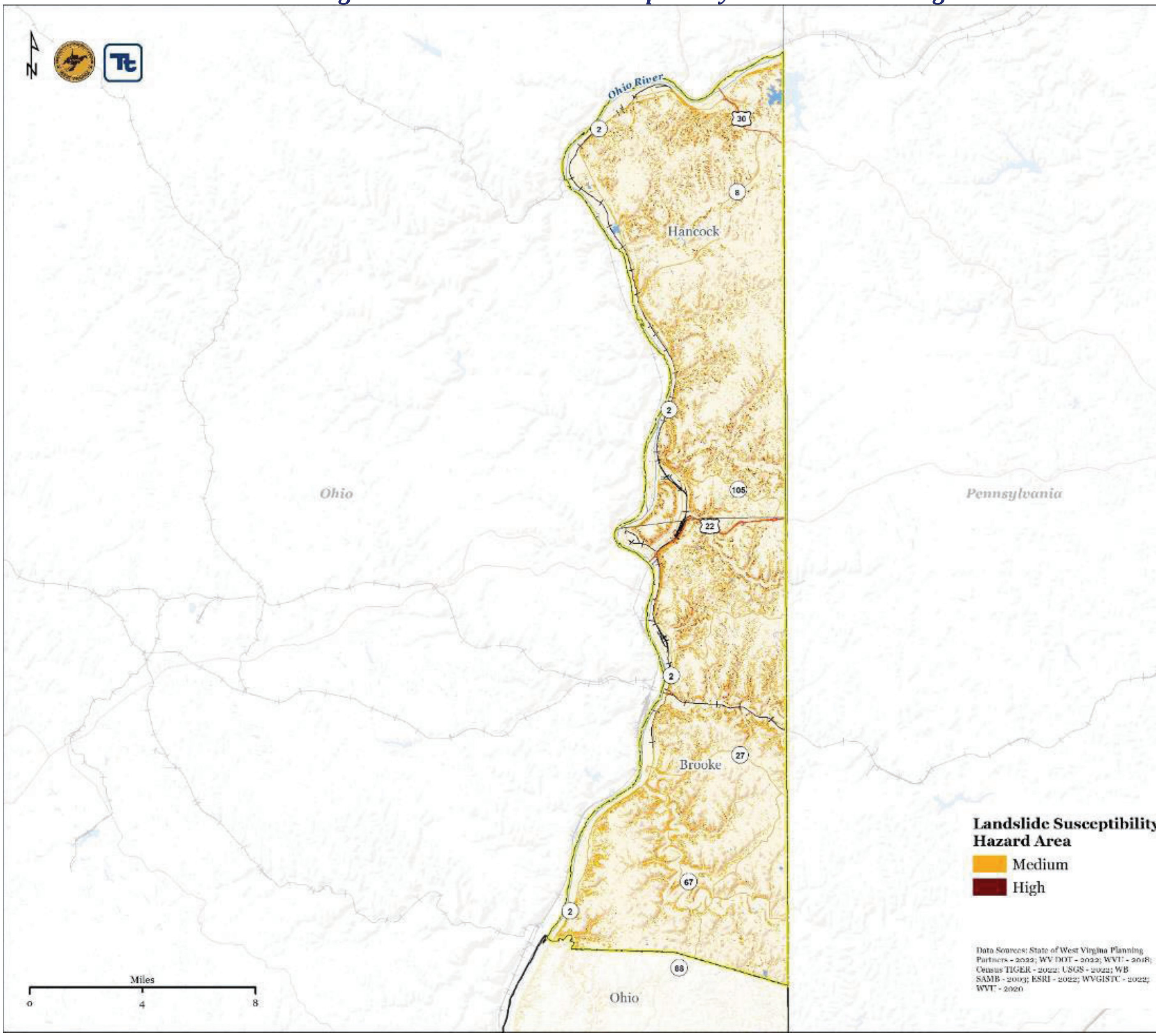
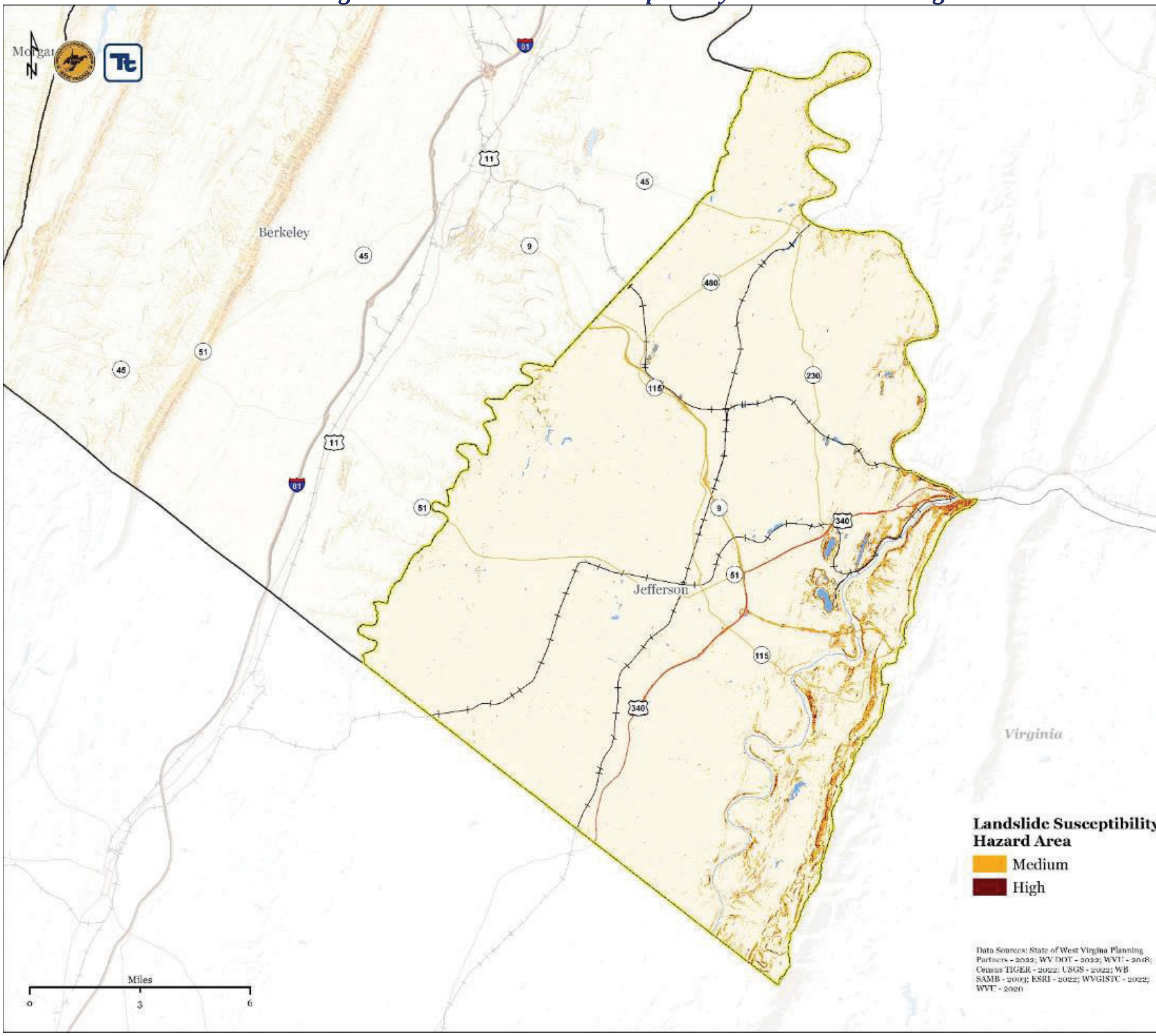


Figure 5.7-14: Landslide Susceptibility Hazard Area in Region 12



EXTENT

In examining how experts and agencies measure the extent of landslides, the word "extent" can often be seen as part of the term "areal extent," referring to the geographic space a past landslide has covered or the geographic space a future landslide might be expected to cover (Highland and Bobrowsky 2008). The West Virginia Landslide Tool contains information on historical and LiDAR-identified landslides, hazard susceptibility modeling results, model inputs, and reference layers and was created as part of Hazard Mitigation Grant Program funded by FEMA and WVEMD (FEMA 2022). In this process, thousands of laser beams per second scan the earth from their position attached to fixed-wind planes or helicopters and create a map of the landscape beneath. Once processed, trees and buildings can be removed to reveal what the true ground surface looks like, down to foot trails and roads. Scientists can then analyze if there is a particular cause of a landslide and look to see if there is a landslide concern (Board 2014).

Figure 5.7-15. Landslide in LiDAR Imagery

Historic photo shows a landslide associated with strip mining, which can be seen in the LiDAR imagery.

Source: Board 2014

Warning Time

The warning time for landslides depends on the geology, the vegetation, and the amount of predicted precipitation for an area. The current standard operating procedure is to monitor situations on a case-by-case basis and respond after the event has occurred. Generally accepted warning signs for landslide activity include:

- Tilting or cracking of concrete floors and foundations;
- Changes in the landscape, such as patterns of storm-water drainage on slopes (especially the places where runoff water converges), land movement, small slides, flows, or progressively leaning trees;
- Doors or windows stick or jam for the first time;
- New cracks appear in plaster, tile, brick, or foundations;
- Outside walls, walks, or stairs begin pulling away from the building;
- Slowly developing, widening cracks appear on the ground or on paved areas such as streets or driveways;
- Underground utility lines break;
- Bulging ground appears at the base of a slope;

- Water breaks through the ground surface in new locations;
- Fences, retaining walls, utility poles, or trees tilt or move;
- A faint rumbling sound that increases in volume is noticeable as the landslide nears;
- Unusual sounds, such as trees cracking or boulders knocking together, might indicate moving debris; and
- Collapsed pavement, mud, fallen rocks, and other indications of possible debris flow can be seen when driving (embankments along roadsides are particularly susceptible to landslides) (FEMA 2017).

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, the State was included in 32 disaster (DR) or emergency (EM) declarations for landslide-related events. Generally, these disasters cover a wide region of the state; therefore, they can impact many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2023). Table 5.7-2 summarizes the landslide-related FEMA disaster declarations between January 1, 1953, and December 31, 2022.

Table 5.7-2. Landslide-Related Federal Declarations (1953 to 2022)

Date(s) of Event	Incident	Federal Designation	Counties Affected
August 24, 1977	Severe Storms, Landslides, & Flooding	EM-3052-WV	Boone, Logan, Mingo
July 18-31, 1996	Heavy Rains, High Winds, Flooding, and Slides	DR-1132-WV	Barbour, Braxton, Cabell, Clay, Gilmer, Monongalia, Nicholas, Randolph, Upshur, Webster
February 28-March 15, 1997	Heavy and Wind Driven Rain, High Winds, Flooding, Landslides, and Mudslides	DR-1168-WV	Braxton, Cabell, Calhoun, Clay, Gilmer, Jackson, Kanawha, Lincoln, Mason, Putnam, Roane, Tyler, Wayne, Wetzel, Wirt, Wood
February 18-22, 2000	Flooding, Severe Storms, and Landslides	DR-1319-WV	Barbour, Braxton, Cabell, Calhoun, Doddridge, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Marion, Mason, Monongalia, Preston, Putnam, Randolph, Ritchie, Roane, Taylor, Tucker, Tyler, Upshur, Wetzel, Wirt
May 15-September 4, 2001	Severe Storms, Flooding, and Landslides	DR-1378-WV	Boone, Cabell, Calhoun, Clay, Doddridge, Fayette, Greenbrier, Kanawha, Lincoln, Logan, Marion, Mason, McDowell, Mercer, Mingo, Nicholas, Preston, Putnam, Raleigh, Roane, Summers, Taylor, Wayne, Wyoming
May 2-20, 2002	Severe Storms, Flooding, and Landslides	DR-1410-WV	Kanawha, Logan, McDowell, Mercer, Mingo, Raleigh, Summers, Wyoming
February 16-March 28, 2003	West Virginia Severe Winter Storms	DR-1455-WV	Berkeley, Boone, Braxton, Brooke, Cabell, Calhoun, Clay, Fayette, Gilmer, Grant, Greenbrier, Hampshire, Hancock, Hardy, Harrison, Jackson, Jefferson, Kanawha, Lewis, Lincoln, Logan, Marion, Marshall, Mason, McDowell, Mercer, Mineral,

Date(s) of Event	Incident	Federal Designation	Counties Affected
			Mingo, Monongalia, Monroe, Morgan, Nicholas, Ohio, Pendleton, Pocahontas, Preston, Putnam, Raleigh, Roane, Summers, Taylor, Tucker, Tyler, Upshur, Wayne, Webster,Wetzel, Wirt, Wyoming
June 11-July 15, 2003	Severe Storms, Flooding, and Landslides	DR-1474-WV	Berkeley, Boone, Cabell, Doddridge, Harrison, Kanawha, Lincoln, Logan, Marion, Mason, McDowell, Mingo, Monongalia, Nicholas, Preston, Putnam, Ritchie, Tucker, Wayne, Wyoming
November 11-30, 2003	Severe Storms, Flooding, and Landslides	DR-1500-WV	Barbour, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Greenbrier, Harrison, Kanawha, Lewis, Logan, Marion, Marshall, McDowell, Mercer, Monongalia, Monroe, Nicholas, Pendleton, Pocahontas, Putnam, Raleigh, Ritchie, Summers, Taylor, Upshur, Wayne, Webster, Wetzel, Wyoming
May 27-June 28, 2004	Severe Storms, Flooding, and Landslides	DR-1522-WV	Boone Braxton,, Cabell, Clay, Fayette, Gilmer, Jackson, Kanawha, Lewis, Lincoln, Logan, McDowell, Mason, Mercer, Mingo, Nicholas, Putnam, Raleigh, Roane, Wayne, Webster, Wirt, Wyoming
July 22-September 1, 2004	Severe Storms, Flooding, and Landslides	DR-1536-WV	Fayette, Lincoln, Logan, Mingo
September 16-27, 2004	Severe Storms, Flooding, and Landslides	DR-1558-WV	Berkeley, Boone, Brooke, Cabell, Clay, Hancock, Jackson, Kanawha, Lincoln, Logan, Marshall, Mason, Mingo, Morgan, Ohio, Pleasants, Putnam, Tyler, Wayne, Wetzel, Wirt, Wood
January 4-25, 2005	Severe Storms, Flooding, and Landslides	DR-1574-WV	Brooke, Hancock, Marshall, Ohio, Tyler, Wetzel
April 14-18, 2007	Severe Storms, Flooding, Landslides, and Mudslides	DR-1696-WV	Barbour, Boone, Cabell, Gilmer, Grant, Hardy, Lewis, Lincoln, Logan, McDowell, Mingo, Pendleton, Pocahontas, Putnam, Upshur, Wayne, Webster, Wyoming
June 3-7, 2008	Severe Storms, Tornadoes, Flooding, Mudslides, and Landslides	DR-1769-WV	Barbour, Braxton, Calhoun, Clay, Doddridge, Gilmer, Harrison, Jackson, Jefferson, Lewis, Marion, Ritchie, Taylor, Tucker, Tyler, Webster, Wetzel, Wirt,
May 3-June 8, 2009	Severe Storms, Flooding, Mudslides, and Landslides	DR-1838-WV	Calhoun, Gilmer, Lewis, McDowell, Mercer, Mingo, Raleigh, Roane, Upshur, Wirt, Wyoming
March 12-April 9, 2010	Severe Storms, Flooding, Mudslides, and Landslides	DR-1893-WV	Fayette, Greenbrier, Kanawha, Mercer, Raleigh, Summers

Date(s) of Event	Incident	Federal Designation	Counties Affected
June 12-29, 2010	Severe Storms, Flooding, Mudslides, and Landslides	DR-1918-WV	Lewis, Logan, McDowell, Mingo, Wyoming
February 29-March 5, 2012	Severe Storms, Tornadoes, Flooding, Mudslides, and Landslides	DR-4059-WV	Doddridge, Harrison, Lincoln, Marion, Mingo, Monongalia, Preston, Ritchie, Roane, Taylor, Wayne
March 15-31, 2012	Severe Storms, Flooding, Mudslides, and Landslides	DR-4061-WV	Lincoln, Logan, Mingo
March 3-14, 2015	Severe Winter Storm, Flooding, Landslides, and Mudslides	DR-4210-WV	Barbour, Boone, Braxton, Cabell, Doddridge, Fayette, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Marshall, McDowell, Mercer, Mingo, Monongalia, Putnam, Raleigh, Ritchie, Roane, Summers, Tucker, Taylor, Tyler, Upshur, Wayne, Webster, Wetzel, Wirt, Wood, Wyoming
April 3-5, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4219-WV	Boone, Cabell, Lincoln, Logan, Mingo, Wayne
April 8-11, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4220-WV	Braxton, Brooke, Doddridge, Gilmer, Jackson, Lewis, Marshall, Ohio, Pleasants, Ritchie, Tyler, Wetzel
April 13-15, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4221-WV	Cabell, Calhoun, Greenbrier, Jackson, Pleasants, Roane, Summers, Wirt
July 10-14, 2015	Severe Storms, Straight-Line Winds, Flooding, Landslides, and Mudslides	DR-4236-WV	Braxton, Clay, Jackson, Lincoln, Logan, Nicholas, Roane, Webster, Wood
June 22-29, 2016	Severe Storms, Flooding, Landslides, and Mudslides	DR-4273-WV	Clay, Fayette, Greenbrier, Jackson, Kanawha, Lincoln, Monroe, Nicholas, Pocahontas, Roane, Summers, Webster
July 28-29, 2017	Severe Storms, Flooding, Landslides, and Mudslides	DR-4331-WV	Doddridge, Harrison, Marion, Marshall, Monongalia, Ohio, Preston, Randolph, Taylor, Tucker, Tyler, Wetzel
February 14-20, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4359-WV	Brooke, Cabell, Calhoun, Doddridge, Hancock, Harrison, Lincoln, Logan, Marshall, Mason, Monongalia, Ohio, Pleasants, Preston, Ritchie, Taylor, Tyler, Wayne, Wetzel, Wirt, Wood
May 28-June 3, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4378-WV	Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan, Pendleton
June 29-30, 2019	Severe Storms, Flooding, Landslides, and Mudslides	DR-4455-WV	Grant, Pendleton, Preston, Randolph, Tucker
July 12-13, 2022	Severe Storms, Flooding, Landslides, and Mudslides	DR-4678-WV	McDowell
August 14-15, 2022	Severe Storms, Flooding, Landslides, and Mudslides	DR-4679-WV	Fayette

Source: FEMA 2023

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was included in two landslide-related agricultural disaster declarations, as shown in Table 5.7-3 (USDA 2023).

Table 5.7-3. Landslide-Related USDA Declarations (2012 to 2022)

Date(s) of Event	Designation Number	Description of Disaster	Counties Declared
March 1-August 25, 2015	USDA-S3934	Mudslides, Debris Flows, Landslides	Cabell, Hancock, Jackson, Marshall, Mason, Ohio, Pleasants, Tyler, Wayne, Wetzel, Wood
July 26-29, 2022	USDA-S5322	Mudslides, Debris Flows, Landslides	Mingo, Wayne

Source: USDA 2023

Previous Events

Many sources provided landslide information regarding previous occurrences and losses associated with landslide events throughout the State. The 2018 SHMP discussed specific landslide events that occurred in the State through 2018. For this 2023 SHMP, landslide events were summarized between January 1, 1977, and December 31, 2022.

Table 5.7-4 includes details of major landslide events that occurred in the state between 2018 and 2022. Major events include those that resulted in losses or fatalities, as reported by the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI), events that led to a FEMA disaster declaration, and/or event that led to a USDA declaration. Associated precursor hazards to landslides, including heavy rain, flood, flash flood, heavy snow, and wildfire are presented to provide an indication of the potential for landslide events, as the NOAA NCEI Storm Events Database does not report landslide events.

Table 5.7-4. Landslide Events in the State of West Virginia (2018 to 2022)

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
February 16-21, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4359-WV	Barbour, Cabell, Doddridge, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Mason, Pleasants, Putnam, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Wood	A wave of low pressure and surface front crossed West V on the 16th. Generally, one to two inches of rain fell on a resulted in creek and stream flooding on the 16th and in through the river system, smaller main stem rivers flood flooding along the Ohio River. $168,500 of property dam event.
April 15-16, 2018	Flood, Flash Flood, Heavy Rain, Landslide	N/A	Barbour, Berkeley, Braxton, Fayette, Gilmer, Grant, Greenbrier, Hampshire, Hardy, Harrison, Jefferson, Lewis, Marion, Mason,McDowell, Monongalia, Monroe, Morgan, Nicholas, Pendleton, Pocahontas, Preston, Randolph, Taylor, Tyler, Upshur, Webster	A strong upper-level system combined with a lot of low-l heavy rainfall on the 15th into the 16th. Widespread rain in 24 to 36 hours from north central West Virginia into th led to flooding on many rivers and streams. Low pressure passed through during the early morning hours of April 1 inches fell in portions of the state, causing flooding main Hardy Counties. This water then moved downstream, ca the 17th and 18th. A period of moderate to heavy rain in led to some isolated flooding across the upper Ohio Valle ground because of several rounds of rain across the area which did cause some problems in western Pennsylvania $136,000 of property damages were incurred from this e
May 28 - June 3, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4378-WV	Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan, Pendleton	Heavy rain of one to four inches fell on June 1st across th panhandle, causing flooding and a few instances of flash Flooding continued into the overnight hours. Then, persi the flooding, along with isolated flash flooding in and nea three inches of rain was observed. A landslide triggered associated floodwaters, caused the closure of U.S.-220 ju Valley View Golf Club. No monetary damages were incur
February 20-25, 2019	Flood, Heavy Rain, Landslide	N/A	Doddridge, Fayette, Harrison, Jackson, Kanawha, Lincoln, Logan, Mason, McDowell, Mercer,	From February 20th to 25th, multiple rounds of precipita West Virginia, resulting in liquid accumulations ranging f storm started out on the 20th as a combination of snow, the mountains with liquid equivalents of 0.50 up to 2 inc early late on February 21st, with warmer air arriving with

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
			Mineral, Mingo, Monroe, Ritchie, Tyler	precipitation to fall mainly as rain, which helped to quick which fell during the 24-36 hours prior. With soils alread precipitation, runoff from this storm caused mainly minc one significant landslide. $120,000 of property damages of which $70,000 were attributed to flooding.
June 29-30, 2019	Severe Storms, Flooding, Landslides, and Mudslides	DR-4455-WV	Grant, Pendleton, Preston, Randolph, Tucker	Showers and thunderstorms with heavy rain developed i Mason-Dixon line in the afternoon on the 29th. These sh parts of Marion, Monongalia, and Preston counties in W County in Maryland. Two to three inches of rain were re addition to the rain from earlier in the day with the pass were made impassable by fast-moving floodwaters and homes and businesses were impacted in Marion, Monon combined. Estimated damage to public property, Marion and Preston $855,000.
July 12-13, 2022	Severe Storms, Flooding, Landslides, and Mudslides	FEMA-DR-4678	Kanawha, McDowell, Putnam, Raleigh	Showers and storms with strong winds, large hail, and he water issues across the state. Roughly $1.008 million of from this event.
August 15-16, 2022	Severe Storms, Flooding, Landslides, and Mudslides	FEMA-DR-4679	Fayette, Greenbrier, Kanawha	A narrow band of heavy rain fell across the I-64 corridor of August 15th. The Charleston airport reported 4.33 inc previous evening, with radar estimates ranging from two Fayette Counties. The Campbells Creek area of Kanawha damage from flash flooding, with damage costs extendin Flash flooding was also observed in the Scrabble Creek a Governor of West Virginia declared a State of Emergency Counties due to the flooding, and recovery and clean-up event occurred. Another round of showers and storms t August 16th, which once again caused high water issues $10 million of property damages were incurred from this

Sources: FEMA 2023; USDA 2023; NOAA NCEI 2023
Notes: DLNR Department of Land and Natural Resources
FEMA Federal Emergency Management Agency

PROBABILITY OF FUTURE HAZARD EVENTS

Overall Probability

The stability of natural and engineered slopes will likely lead to more landslides due to the increased frequency and intensity of future rain events. In most cases, this will be directly connected to flooding events. What is less clear, however, are the details of those consequences: the type, extent, magnitude, and direction of the changes in the stability conditions and on the location, abundance, activity, and frequency of landslides in response to the projected future conditions. Conditions that increase the risk of a landslide include heavy rain, snowmelt, and changes in groundwater level which may trigger landslides. Erosion may remove the toe and lateral support of certain areas, triggering potential landslides (West Virginia Emergency Management Division 2018).

Impacts from landslides can be reduced by avoiding construction on steep slopes and existing landslides, or by stabilizing the slopes. Stability increases when groundwater is prevented from rising in the landslide mass by (1) covering the landslide with an impermeable membrane, (2) directing surface water away from the landslide, (3) draining groundwater away from the landslide, and (4) minimizing surface irrigation. Slope stability is also increased when a retaining structure and/ or the weight of a soil/rock berm are placed at the toe of the landslide or when mass is removed from the top of the slope (USGS 2022).

Vulnerability to landslide hazards is a function of location, type of human activity, use, and frequency of landslide events. Human activities triggering landslides are usually associated with construction and changes in slope and surface water and groundwater levels. Changes in irrigation, runoff, and drainage can increase erosion and change groundwater levels and ground saturation. The effects of landslides on people and structures can be lessened by total avoidance of landslide hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity. Local governments can reduce landslide effects through land-use policies and regulations. Individuals can reduce their exposure to hazards by educating themselves on the past hazard history of a site and by making inquiries to planning and engineering departments of local governments. They can also obtain the professional services of an engineering geologist, a geotechnical engineer, or a civil engineer, who can properly evaluate the hazard potential of a site, built or unbuilt (USGS 2022).

According to FEMA, USDA, NOAA-NCEI, and the 2018 SHMP, the State experienced 35 landslide events between 1976 and 2022, as summarized in Table 5.7-5.

Table 5.7-5: Probability of Future Landslide Events in West Virginia

Hazard Type	Number of Occurrences Between 1976 and 2022	Percent Chance of Occurrence in Any Given Year
Landslide	35	48.6

Sources: FEMA 2023; USDA 2023; NOAA NCEI 2023; West Virginia Emergency Management Division 2018

Projected Future Conditions

Heavy rains and floods, as described in the Hazard Profile, are precursors to the landslide hazard. In the future, rain events are expected to become more frequent and more intense across the United States. Moderate flooding events are expected to become more frequent in most of the Northeast during the 21st century because of more intense precipitation (U.S. Global Change Research Program 2018). Annual precipitation is projected to increase for West Virginia over this century, with the largest increases occurring during winter and spring.

Projections indicate that future conditions may include an increase in temperatures across the State of Virginia. Temperatures in West Virginia have risen 1°F since the beginning of the 20th century. Drier conditions in the future may increase the likelihood of wildfires. Wildfires destroy landscapes by decimating trees, shrubs, and other vegetation. Similar to issues presented by logging actives (refer to Impacts to the Environment), the elimination of vegetation in forested areas results in loose soil and increases the amount of water that remains on top of the soil since it can no longer be absorbed by vegetation; these conditions may exacerbate the possibility of a landslide event (Geertsema, Highland and Vaugeouis 2009).

5.7.2 Vulnerability Assessment

A statewide assessment was conducted based on landslide susceptibility data provided by West Virginia Department of Transportation, U.S. Geological Survey, and West Virginia University. Landslide susceptibility mapping describes the relative likelihood of future landslides based solely on prior failure (from a landslide inventory), rock or soil strength, and steepness of slope. This analysis used the areas mapped having high or very high susceptibility to landslides (U.S. Geological Survey 2023).

State Assets

Table 5.7-6 and Table 5.7-7 summarize the number and replacement cost value of state assets located in high landslide susceptibility areas; both tables reflect only the counties with state facilities. All other counties do not have state facilities within high susceptibility landslide hazard areas. Pocahontas and Fayette County both have one state facility within the landslide hazard area. Pocahontas County contains the Miner's Health Safety, Division of Training, which has a total replacement cost value (RCV) of $3.4 million. The Department of Health & Human Resources is located in Fayette County and has a total RCV of $130,000.

Table 5.7-6. State Facilities Located within the High Susceptibility Landslide Hazard Area

State Facilities located Within the High Susceptibility Landslide Hazard Area		Replacement Cost Value for State Facilities Within the High Susceptibility Landslide Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Fayette	1	$1,900,000	$1,500,000	$3,400,000
Pocahontas	1	$0	$130,000	$130,000
Total	**2**	**$1,900,000**	**$1,630,000**	**$3,530,000**

Source WVEMD 2023; WVU 2020

Table 5.7-7: State Facilities Located within the High Susceptibility Landslide Hazard Area by Agency

State Facilities located within the High Susceptibility Landslide Hazard Area		Replacement Cost Value for State Facilities within the High Susceptibility Landslide Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Health & Human Resources, Department of State of West Virginia	1	$0	$130,000	$130,000
Miner's Health Safety, Division of Training, State of West Virginia	1	$1,900,000	$1,500,000	$3,400,000

State Facilities located within the High Susceptibility Landslide Hazard Area		Replacement Cost Value for State Facilities within the High Susceptibility Landslide Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Total (WV State)	**2**	**$1,900,000**	**$1,630,000**	**$3,530,000**

Source WVEMD 2023; WVU 2020

Critical Facilities and Community Lifelines

One critical facility and lifeline is located in the high susceptibility landslide hazard area in the state. This facility is located in Fayette County, under the Safety and Security lifeline, shown in Table 5.7-8.

Table 5.7-8: Critical Facilities Located within the High Susceptibility Landslide Hazard Area

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Fayette	0	0	0	0	0	1	0	1
Total	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**

Source WVEMD 2023; WVU 2020

In addition to critical facilities, a significant amount of infrastructure can be exposed to landslides:

- Roads—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems, and delays for public and private transportation.
- Bridges—Landslides can significantly impact road bridges. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.
- Power Lines—Power lines are generally elevated above steep slopes; but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil underneath a tower, causing it to collapse and ripping down the lines.
- Rail Lines—Similar to roads, rail lines are important for response and recovery operations after a disaster. Landslides can block travel along the rail lines, which would become especially troublesome, because it would not be as easy to detour a rail line as it is on a local road or highway.

Population

Generally, a landslide event would be an isolated incidence and impact the populations within the immediate area of the incident. Populations downslope of a landslide hazard area are particularly vulnerable to this hazard. Health threats from landslides include: 1) trauma caused by rapidly moving water and debris; 2) broken electrical, water, gas and sewage lines that can lead to injury or illness; and 3) disrupted roadways that can endanger motorists and disrupt transport and access to health care (Centers for Disease Control and Prevention [CDC] 2018).

To understand the risk to populations residing in high landslide susceptibility areas, a spatial analysis was conducted using the 2020 U.S. Census data. Table 5.7-9 evaluates the population located in the high susceptibility areas. Overall, 49,465 people in West Virginia are living in the high susceptibility landslide hazard areas.

Table 5.7-9: Population Located in High Susceptibility Landslide Hazard Areas

County	Total County Population	Total Population	% Total Population	Highly Vulnerable Population	% Highly Vulnerable Population
Barbour	16,543	382	2.31%	47	12.23%
Berkeley	117,615	766	0.65%	32	4.15%
Boone	21,897	1,683	7.69%	324	19.28%
Braxton	14,032	724	5.16%	180	24.87%
Brooke	22,162	218	0.98%	51	23.56%
Cabell	93,328	2,592	2.78%	254	9.80%
Calhoun	7,185	130	1.81%	0	0.00%
Clay	8,599	302	3.51%	33	10.82%
Doddridge	8,499	150	1.76%	0	0.00%
Fayette	43,087	1,176	2.73%	566	48.13%
Gilmer	7,970	248	3.11%	102	41.16%
Grant	11,565	576	4.98%	279	48.38%
Greenbrier	34,893	1,295	3.71%	499	38.49%
Hampshire	23,304	773	3.32%	250	32.36%
Hancock	29,118	394	1.35%	83	21.11%
Hardy	13,789	701	5.08%	0	0.00%
Harrison	67,620	1,115	1.65%	119	10.64%
Jackson	28,793	420	1.46%	0	0.00%
Jefferson	56,922	226	0.40%	0	0.01%
Kanawha	181,014	8,834	4.88%	1,661	18.80%
Lewis	16,024	366	2.28%	45	12.36%
Lincoln	20,617	862	4.18%	156	18.12%
Logan	32,593	2,513	7.71%	1,671	66.50%
Marion	56,233	987	1.76%	45	4.58%
Marshall	30,900	311	1.01%	0	0.00%
Mason	26,700	345	1.29%	0	0.00%
McDowell	18,083	441	2.44%	195	44.23%
Mercer	59,370	2,142	3.61%	800	37.37%
Mineral	27,047	979	3.62%	51	5.25%
Mingo	23,808	1,510	6.34%	840	55.63%
Monongalia	106,196	1,429	1.35%	149	10.41%
Monroe	13,344	447	3.35%	0	0.00%
Morgan	17,800	400	2.25%	0	0.00%
Nicholas	24,857	660	2.66%	0	0.00%
Ohio	41,875	573	1.37%	67	11.65%
Pendleton	6,968	659	9.46%	0	0.00%
Pleasants	7,457	87	1.17%	0	0.00%
Pocahontas	8,382	443	5.29%	0	0.00%
Preston	33,610	929	2.76%	4	0.41%
Putnam	56,604	2,074	3.66%	0	0.00%
Raleigh	74,452	1,172	1.57%	730	62.25%
Randolph	28,763	876	3.05%	222	25.33%

County	Total County Population	Total Population	% Total Population	Highly Vulnerable Population	% Highly Vulnerable Population
Ritchie	9,747	144	1.48%	0	0.00%
Roane	13,831	527	3.81%	99	18.78%
Summers	12,710	1,171	9.21%	408	34.84%
Taylor	16,817	218	1.30%	63	28.83%
Tucker	6,943	464	6.68%	0	0.00%
Tyler	8,736	17	0.19%	0	0.00%
Upshur	24,451	400	1.64%	0	0.00%
Wayne	39,952	1,944	4.87%	0	0.00%
Webster	8,289	369	4.45%	0	0.00%
Wetzel	15,291	88	0.58%	0	0.00%
Wirt	5,764	82	1.42%	0	0.00%
Wood	84,387	515	0.61%	18	3.40%
Wyoming	20,890	616	2.95%	68	11.06%
Total	**1,807,426**	**49,465**	**2.74%**	**10,111**	**20.44%**

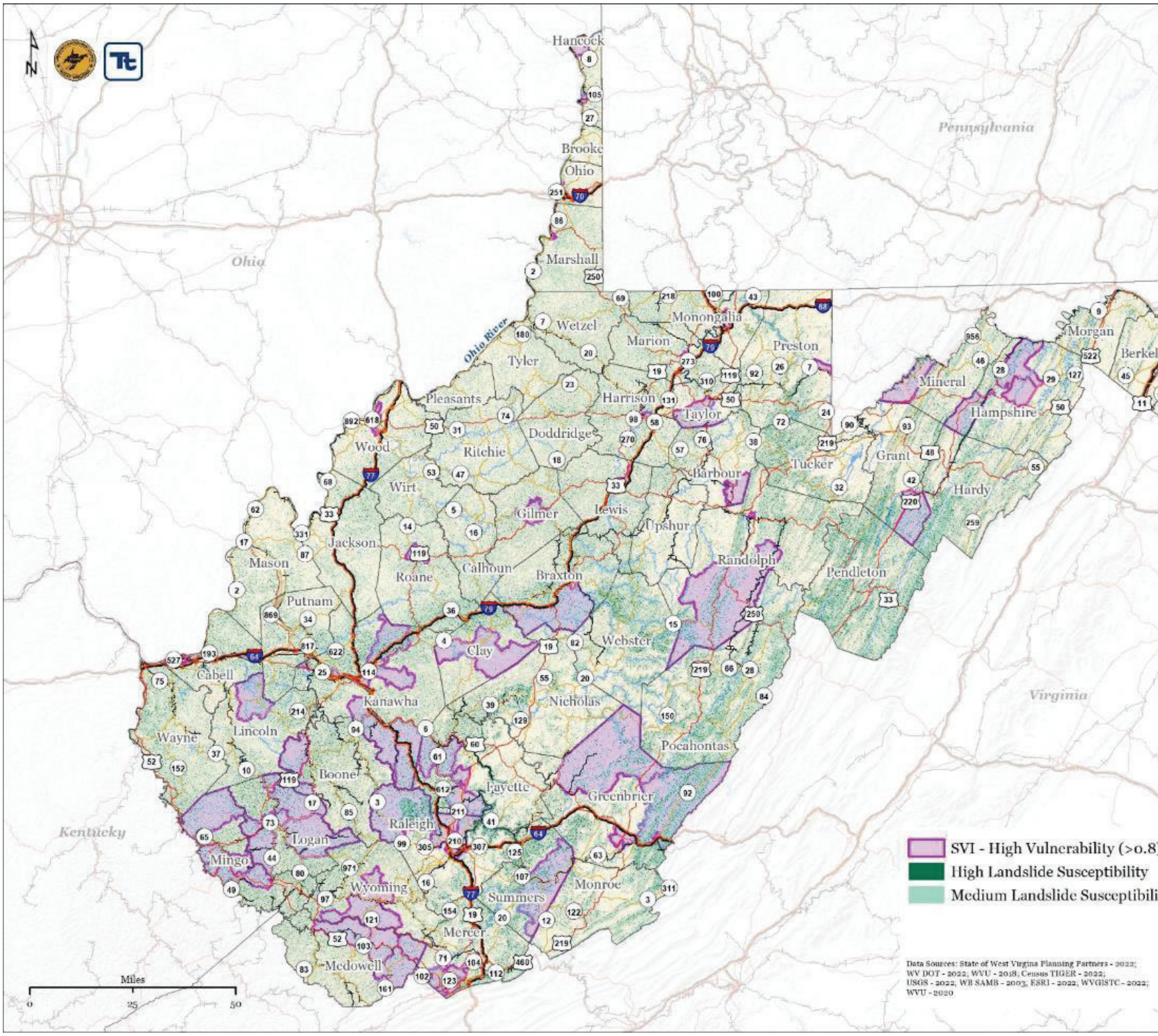
Source CDC 2020; WVU 2020

Impacts on Socially Vulnerable Populations

Socially vulnerable populations are most susceptible to the landslide hazard 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 evacuate. Power and communication failures due to landslides can also create problems for vulnerable populations and businesses.

Figure 5.7-16 illustrates the location of the socially vulnerable populations within the landslide susceptibility hazard areas. Of the total population located within the high susceptibility landslide hazard area (49,465) 20.4 percent are identified as being socially vulnerable. These residents may be displaced by the destruction of their homes, requiring them to seek temporary shelter with friends and family or in emergency shelters. These populations may also lack access to vehicles for any necessary evacuations. Logan County has the greatest percentage (66.5 percent) of its socially vulnerable population located in the high susceptibility landslide hazard areas, followed by Raleigh County, at 62.25 percent. Of the total population exposed, 10,111 persons are identified as socially vulnerable and may be impacted more severely by landslide events.

Figure 5.7-16: Social Vulnerability Index for Landslides



Future Changes That May Impact State Vulnerability

Understanding future changes that may impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors in examining potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including impacts of future conditions.

Potential or Projected Development

It is anticipated that any new development in the high susceptibility landslide hazard area will be exposed to the hazard. Further development in the hazard area would expose the population and structures to the landslide hazard.

Projected Changes in Population

West Virginia is losing population faster than recent forecasts, which do not account for county-by-county increases. According to population projections in 2022 from the WVU Bureau of Business and Economic Research, West Virginia's population was projected to fall from 1,793,716 in 2020 to 1,705,509 in 2040 (West Virginia University 2022). As of July 1, 2019, according to estimates by the U.S. Census Bureau, West Virginia's total population is 1,792,147, representing a 3.3 percent decline since 2010 (approximately 60,487 fewer residents). West Virginia lost population both naturally, with 19,000 more deaths than births, and through migration, with 27,000 more people leaving the state than moving in (WVDOT 2020). Refer to Section 2 (County Profile), which includes a discussion on population trends for the County. As population in the state continues to decrease there is the potential that less people will reside or work within the state's high susceptibility landslide hazard area.

Other Factors of Change

Projections may alter the stability of land in the high susceptibility landslide hazard area. More frequent and intense rain and storms can increase the likelihood of soil erosion and movement. Similarly, due to projected increases in temperatures, there may be an escalated risk of wildfires, which can also be a precursor to soil erosion and movement.

Current land uses may be exacerbating the possibility of landslides occurring. As discussed in Impacts to the Environment, forested areas may be seeing an increase in landslides due to deforestation caused by logging activities.

5.7.3 Consequence Analysis

Impacts to the Public

Residents, buildings, and infrastructure located within the high susceptibility landslide hazard areas of the state are the most at risk to landslides. Generally, a landslide event would be an isolated incident and impact the populations within the immediate area of the incident, particularly if the population is located downslope. Loss of property can also leave individuals homeless, which can be detrimental for vulnerable populations, particularly those who rely on medical equipment or home-health care.

An analysis performed on the population of the State revealed that an estimated 49,465 West Virginian residents are located in the high susceptibility landslide hazard area and 20.44 percent are highly vulnerable. Please reference Table 5.7-9 for more information regarding populations in the high susceptibility landslide hazard area.

Impacts to Responders

Significant landslide events may hinder the delivery of emergency services. Landslides can cause delays or impair rail and road transportation, halt supply chains, and disrupt medical and emergency services that provide lifesaving support. Landslide events can collapse buildings and knock down trees and power lines, making it difficult for responders to get to reach an impacted area and maintain communications with one another; communications may also be impacted for the public if any communication towers are impacted by the subsidence event.

Responders, especially those in search and rescue or recovery operations, should maintain situational awareness when entering a structure with damage from a landslide. Unstable ground may cause the structure to collapse, as land movements have been known to cause the support and stability of a structure's foundation to collapse or sink. Responders should listen and watch for any additional rushing water or mud, as it will signal another landslide is underway. Unusual sounds such as trees cracking or boulders knocking together, might indicate moving debris. A faint rumbling sound that increases in volume is noticeable as the landslide nears (U.S. DHS 2022).

Impacts to Continuity of Operations

Landslide events have the potential to bring down trees, electrical wires, telephone poles and lines, and communication towers. Communication and power can be disrupted for extended periods of time while utility companies repair damages, impacting day-to-day operations. Larger events may interrupt transportation flow in communities as damages could include downed trees, utility line, and structural collapses near major roadways. If damages are along major throughways, the roads may be impacted for an undetermined amount of time, stopping the flow of supplies and disrupting emergency and medical services. Although there are only two state facilities in the high susceptibility landslide hazard area, one is identified as a critical facility.

Impacts to Property, Facilities, and Infrastructure

Landslides have the potential to cause extensive amounts of property damage. Recognizing signs of slope instability can help avoid future costly repairs. Signs of slope instability include:

- Cracks or fissures in the ground,
- Cracks in or displacement of paved surfaces,
- Cracked or bent walls, foundations, and chimneys,
- Tilted, warped, or cracked retaining walls,
- Tilted fence posts, utility poles, signs, etc.,
- Curved tree trunks, indicating soil creep, and
- Irregular topography indicating the occurrence of past landslides (WVU 2020).

Infrastructure may also incur damages from landslides. Roadways, bridge, and rail lines may have soil and debris strewn across the easements, making it dangerous for drivers and operators to attempt to utilize the structures. Damages to these structures could interrupt public and private methods of transportation, including public buses and trains, commercial vehicles and trains, and emergency response vehicles.

Power lines, although generally elevated above steep slopes, may be impacted as sediment and debris tumble downslope, knocking down the towers supporting them. The loss of power would impact methods of communication, making it difficult or nearly impossible for individuals to connect one another.

Table 5.7-10 details state roads that are located in the high susceptibility landslide area; counties without any vulnerable state roads are not shown in the table. In total, the state has 7.98 miles of roadway that is located in the high susceptibility landslide hazard area, with Pocahontas County having the most miles of state roadways in the hazard area (1.02 miles).

Table 5.7-10: State Roads in the High Susceptibility Landslide Area

State Roads located within the High Susceptibility Landslide Hazard Area		State Roads located within the High Susceptibility Landslide Hazard Area	
County	**Mileage of Roadway**	**County**	**Mileage of Roadway**
Barbour	0.19	Mingo	0.02
Berkeley	0.03	Monongalia	0.02
Braxton	0.27	Monroe	0.01
Calhoun	0.05	Morgan	0.01
Doddridge	0.01	Nicholas	0.06
Fayette	0.06	Pocahontas	1.02
Gilmer	0.16	Preston	0.02
Grant	0.01	Raleigh	0.66
Hampshire	0.02	Randolph	0.28
Jefferson	0.12	Ritchie	0.02
Kanawha	0.03	Summers	0.52
Lewis	0.02	Taylor	0.02
Logan	0.63	Tucker	0.06
Marion	0.01	Upshur	0.15
Marshall	0.01	Webster	0.90
McDowell	0.93	Wetzel	0.08
Mercer	0.56	Wood	0.04
Mineral	0.19	Wyoming	0.75
		Total	**7.98**

Source WVU 2020; WVDOT 2021

Impacts to the Environment

Landslides change and modify the landscape it interrupts. The hazard can overwhelm and pollute bodies of water with excess sediment deposits; in some cases, the amount of sediment may be enough to dam streams and rivers, impacting water quality and habitats (Geertsema, Highland and Vaugeouis 2009).

West Virginia is a largely forested state, of which landslides can also impact. Forest destruction caused by landslides is a result of heavy rains and soil movement. Areas which participate in logging, which is the process of cutting, processing, and moving trees to a location or transport, may have an increased likelihood to be impacted by landslides. Each of the state's 55 counties participate in the wood industry; the forest products sector is the largest employer in many of the counties (West Virginia Division of Forestry 2021). The removal of trees in forested areas adversely impacts forested areas and increases vulnerability to the landslide hazard as the soil which was once held in place by the roots of the trees, and the water which was absorbed by the trees, become loose and susceptible to becoming eroded or cause landslides (Geertsema, Highland and Vaugeouis 2009).

Impacts to the Economic Condition of the State

Landslides can impose direct and indirect impacts on the state's economy. Direct costs include actual damage sustained to buildings, property, and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity, are difficult to measure. There are 1,117 State-owned or leased facilities located throughout West Virginia. While landslides can cause significant damage to state assets, there are no standard formulas for estimating associated losses. In the event of complete losses, the two state facilities located the high susceptibility landslide hazard area have a replacement cost value of over $2.1 million.

Impacts to Public Confidence in State Governance

The public confidence in state governance would mainly depend on how effective the State has been in the past at preparing for and responding to landslides. Public confidence also depends on the size of the event and the preparation the State takes for each potential event. In general, if the State is transparent in sharing relevant information with the public regarding landslides and demonstrates its reliability to the public through availability of programs and services relevant to landslides, then the public will remain confident in the State's governance (Chew, et al. 2021).

The West Virginia Geological and Economic Survey's website offers information on how homeowners can prepare for various geologic hazards, including landslides.

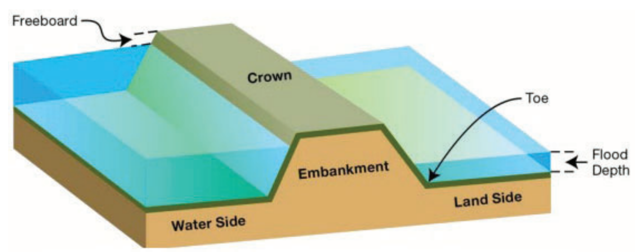
West Virginia's Division of Emergency Management partnered with FEMA and the WVU GISTC to create guidance for homeowners on how to recognize landslide risk on their property and how to mitigate that risk. Similarly, these organizations partnered to create a landslide risk assessment for the State and its Major Land Resource Areas.

5.8. Levee Failure

2023 SHMP Update Changes

- The hazard profile was reorganized and significantly enhanced to include detailed descriptions of the following: hazard definition, location, extent, previous occurrences, and probability of future occurrences (including how future conditions may impact the hazard).
- Levee failure events that occurred in the State of West Virginia (the State) from January 1, 2018, through December 31, 2022, were researched for this 2023 SHMP update.
- New and updated figures from federal, state, and local agencies are incorporated.
- Analyzed state asset exposure to levee failures.

5.8.1. Hazard Profile



Title 44, Chapter 1, Section 59.1 of the Code of Federal Regulations (44 C.F.R. §59.1) defines a levee as "a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to reduce risk from temporary flooding" and a levee system as "a flood protection system which consists of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices" (44 C.F.R. §59.1). Levees are built along waterways, usually rivers, to reduce the flood risk of areas on the landward side of the levee (FEMA 2020).

Hazard Description

Levees can pose a risk to communities if not designed, constructed, operated, and maintained properly. Causes of levee failure include a flood exceeding the capacity of the levee, lack of maintenance, inadequate foundations, erosion, seepage, earthquakes or other seismic activity, or even animals burrowing into the earth that forms the levee (FEMA 2020). In the event of a catastrophic levee failure, the energy the water released from even a small structure can cause extensive property damage, injury, and potential loss of life. This is especially true in West Virginia, where many communities lie along steep (or high) gradient streams and rivers within narrow valleys.

Failure of any one of the levees in West Virginia has the potential to inundate the surrounding areas, particularly those that are low-lying. Levee failure can occur with little or no advance warning; however, there is likely to be some warning for larger levees that are being loaded by water and not performing adequately.

LOCATION

According to the U.S. Army Corps of Engineers National Levee Database (NLD) there are 21 levees in the State (USACE 2023). Of these 21 levees, 18 were federally constructed and turned over to the public for operations and maintenance, and 5 were locally constructed, operated, and maintained. However, two levees (East Bayard and West Bayard) are listed in the NLD as both federally constructed and locally constructed. Table 5.8-1 shows the name, location, and ownership of levees in the state. All 21 levees in the state were constructed for flood risk protection. They are shown on the map in Figure 5.8-1.

Table 5.8-1. Levees in West Virginia

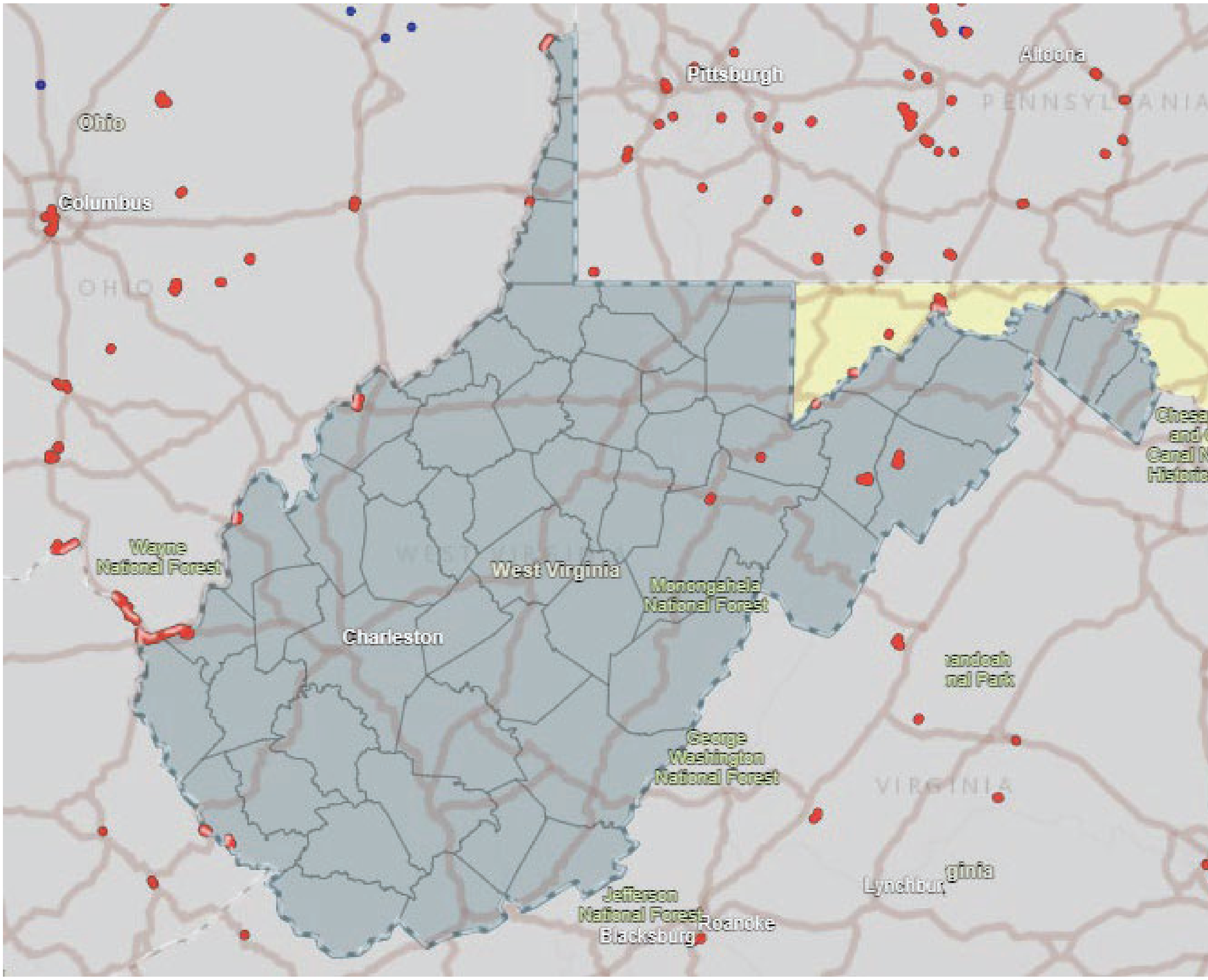
Name	Location	Summary
Benwood – Left Bank Ohio River, Locally Preferred Plan (LPP)	Benwood, Marshall County	Non-federally authorized urban flood protection project maintained by the City of Benwood. Levee includes 1,900 feet of earthen levee, a concrete floodwall, a total of five gravity drains structures, three pump station and two gate closure structures incorporated to allow for rail traffic. Rail lines are no longer in use and track have been removed.
Blackwater River Levee (Left Bank)	Hendricks, Tucker County	No data entered
Blackwater River Levee (Right Bank)	Hendricks, Tucker County	No data entered
Blaine Flood Risk Management System (FRMS), Flood Risk Management Project (FRMP)	Mineral County	Part of the Kitzmiller federally authorized and constructed FRMP. Designed to provide flood risk managemen for discharge of 52,000 cubic feet per second on the North Branch of the Potomac River.
Ceredo-Kenova, WV, LPP	Kenova, Wayne County	USACE constructed the Ceredo-Kenova System in 1940 to provide flood damage reduction to the Town of Ceredo and City of Kenova. The Town and City now operate and maintain their respective segments.
East Bayard, FRMS, FRMP	Bayard, Grant County	Part of Federally authorized and constructed FRMP. System contains both East and West Bayard. Originally designed to provide flood risk management for a discharge of 5,000 cubic feet per second on Buffalo Creek Both systems are owned and maintained by the Town of Bayard.
Elkins, WV – Tygart River	Elkins, Randolph County	A federally authorized urban flood protection project that was Designed by USACE and maintained and operated by City of Elkins. The protection levee is 43 feet high and includes 5’-2”H x 6’-2”V reinforced concrete outlet structures with sluice gates and emergency closures.
Huntington, WV, LPP	Huntington, Cabell County	The LPP serves as a flood damage reduction measure to urban lands and consists of two systems: Huntingto and Guyandotte systems. The project is federally authorized, non-federally operated and maintained, and does not serve as a multipurpose project.
Huntington, WV, LPP – Guyandotte	Huntington, Cabell County	The project is federally authorized, non-federally operated and maintained, and does not serve as a multipurpose project.
Magnolia Ringwall, WV	Matewan, Mingo County	The Magnolia School Ringwall Project is located along the right descending bank of the Tug Fork of the Big Sandy River. The project is approximately 2.6 miles downstream of the Town of Matewan, WV. The project i located on the WV/KY border in Mingo County. The project consists of 2,200 feet of concrete I-Wall type

Name	Location	Summary
		floodwall and steel sheet piling. The project also has about 36 feet of levee constructed to provide access int the project in lieu of another traffic closure. The levee is constructed primarily of impervious soils, and the compaction efforts and construction methods were controlled.
Matewan, WV, LPP	Matewan, Mingo County	Situated on the Tug Fork of the Big Sandy River in Mingo County, WV, the Matewan Local Protection Projec reduces flood risk for the Town of Matewan. The levee is owned by Mingo County but is operated and maintained by the Town of Matewan. The Matewan levee system consists of about ½ mile of concrete floodwall, ten gate closures, and one storm water pump station.
North Moorefield	Moorefield, Hardy County	The Moorefield FRMP consists of two hydraulically independent systems located at the confluence of the South Fork and the South Branch Potomac River in western Hardy County, West Virginia. The North Moorefield system is comprised of 14,140 feet of earthen levee, 898 feet of half-levee with a mechanically stabilized earth (MSE) wall, 332 feet of double-sided MSE wall, a railroad closure, and 15 drainage structures
North Petersburg	Petersburg, Grant County	The Petersburg LPP consists of two hydraulically independent systems; one on the north and one on the sou side of the South Branch of the Potomac River. It consists of 7,000 feet of zoned-earth levees and 913 feet c floodwall (steel sheet piling with precast concrete panels on the landside-face of the piles) along the South Branch, and 4,100 feet of impervious embankment along Lunice Creek.
Parkersburg, WV, LPP	Parkersburg, Wood County	USACE constructed the Parkersburg Levee System in 1950 to provide flood damage reduction to the City of Parkersburg, WV, and now operates and maintains the system. The levee system consists of approximately 1 miles of earthen embankment and 2.0 miles of concrete wall for a total length of approximately 3.8 miles. Th levee system is located at the confluence of the Little Kanawha and Ohio Rivers. The leveed area includes residential and commercial areas with a population of almost 5,500 people and includes 835 homes and businesses.
Point Pleasant, WV, LPP	Point Pleasant, Mason County	USACE constructed the Point Pleasant Levee System in 1951 to provide flood damage reduction to the City c Point Pleasant, WV who now operates and maintains the system. The levee system consists of 0.9 miles of earthen embankment and 1.4 miles of concrete wall for a total length of 2.3 miles. The levee system is locate at the confluence of the Ohio and Kanawha Rivers in Mason County. The leveed area includes residential an commercial areas with a population of over 1,200 people and includes 580 homes and businesses.
Ridgeley	Ridgeley, Mineral County	The Cumberland-Ridgeley Flood Risk Management (FRM) Project is divided into three independent flood damage reduction (FDR) Systems-- Cumberland, West Cumberland, and Ridgeley. All three systems are operated and maintained by the City of Cumberland, Maryland. The Ridgeley System is located along the rig bank of the North Branch Potomac River near the confluence with Wills Creek and provides flood risk reduction for the Town of Ridgeley, WV. The project consists of approximately 7,000 feet of levee embankment, ~ 600 feet of floodwall, 2 sandbag closure structures, and 1 pump station. The line of protectic also consists of roughly 800 feet of natural high ground.
South Moorefield	Moorefield, Hardy County	The system consists of two hydraulically independent systems: North Moorefield and South Moorefield. It w designed to provide 0.01 annual chance of exceedance (ACE) protection, but recent reanalysis indicates the design provides about 0.015 ACE protection, and the 0.01 ACE would fully load the project. The South

Name	Location	Summary
		Moorefield system is comprised of 9,115 feet of levee, a 20'-wide by 6'8"-high swing gate at a railroad closu that is loaded by about the 0.04 ACE event, and 7 drainage structures.
South Petersburg, LPP	Petersburg, Grant County	The Petersburg LPP consists of two hydraulically independent systems; one on the north and one on the sou side of the South Branch of the Potomac River. The South Petersburg system consists of 11,560 feet of eart levees and 4 drainage structures to provide conveyance of water through the line of protection.
West Bayard	Bayard, Grant County	The West Bayard FRMS is part of the Bayard federally authorized and constructed FRMP located in Grant County, West Virginia, along both banks of Buffalo Creek, immediately upstream of its confluence with the North Fork of the Potomac River. The project includes two systems: East Bayard and West Bayard. The proje was originally designed to provide flood risk management for a discharge of 5,000 cubic feet per second (cf on Buffalo Creek. Both systems are operated and maintained locally by the Town of Bayard, West Virginia. T West Bayard system is comprised of one segment and is located along the west bank (left descending) of Buffalo Creek immediately upstream of its confluence with the North Branch of the Potomac River. The system reduces the flood risk from Buffalo Creek for the Town of Bayard.
West Williamson, WV, LPP	Williamson, Mingo County	The West Williamson levee system is located on the Tug Fork of the Big Sandy River and reduces flood risk f the western area of the City of Williamson, West Virginia. The levee is owned by Mingo County but is operat and maintained by the City of Williamson. The system consists of about 1 mile of concrete floodwall and 12 feet of earthen levee. It has one pumping station and six traffic openings that must be closed quickly during flood event.
Williamson, WV, LPP	Williamson, Mingo County	The Williamson levee system is located on the Tug Fork of the Big Sandy River and reduces flood risk for th central business district of Williamson, West Virginia. The levee is owned by Mingo County but is operated a maintained by the City of Williamson. The system is ¾ miles long with ½ mile of 53-ft tall steel sheet pile cel and ¼ mile of concrete floodwall. It has two pumping stations and five traffic openings that must be closed quickly during a flood event.

Source: USACE 2023
Notes: *FRMS – Flood Risk Management System, FRMP – Flood Risk Management Project, LPP – Local Protection Project, USACE – United State Ar*

Figure 5.8-1. Levees in West Virginia



Source: USACE 2023

There are levee systems that are identified as Moderate/High risk. These systems have a large number of residents and businesses located within the protected area. Failure of any one of the levees in West Virginia has the potential to inundate the surrounding areas, particularly those that are low-lying.

Table 5.8-2 summarizes the number of levee systems and the area that they protect by county. Eight levee systems are located in Grant and Mingo County alone.

Table 5.8-2. Total Square Miles of Levee Failure Inundation Area in each County

County	Total Levee Count	Total Square Miles of Land Area	Total Square Miles of Land Area (Excluding Waterbodies) Located in the Levee Failure Inundation Hazard Areas	
			Total Square Miles	Percent of Total
Barbour	0	342	0.00	0.0%
Berkeley	0	321	0.00	0.0%
Boone	0	503	0.00	0.0%
Braxton	0	513	0.00	0.0%
Brooke	0	93	0.00	0.0%
Cabell	2*	288	5.56	1.9%
Calhoun	0	280	0.00	0.0%
Clay	0	344	0.00	0.0%
Doddridge	0	320	0.00	0.0%
Fayette	0	668	0.00	0.0%
Gilmer	0	339	0.00	0.0%
Grant	4	477	1.08	0.2%
Greenbrier	0	1,022	0.00	0.0%
Hampshire	0	644	0.00	0.0%
Hancock	0	88	0.00	0.0%
Hardy	2	584	1.33	0.2%
Harrison	0	416	0.00	0.0%
Jackson	0	470	0.00	0.0%
Jefferson	0	211	0.00	0.0%
Kanawha	0	910	0.00	0.0%
Lewis	0	385	0.00	0.0%
Lincoln	0	438	0.00	0.0%
Logan	0	455	0.00	0.0%
Marion	0	311	0.00	0.0%
Marshall	1	311	0.05	0.0%
Mason	1	444	0.37	0.1%
McDowell	0	535	0.00	0.0%
Mercer	0	420	0.00	0.0%
Mineral	2	328	0.15	0.0%
Mingo	4	423	0.33	0.1%
Monongalia	0	363	0.00	0.0%

County	Total Levee Count	Total Square Miles of Land Area	Total Square Miles of Land Area (Excluding Waterbodies) Located in the Levee Failure Inundation Hazard Areas	
			Total Square Miles	Percent of Total
Monroe	0	473	0.00	0.0%
Morgan	0	229	0.00	0.0%
Nicholas	0	649	0.00	0.0%
Ohio	0	109	0.00	0.0%
Pendleton	0	698	0.00	0.0%
Pleasants	0	134	0.00	0.0%
Pocahontas	0	940	0.00	0.0%
Preston	0	649	0.00	0.0%
Putnam	0	350	0.00	0.0%
Raleigh	0	607	0.00	0.0%
Randolph	1	1,039	1.72	0.2%
Ritchie	0	454	0.00	0.0%
Roane	0	483	0.00	0.0%
Summers	0	365	0.00	0.0%
Taylor	0	173	0.00	0.0%
Tucker	2	415	0.04	0.0%
Tyler	0	261	0.00	0.0%
Upshur	0	354	0.00	0.0%
Wayne	2*	509	2.15	0.4%
Webster	0	556	0.00	0.0%
Wetzel	0	361	0.00	0.0%
Wirt	0	235	0.00	0.0%
Wood	1	377	1.19	0.3%
Wyoming	0	501	0.00	0.0%
Total	**22***	**24,167**	**13.97**	**0.1%**

Source: USACE 2023; West Virginia University GIS Technical Center (WVU GISTC) 2022
Notes:
**The Huntington, WV, LPP levee is listed in the NLD in both Cabell and Wayne Counties. Therefore, it is double counted in the totals above.*
The Square Mileage in this table excludes waterbody area.

EXTENT

A complete levee failure, like a dam failure, is infrequent and typically coincides with incidents like heavy rainfall or tropical cyclones. In the event of a levee failure, floodwaters may ultimately inundate the protected area landward of the levee. The extent of inundation is dependent on the flooding intensity. Failure of a levee during a 1 percent annual chance flood will inundate the approximate 100-year flood plain previously protected by the levee. Residential and commercial buildings located nearest the levee failure or breach location will suffer the most damage from the initial embankment failure flood wave. Landward buildings will be damaged by inundation (FEMA 2020).

Warning Time

The amount of time that a community may have before a levee fails varies by the cause of the levee failure. A levee failing due to seismic activity will likely have no warning time. The possibility of a levee failure due to overtopping during a flood event can be identified by monitoring flood levels and comparing them to the design elevation of the levee; when a river with a levee is predicted to flood higher than the levee, the community can issue warnings of the possibility of a failure. Levee failure due to seepage, erosion, or animal activity may be predicted well ahead of time during routine inspections and maintenance of the levee, assuming that inspections and maintenance occur.

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, the State was not included in any disaster (DR) or emergency (EM) declarations for levee failure events (FEMA 2023).

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2016 and 2022, West Virginia was not included in any agricultural disaster declarations pertaining to levee failure (USDA 2023).

Previous Events

No records of levee failure incidents in the State were identified during the SHMP update.

Probability of Future Hazard Events

Overall Probability

The probability of a levee failure is difficult to quantify. As discussed above and shown in Table 5.8-3, the likelihood of a future levee failure cannot be determined based on past occurrences, as there have been none in the state.

Table 5.8-3. Probability of Future Levee Failure Events

Hazard Type	Number of Occurrences	Percent Chance of Occurrence in Any Given Year
Levee Failure	None identified	Cannot be determined based on past events

However, there is a concern for the possibility of levee failures nationwide, including in West Virginia, based on the condition and maintenance of the levees in the state. In its 2021 Infrastructure Report Card, the American Society of Civil Engineers (ASCE) noted a need for significant funding for the maintenance and improvement of high-risk levees across the country (ASCE 2022):

> "In 2018, it was [estimated] that $21 billion is needed to improve and maintain the moderate-, high-, and very high-risk levees in the USACE's levee portfolio. This estimate does not include any of the levees

outside of the USACE portfolio, so the actual cost to improve and maintain levees is unknown and is likely much higher. Federal funding for non-federally operated and maintained levees is limited, and most levee operation, maintenance, and repair is the responsibility of the levee owner."

This is of particular concern given the number of levees across West Virginia, their average age, and the number of residents being protected.

Projected Future Conditions

Future climate conditions may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Because levee failure is often caused by excessive rainfall, it is appropriate to relate the future vulnerability of levees directly with the potential for increased rainfall.

As predictions indicate increased precipitation and more extreme weather events, the flood control and impoundment infrastructure in West Virginia becomes more of a concern. Like most of the country, the infrastructure in West Virginia is overwhelmingly privately owned and maintained, and it is aging to the end of its design life in many cases. The occurrence of more frequent high-intensity rainfall events may create conditions that exceed the original design criteria of these aging facilities.

5.8.2. Vulnerability Assessment

This section describes the vulnerability of state facilities, critical facilities across the state, and people to the levee failure hazard.

State Assets

To assess the vulnerability of the state-owned or -leased facilities, GIS software was used to overlay the statewide levee inundation hazard area with the state facilities. Table 5.8-4 and Table 5.8-5 summarize the state buildings located in the areas protected by levees by county and by agency, respectively. The spatial analysis indicates that there are 54 state-owned or -leased buildings vulnerable to levee failure. Cabell County has the highest number of state buildings (13) and the highest replacement cost value ($113.2 million) exposed to this hazard. The Supreme Court of Appeals has the most state facilities (11), and Marshall University has the highest replacement cost value ($82.7 million) in the levee hazard area.

Table 5.8-4. State Buildings Exposed to Levee Failure by County

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Barbour	0	$0	$0	$0
Berkeley	0	$0	$0	$0
Boone	0	$0	$0	$0
Braxton	0	$0	$0	$0
Brooke	0	$0	$0	$0
Cabell	13	$107,719,188	$5,440,383	$113,159,571

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Calhoun	0	$0	$0	$0
Clay	0	$0	$0	$0
Doddridge	0	$0	$0	$0
Fayette	0	$0	$0	$0
Gilmer	0	$0	$0	$0
Grant	3	$423,675	$846,800	$1,270,475
Greenbrier	0	$0	$0	$0
Hampshire	0	$0	$0	$0
Hancock	0	$0	$0	$0
Hardy	6	$0	$485,000	$485,000
Harrison	0	$0	$0	$0
Jackson	0	$0	$0	$0
Jefferson	0	$0	$0	$0
Kanawha	0	$0	$0	$0
Lewis	0	$0	$0	$0
Lincoln	0	$0	$0	$0
Logan	0	$0	$0	$0
Marion	0	$0	$0	$0
Marshall	0	$0	$0	$0
Mason	7	$225,000	$406,050	$631,050
McDowell	0	$0	$0	$0
Mercer	0	$0	$0	$0
Mineral	0	$0	$0	$0
Mingo	11	$15,995,822	$4,415,300	$20,411,122
Monongalia	0	$0	$0	$0
Monroe	0	$0	$0	$0
Morgan	0	$0	$0	$0
Nicholas	0	$0	$0	$0
Ohio	0	$0	$0	$0
Pendleton	0	$0	$0	$0
Pleasants	0	$0	$0	$0
Pocahontas	0	$0	$0	$0
Preston	0	$0	$0	$0
Putnam	0	$0	$0	$0
Raleigh	0	$0	$0	$0
Randolph	4	$401,784	$386,000	$787,784
Ritchie	0	$0	$0	$0

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Roane	0	$0	$0	$0
Summers	0	$0	$0	$0
Taylor	0	$0	$0	$0
Tucker	0	$0	$0	$0
Tyler	0	$0	$0	$0
Upshur	0	$0	$0	$0
Wayne	0	$0	$0	$0
Webster	0	$0	$0	$0
Wetzel	0	$0	$0	$0
Wirt	0	$0	$0	$0
Wood	10	$8,765,081	$1,603,182	$10,368,263
Wyoming	0	$0	$0	$0
Total	**54**	**$133,530,550**	**$13,582,715**	**$147,113,265**

Source: *WVBRIM 2022; USACE 2023*

Table 5.8-5. State Buildings Exposed to Levee Failure by Agency

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Adjutant General's Office State of West Virginia	0	$0	$0	$0
Administration, Secretary of Department of Administration	0	$0	$0	$0
Agriculture, Department of State of West Virginia	0	$0	$0	$0
Air And Environmental Quality Boards State of West Virginia	0	$0	$0	$0
Alcohol Beverage Control Administration State of West Virginia	0	$0	$0	$0
Architects, Board of State of West Virginia	0	$0	$0	$0
Armory Board State of West Virginia	2	$0	$0	$0
Arts, Culture & History, Department of State of West Virginia	0	$0	$0	$0
Attorney General, Office of The State of West Virginia	0	$0	$0	$0
Aviation, Division of	0	$0	$0	$0
Bar, State State of West Virginia	0	$0	$0	$0
Barbers & Cosmetologists, Board of State of West Virginia	0	$0	$0	$0
Blue Ridge Community & Technical College	0	$0	$0	$0

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Bluefield State College	0	$0	$0	$0
Board of Treasury Investments	0	$0	$0	$0
Bridgevalley Community & Tech College	0	$0	$0	$0
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	0	$0	$0	$0
Commission For National And Community Service, WV	0	$0	$0	$0
Concord University	0	$0	$0	$0
Conservation Agency, West Virginia State of West Virginia	2	$0	$15,400	$15,400
Consolidated Public Retirement Board Department of Administration	0	$0	$0	$0
Consumer Advocate, Division of WV Public Service Commission	0	$0	$0	$0
Corrections, Division of State of West Virginia	0	$0	$0	$0
Courthouse Facilities Improvement Authority	0	$0	$0	$0
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	0	$0	$0	$0
Dietitians, Board of Licensed	0	$0	$0	$0
Eastern Panhandle Instructional Coop	1	$0	$20,000	$20,000
Eastern WV Community & Tech. College	1	$423,675	$736,000	$1,159,675
Economic Development Authority State of West Virginia	0	$0	$0	$0
Economic Development, WV Dept of	0	$0	$0	$0
Education, Department of State of West Virginia	1	$0	$100,000	$100,000
Educational Broadcasting Authority State of West Virginia	0	$0	$0	$0
Enterprise Resource Planning Board, WV	0	$0	$0	$0
Environmental Protection, Division of State of West Virginia	1	$0	$50,000	$50,000
Ethics Commission, West Virginia Department of Administration	0	$0	$0	$0
Examiners In Counseling, Board of State of West Virginia	0	$0	$0	$0
Fairmont State University	0	$0	$0	$0
Fire Commission State of West Virginia	0	$0	$0	$0
Fleet Management Office, Dept of Admin State of West Virginia	0	$0	$0	$0
Forestry, Division of State of West Virginia	0	$0	$0	$0
General Services Division Department of Administration	1	$10,184,000	$500,000	$10,684,000

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Geological And Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	0	$0	$0	$0
Governor, Office of The State of West Virginia	0	$0	$0	$0
Health & Human Resources, Department of State of West Virginia	4	$480,000	$1,125,000	$1,605,000
Higher Education Policy Commission, WV	0	$0	$0	$0
Highways, Division of State of West Virginia	5	$19,344,938	$1,090,000	$20,434,938
Homeland Security & Emergency Management Division	0	$0	$0	$0
Insurance Commissioner, Office of The State of West Virginia	0	$0	$0	$0
Investment Management Board, WV State of West Virginia	0	$0	$0	$0
Joint Committee On Government & Finance State of West Virginia	0	$0	$0	$0
Justice & Community Services, Div. of	0	$0	$0	$0
Juvenile Services, Division of	0	$0	$0	$0
Labor, Division of State of West Virginia	0	$0	$0	$0
Land Division/Dept of Agriculture State of West Virginia	0	$0	$0	$0
Landscape Architects, Board of State of West Virginia	0	$0	$0	$0
Library Commission State of West Virginia	0	$0	$0	$0
Lottery Commission State of West Virginia	0	$0	$0	$0
Marshall University	1	$78,454,356	$4,269,858	$82,724,214
Military Affairs, Secretary of And Public Safety	0	$0	$0	$0
Miner's Health Safety, Division of And Training, State of West Virginia	0	$0	$0	$0
Motor Vehicles, Division of State of West Virginia	2	$0	$250,000	$250,000
Mountain State Esc	0	$0	$0	$0
Mountwest Community & Technical College	0	$0	$0	$0
National Coal Heritage Area Authority	0	$0	$0	$0
Natural Resources, Division of State of West Virginia	1	$0	$200,000	$200,000
New River Community & Technical College	0	$0	$0	$0
Northern Community & Tech College, WV College Square	0	$0	$0	$0
Occupational Therapy Board State of West Virginia	0	$0	$0	$0
Office of Technology/Is&C Department of Administration	0	$0	$0	$0
Osteopathic Medicine, WV Board of State of West Virginia	0	$0	$0	$0

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Osteopathic Medicine, WV School of	2	$0	$24,425	$24,425
Parks, West Virginia State C\O Division of Natural Resources	5	$8,760,781	$795,682	$9,556,463
Pharmacy, Board of State of West Virginia	0	$0	$0	$0
Physical Therapy, Board of State of West Virginia	0	$0	$0	$0
Pierpont Community And Technical College	0	$0	$0	$0
Practical Nurses, Board of State of West Virginia	0	$0	$0	$0
Prosecuting Attorneys Institute, WV	0	$0	$0	$0
Psychologists Examiners, Board of State of West Virginia	0	$0	$0	$0
Public Service Commission State of West Virginia	0	$0	$0	$0
Purchasing, Division of Department of Administration	0	$0	$0	$0
Rail Authority State of West Virginia	0	$0	$0	$0
Real Estate Commission State of West Virginia	0	$0	$0	$0
Regional Jail & Corr. Fac. Authority State of West Virginia	0	$0	$0	$0
Registered Nurses, Board of State of West Virginia	0	$0	$0	$0
Rehabilitation Services Division of Commerce	3	$0	$125,650	$125,650
Respiratory Care, WV Board of	0	$0	$0	$0
School Building Authority, West Virginia	0	$0	$0	$0
Schools For The Deaf And The Blind State of West Virginia	0	$0	$0	$0
Senior Services, Bureau of State of West Virginia	0	$0	$0	$0
Shepherd University	0	$0	$0	$0
Southern Educational Services Coop	0	$0	$0	$0
Southern WV Community & Tech College	1	$15,882,800	$3,515,000	$19,397,800
Speech Pathology & Audiology Examiners West Virginia Board of	0	$0	$0	$0
State Police, West Virginia Dept of Military Affairs & Public Safety	2	$0	$0	$0
Supreme Court of Appeals State of West Virginia	11	$0	$662,700	$662,700
Tax Appeals, WV Office of	0	$0	$0	$0
Tax Department State of West Virginia	0	$0	$0	$0
Treasurer of State State of West Virginia	0	$0	$0	$0
University Physicians And Surgeons	0	$0	$0	$0
Unknown	5	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	2	$0	$18,000	$18,000
Veterinary Medicine, Board of State of West Virginia	0	$0	$0	$0

State Facilities Located Within the Levee Hazard Area		Replacement Cost Value for State Facilities Within the Levee Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Water Development Authority State of West Virginia	0	$0	$0	$0
West Liberty University	0	$0	$0	$0
West Virginia Parkways Authority	0	$0	$0	$0
West Virginia State University - Institute	0	$0	$0	$0
West Virginia State University - Malden	0	$0	$0	$0
West Virginia University	0	$0	$0	$0
West Virginia University Arthurdale	0	$0	$0	$0
West Virginia University At Parkersburg	0	$0	$0	$0
West Virginia University Beckley	0	$0	$0	$0
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	0	$0	$0	$0
West Virginia University Fort Ashby	0	$0	$0	$0
West Virginia University Granville	0	$0	$0	$0
West Virginia University Jacksons Mill	0	$0	$0	$0
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	0	$0	$0	$0
West Virginia University Montgomery	0	$0	$0	$0
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	0	$0	$0	$0
West Virginia University Wardensville	0	$0	$0	$0
West Virginia University Weston	0	$0	$0	$0
Workforce West Virginia	1	$0	$85,000	$85,000
WV Public Employees Grievance Board	0	$0	$0	$0
WVsom Clinic Inc Dba Robert C Byrd Clinic	0	$0	$0	$0
Total (WV State)	**54**	**$133,530,550**	**$13,582,715**	**$147,113,265**

Source: WVBRIM 2022; USACE 2023

There are portions of state roads that are exposed to flood waters should a levee failure occur. Flood waters can undermine or fully submerge roads for a period of time resulting in closures and cutting off critical access to communities. In addition, the flood waters can degrade the integrity of the roads. Sometimes the damage is apparent — a road that washes away, a sinkhole that appears, a bridge that crumbles — but often the damage is less obvious on the surface. Table 5.8-6 shows the length of state roads in areas protected by levees by county. Wood County has the greatest length of state roads (6.11 miles) exposed to the levee failure.

Table 5.8-6. State Roads Exposed to Levee Failure by County

County	Miles of State Road		County	Miles of State Road		County	Miles of State Road
Barbour	0.00		Kanawha	0.00		Preston	0.00
Berkeley	0.00		Lewis	0.00		Putnam	0.00
Boone	0.00		Lincoln	0.00		Raleigh	0.00
Braxton	0.00		Logan	0.00		Randolph	0.24
Brooke	0.00		Marion	0.00		Ritchie	0.00
Cabell	4.15		Marshall	0.00		Roane	0.00
Calhoun	0.00		Mason	1.97		Summers	0.00
Clay	0.00		McDowell	0.00		Taylor	0.00
Doddridge	0.00		Mercer	0.00		Tucker	0.17
Fayette	0.00		Mineral	0.68		Tyler	0.00
Gilmer	0.00		Mingo	0.47		Upshur	0.00
Grant	0.46		Monongalia	0.00		Wayne	0.37
Greenbrier	0.00		Monroe	0.00		Webster	0.00
Hampshire	0.00		Morgan	0.00		Wetzel	0.00
Hancock	0.00		Nicholas	0.00		Wirt	0.00
Hardy	0.81		Ohio	0.00		Wood	6.11
Harrison	0.00		Pendleton	0.00		Wyoming	0.00
Jackson	0.00		Pleasants	0.00			
Jefferson	0.00		Pocahontas	0.00		**TOTAL**	**15.44**

Source: USACE 2023

Critical Facilities and Community Lifelines

It is important to determine the critical facilities and infrastructure within the State that may be at risk to flooding due to a levee failure and that may be impacted should damage occur. Critical services during and after a levee failure event may not be available if facilities are directly damaged or transportation routes to access these critical facilities are impacted. Roads that are blocked or damaged can isolate residents and can prevent access throughout the state to many service providers needing to get to vulnerable populations or to make repairs. Utilities such as overhead power, cable, and phone lines could also be vulnerable because of damage to utility poles by standing water or the surge of water from a levee failure event. Loss of these utilities could create additional isolation issues for the inundated areas.

Table 5.8-7 summarizes the total number of critical facilities by lifeline category located in areas protected by a levee by county. Cabell County has the greatest number of critical facilities (3) within the levee-protected areas, with the majority of the facilities being categorized as Safety and Security lifelines.

Table 5.8-7. Critical Facilities Exposed to Levee Failure by County

County	Communi-cations	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transport-ation	Total
Barbour	0	0	0	0	0	0	0	0
Berkeley	0	0	0	0	0	0	0	0
Boone	0	0	0	0	0	0	0	0

County	Communi-cations	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transport-ation	Total
Braxton	0	0	0	0	0	0	0	0
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	2	1	3
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	0	0	0
Fayette	0	0	0	0	0	0	0	0
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	0	0	0	0	0	0
Hampshire	0	0	0	0	0	0	0	0
Hancock	0	0	0	0	0	0	0	0
Hardy	0	0	0	0	0	2	0	2
Harrison	0	0	0	0	0	0	0	0
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	0	0	0	0	0	0
Kanawha	0	0	0	0	0	0	0	0
Lewis	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	0	0	0
Marion	0	0	0	0	0	0	0	0
Marshall	0	0	0	0	0	0	0	0
Mason	0	0	0	0	0	1	0	1
McDowell	0	0	0	0	0	0	0	0
Mercer	0	0	0	0	0	0	0	0
Mineral	0	0	0	0	0	0	0	0
Mingo	0	0	0	0	0	2	0	2
Monongalia	0	0	0	0	0	0	0	0
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	0	0	0
Ohio	0	0	0	0	0	0	0	0
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	0	0	0
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0
Putnam	0	0	0	0	0	0	0	0
Raleigh	0	0	0	0	0	0	0	0
Randolph	0	0	0	0	0	0	0	0

County	Communi-cations	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transport-ation	Total
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	0	0	0
Summers	0	0	0	0	0	0	0	0
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0
Tyler	0	0	0	0	0	0	0	0
Upshur	0	0	0	0	0	0	0	0
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	2	0	2
Wyoming	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**9**	**1**	**10**

Source: WVEMD 2022, USACE 2023

POPULATION

Vulnerable populations are all populations in areas protected by levees that are incapable of escaping the area within the allowable time frame. This population includes the elderly, young, and individuals with disabilities, access, or functional needs who may be unable to get themselves out of the inundated areas. The vulnerable population also includes those who would not have adequate warning from the emergency warning system (e.g., television or radio).

Floods created from a levee failure and their aftermath present numerous threats to public health and safety, including exposure to unsafe food, contaminated drinking and washing water, mosquitoes, animals, mold, and mildew. For more detailed descriptions of these and additional threats to public health and safety, refer to Section 5.5 (Flood). The best preparation for these effects includes awareness that they can occur, education of the public on prevention, and planning to deal with them during responses to levee failure events.

The population exposed to the failure of a levee is summarized in Table 5.8-8. The table shows the total number of people exposed to levee failure, the number of people identified as "highly vulnerable" in the Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI) data, and the percentage of the exposed people who are considered highly vulnerable. Proportionally, Mingo and Wood Counties are the most vulnerable, with all of their exposed population being considered highly vulnerable. Cabell County has the most people and the most highly vulnerable people exposed to levee failure.

Table 5.8-8. 2020 U.S. Census Population Located in the Levee Failure Inundation Areas by County

Population Located Within the Levee Hazard Area								
County	Total Exposed Population	Highly Vulnerable Exposed Population	% Exposed Population Highly Vulnerable		County	Total Exposed Population	Highly Vulnerable Exposed Population	% Exposed Population Highly Vulnerable
Barbour	0	0	0.00%		Mineral	61	1	0.89%
Berkeley	0	0	0.00%		Mingo	290	290	100.00%
Boone	0	0	0.00%		Monongalia	0	0	0.00%
Braxton	0	0	0.00%		Monroe	0	0	0.00%
Brooke	0	0	0.00%		Morgan	0	0	0.00%
Cabell	19,550	9,124	46.67%		Nicholas	0	0	0.00%
Calhoun	0	0	0.00%		Ohio	0	0	0.00%
Clay	0	0	0.00%		Pendleton	0	0	0.00%
Doddridge	0	0	0.00%		Pleasants	0	0	0.00%
Fayette	0	0	0.00%		Pocahontas	0	0	0.00%
Gilmer	0	0	0.00%		Preston	0	0	0.00%
Grant	70	69	98.52%		Putnam	0	0	0.00%
Greenbrier	0	0	0.00%		Raleigh	0	0	0.00%
Hampshire	0	0	0.00%		Randolph	1,580	1,194	75.55%
Hancock	0	0	0.00%		Ritchie	0	0	0.00%
Hardy	468	0	0.00%		Roane	0	0	0.00%
Harrison	0	0	0.00%		Summers	0	0	0.00%
Jackson	0	0	0.00%		Taylor	0	0	0.00%
Jefferson	0	0	0.00%		Tucker	2	0	0.00%
Kanawha	0	0	0.00%		Tyler	0	0	0.00%
Lewis	0	0	0.00%		Upshur	0	0	0.00%
Lincoln	0	0	0.00%		Wayne	5,769	0	0.00%
Logan	0	0	0.00%		Webster	0	0	0.00%
Marion	0	0	0.00%		Wetzel	0	0	0.00%
Marshall	320	0	0.00%		Wirt	0	0	0.00%
Mason	214	0	0.00%		Wood	513	513	100.00%
McDowell	0	0	0.00%		Wyoming	0	0	0.00%
Mercer	0	0	0.00%					
					Total	**28,839**	**11,192**	**38.81%**

Source: CDC 2022; USACE 2023

Impacts on Socially Vulnerable Populations

The potential impacts to socially vulnerable populations due to a levee failure would be similar to impacts due to flooding, as described in Section 5.5. As described in Section 2, social vulnerability in the State is primarily based on socioeconomic factors, particularly low income. Individuals with lower income will need to own or rent property with lower property values, which is often in areas at higher risk to flooding. Some of these areas will be in communities or parts of communities that are protected by a levee system.

Future Changes That May Impact State Vulnerability

Understanding factors of change that impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine potential conditions that may affect vulnerability to levee failures:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of future hazard conditions.

Potential or Projected Development

Throughout the state, little new development is being conducted in areas that were not already developed. That is, development is occurring to fill in or redevelop areas that are already developed rather than clearing natural land for new structures and infrastructure. As the state's levees protect developed communities, projected development will not significantly impact the state's vulnerability to levee failure.

Projected Changes in Population

As shown in Section 2, the State is experiencing a net loss of population. This could lead to fewer people in areas protected by levees, reducing overall vulnerability of the population to a levee failure. On the other hand, as economic conditions decline in the state, more people may move into areas vulnerable to levee failure to take advantage of lower property values and rent levels. As the population ages, more residents may face challenges quickly evacuating an area in the event of a levee failure.

Other Factors of Change

The nature of winter precipitation influences the likelihood of a levee failure. If more winter precipitation falls as rain rather than snow, winter flows in waterways with development protected by levees could increase, raising the water levels and threatening to overtop levees. Increased flows could also erode earthen banks of the levees, making levee failure more likely.

5.8.3. Consequence Analysis

Impacts to the Public

Impacts to the public due to levee failure are described in the Vulnerability Assessment section above. In addition, impacts will mirror the impacts from flooding, as described in Section 5.5.

Impacts to Responders

Impacts to responders due to levee failure will mirror the impacts from flooding, as described in Section 5.5.

Impacts to Continuity of Operations

Impacts to continuity of operations due to levee failure will mirror the impacts from flooding, as described in Section 5.5.

Impacts to Property, Facilities, and Infrastructure

The impact of levee failure on property, facilities, and infrastructure is described in the Vulnerability Assessment section, above.

Impacts to the Environment

The environmental impacts of a levee failure mirror similar impacts from flooding, as described in Section 5.5.

Impacts to the Economic Condition of the State

Impacts to the state's economic condition due to levee failure will mirror the impacts from flooding, as described in Section 5.5. There would be impacts on the cost of flood insurance for property owners in areas that are shown on flood insurance rate maps (FIRM) as being protected by the levee. Based on recent changes to flood insurance risk rating, these economic impacts can be significant.

Impacts to Public Confidence in State Governance

If the levee failure is determined to be due to inadequate maintenance of the levee system, the public may have less confidence in the state's regulatory environment being able to protect people and property in West Virginia.

5.9 Pandemic

2023 SHMP Update Changes

- The 2023 State Hazard Mitigation Plan (SHMP) risk assessment was expanded to include this hazard. The hazard profile has been created to describe the hazard, location, extent, previous occurrences, and probability of future occurrence (including how future conditions may impact the hazard). Figures from federal and state agencies are incorporated.

5.9.1 Hazard Profile

Pandemics are large-scale disease outbreaks, defined by the way in which a disease spreads rather than the number of fatalities associated with it. A pandemic outbreak has several recognizable characteristics, including rapid, large-scale (potentially global) spread causing (1) overloaded healthcare systems; (2) inadequate medical supplies; (3) medical supply shortages; and (4) a disrupted economy and society (Centers for Disease Control and Prevention [CDC] 2015). Pandemics typically result from infectious diseases. An infectious disease, as defined by the World Health Organization (WHO), is caused by pathogenic organisms (e.g., bacteria, viruses, fungus, or parasites) that spread from one person to another, whether through direct or indirect contact. Zoonotic disease is a type of infectious disease that occurs when animals transmit a disease to humans (WHO 2015). Although any infectious disease can reach pandemic levels, the 2019 Coronavirus (COVID-19) is the most recent pandemic the United States faced and continues to face.

Hazard Description

The COVID-19 pandemic alerted the entire world to how rapidly a disease outbreak or epidemic can become a large-scale pandemic. This chapter discusses diseases and conditions of concern in West Virginia, with a focus on COVID-19, pandemic influenza, and vector-borne diseases.

Diseases that are usually present in a community have an established baseline or endemic level. This expected level may continue to occur indefinitely. An outbreak refers to when the amount of a disease in a community rises above the endemic level in a limited geographic area. An epidemic refers to an unexpected rise in the amount of disease over a wider area. The greatest spread of a disease, or a pandemic, can affect large numbers of people in several countries, continents, or the entire globe (CDC n.d.).

A new virus strain or subtype that easily transmits between humans can cause a pandemic. Bacteria that become resistant to antibiotic treatment may also be behind a rapid spread. Sometimes pandemics occur when new diseases develop the ability to spread rapidly, such as COVID-19. Humans may have little or no immunity against a new virus. Often, a new virus that previously was unable to spread between animals and people mutates so that it can. It then may start to spread easily, and a pandemic may result.

Seasonal flu epidemics generally occur because of a viral subtype that is already circulating among people. Novel subtypes, such as COVID-19, generally cause pandemics. These subtypes will not previously have circulated among humans. A pandemic can lead to social disruption, economic loss, and general hardship on a wide scale (Felman 2020).

Coronavirus Disease

COVID-19 is an infectious disease caused by the SARS-CoV-2 virus. The virus can spread in small liquid particles from the mouth or nose of infected persons when they cough, sneeze, speak, sing, or breathe. Most people infected with the virus experience mild to moderate respiratory illness and recover without requiring special treatment. However, some become seriously ill and require medical attention. Older people and those with underlying medical conditions, such as cardiovascular disease, diabetes, chronic respiratory disease, or cancer, are more likely to develop serious illness. Anyone at any age can get sick with COVID-19 and become seriously ill or die (World Health Organization 2022).

Influenza

Seasonal Flu

Seasonal flu is a viral infection that occurs every year, attacking the respiratory system (nose, throat, and lungs) in humans. In the United States, the influenza season typically extends from October through May, peaking in January or February, with yearly epidemics of varying severity. Although mild cases may be similar to a viral "cold," influenza is typically much more severe. Influenza usually comes on suddenly and may include fever, headache, tiredness, weakness, dry cough, sore throat, runny or stuffy nose, and body aches. Persons 65 and older, those with chronic illnesses, people who are obese, residents of nursing homes, pregnant women, and young children are at the highest risk for serious complications, including death (Mayo Clinic 2022).

Pandemic Flu

Pandemic flu happens when a new type of flu virus spreads around the world, passing easily from person to person. Because the virus is new and people have not had it before, it can cause large numbers of people to become sick or die. A pandemic flu would likely affect businesses, travel, and some basic services for a period of time (CDC 2020).

Avian Influenza

Avian influenza, commonly referred to as "bird flu," primarily spreads from birds to birds and rarely to humans, but it remains a pandemic threat. An avian flu virus may mutate or change so that it can be passed from birds to humans, potentially causing a pandemic in humans (CDC 2022). Some strains of avian influenza could arise from continents where people have very close contact with infected birds, such as poultry farmers or visitors to live poultry markets (Mayo Clinic 2020).

So far, avian influenza viruses have not mutated and demonstrated easy transmission from person to person. If avian influenza viruses were to mutate into a highly virulent form and become easily transmissible from person to person, the public health community would be very concerned about the potential for a pandemic (CDC 2022). Such a pandemic could disrupt all aspects of society and severely affect the economy. No cases of bird flu in people have been reported yet in West Virginia, but the virus has been found in flocks of poultry in each bordering state (Snyder 2022), and the H5N2 variant resulted in the depopulation of 25,000 turkeys in April 2007.

Swine Influenza

Swine flu typically spreads among pigs, but it can be passed to humans, especially to those who work closely with infected swine. While these types of infections usually cause mild illness, they are concerning because they can cause severe illness, especially in people at higher risk of serious flu complications, and because of their potential to cause a flu pandemic (WV News 2022).

Vector-Borne Diseases

Mosquito-Borne Viruses

Mosquito-borne diseases include diseases caused by viruses (also called arboviruses) and parasites that are transmitted through the bite of an infected mosquito. The most commonly reported mosquito-borne illness in West Virginia is La Crosse encephalitis, followed by West Nile virus; however, travel-associated mosquito-borne diseases (such as dengue fever and malaria) are also reported in West Virginia residents each year. Mosquito-borne diseases are most common during the summer and fall months when mosquitoes are active. Prevention of mosquito-borne illness includes removing containers that collect water near homes (where mosquitoes lay eggs) and the regular use of mosquito repellants (West Virginia Department of Health & Human Resources 2022).

Tick-Borne Diseases

Lyme disease is the most common tick-borne disease in West Virginia. It is transmitted by the black-legged tick, which has been reported in 51 of the 55 West Virginia counties. If an infected person is not treated early with antibiotics, Lyme disease can progress over weeks to years to cause recurrent arthritis, pain and swelling at joints, facial palsy, and neurological complications (West Virginia Department of Health & Human Resources 2022).

Anaplasmosis, ehrlichiosis, and Rocky Mountain spotted fever have also been reported in West Virginia, with about 1–10 cases of each per year.

Tick-borne infection can cause a variety of symptoms, including fever, headache, chills, myalgia, and rash. Most infections occur from late spring through early fall when ticks (and people and pets) are most active (West Virginia Department of Health and Human Resources 2022).

Location

In general, epidemics, pandemics, and vector-borne diseases can occur without regard for location. Location-based factors such as population density, travel, and the length of time spent in a location all contribute to the spread of infectious diseases (Hazarie, et al. 2021). For example, influenza and COVID-19 are more likely spread by persons in close contact. Indoor areas where people are in close contact with each other appear to be significant vectors for diseases that are spread through respiratory droplets (World Health Organization 2020).

Extent

The CDC has defined levels of disease as follows (CDC n.d.):

- *Sporadic* refers to a disease that occurs infrequently and irregularly.
- *Endemic* refers to the amount of a particular disease that is usually present in a community. This level is not necessarily the desired level, but rather is the observed level.
- *Hyperendemic* refers to persistent, high levels of disease occurrence.

- *Epidemic* refers to an increase, often sudden, in the number of cases of a disease above what is normally expected in that population in that area.
- *Outbreak* carries the same definition of epidemic but is often used for a more limited geographic area.
- *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.
- *Pandemic* refers to an epidemic that has spread over several countries or continents, usually affecting a large number of people.

Widespread sickness and loss of life can result from epidemics, pandemics, and vector-borne diseases. As of January 2, 2023, the COVID-19 pandemic infected nearly 745 million people and caused nearly 6.8 million deaths worldwide in less than 3 years (WHO 2023).

Warning Time

Pandemics are inevitable and arrive with very little warning. Warning time for a pandemic will depend on the origin of the virus, virus incubation time (the duration required before an individual begins to develop symptoms of an illness), and the amount of time needed to identify the virus.

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, there was one pandemic FEMA disaster declaration for West Virginia for COVID-19.

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. There have been no USDA disaster declarations for pandemics.

Previous Events

According to West Virginia law, outbreaks are immediately reportable to the local health departments (West Virginia Department of Health & Human Resources 2022). Table 5.9-1 lists reported outbreak and pandemic events from 2018 to 2022.

Table 5.9-1. Reported Outbreak and Pandemic Events in West Virginia 2018–2022

Date	FEMA Declaration Number	Impact
COVID-19 (Statewide)		
January 2020-November 2022	DR-4517-WV EM-3450-WV	613,165 cases 7,597 deaths
Seasonal Flu (Statewide)		
2022	N/A	2,964 cases
2021	N/A	374 cases
2020	N/A	3,056 cases
2019	N/A	2,586 cases
2018	N/A	2,568 cases
Swine Flu		
2022	N/A	3 cases (Jackson County)

Date	FEMA Declaration Number	Impact
La Crosse Encephalitis		
2022	N/A	1 case (Fayette County)
2020	N/A	7 cases (Fayette, Logan, Nicholas, Raleigh, Wyoming Counties)
2019	N/A	3 cases (Greenbrier, Logan, Wyoming Counties)
2018	N/A	6 cases (Fayette, Kanawha, Mercer, Raleigh Counties)
West Nile Virus		
2018-2022	N/A	2 cases (Hardy, Wyoming Counties)
Lyme Disease		
2021 (through 09/23/2021)	N/A	755 confirmed and probable cases (Statewide *except* Grant, Jefferson, Lincoln, Logan, McDowell, Mingo Counties)
2020	N/A	1,065 confirmed and probable cases (Statewide *except* Logan, Morgan, Wyoming Counties)
2019	N/A	898 confirmed and probable cases (Statewide *except* Cabell, McDowell, Mingo Counties)
2018	N/A	671 confirmed and probable cases (49 of 55 counties)

Sources: West Virginia Department of Health & Human Resources 2022; CDC 2022; CDC 2020a; CDC 2020b

PROBABILITY OF FUTURE HAZARD EVENTS

Overall Probability

Based on the historical pandemic and vector-borne disease events in West Virginia, the state has a high probability of future events. According to FEMA and the West Virginia Department of Health & Human Resources, West Virginia experienced at least five pandemic or vector-borne disease events every year between 2018 and 2022 (see Table 5.9-1). It is reasonable to expect multiple such events every year in the future, as indicated in Table 5.9-2.

Table 5.9-2. Probability of Future Pandemic Events in West Virginia

Hazard Type	Number of Occurrences between 2018 and 2022	Percent Chance of Occurrence in Any Given Year
Pandemic or Vector-Borne Diseases	5	100%

Projected Future Conditions

Changes in temperature and precipitation can influence seasonality, distribution, and prevalence of vector-borne diseases, which are influenced significantly by high and low temperature extremes and precipitation patterns (Rocklöv and Dubrow 2020). Changing hazard conditions may also create conditions favorable for invasive mosquitoes in West Virginia.

High temperatures are among the factors associated with vector-borne disease outbreaks. Warmer temperatures associated with changing conditions can accelerate mosquito development, biting rates, and the incubation of the disease within a mosquito (U.S. EPA 2022).

Vector-borne disease transmission can be influenced by many factors other than climate, which makes it difficult to predict how future hazard conditions will influence future outbreaks of vector-borne diseases. These factors include how viruses adapt and change, the availability of hosts, changing ecosystems and land use, human behavior such as time spent indoors, and vector control programs (CDC 2020).

5.9.2 Vulnerability Assessment

State Assets

No structures are anticipated to be directly impacted by a pandemic or infectious disease. However, structures could be damaged if maintenance personnel are unavailable due to illness.

Critical Facilities and Community Lifelines

No critical facilities are anticipated to be directly impacted by a pandemic or infectious disease. However, critical facilities could be damaged if maintenance personnel are unavailable due to illness. This is especially true of critical facilities and businesses with processes (e.g., chemical reactions) that occur continuously.

Population

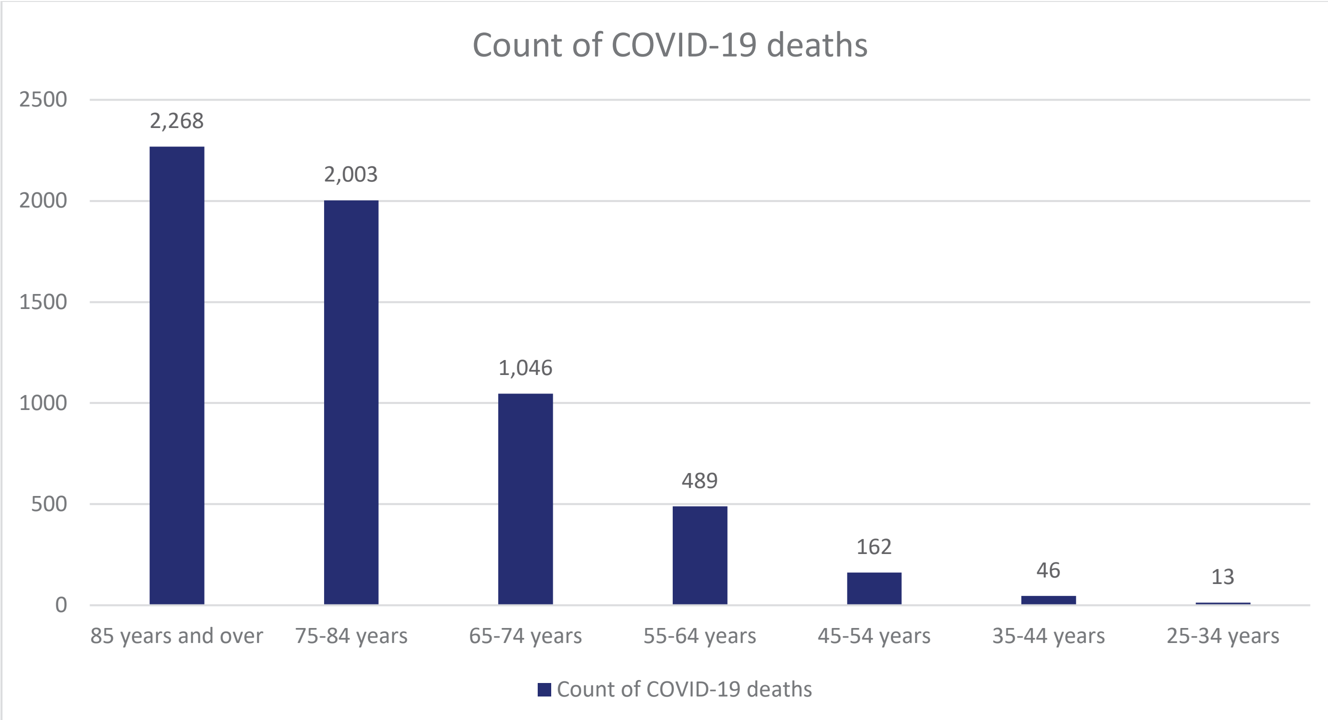
In West Virginia, the entire population is exposed and vulnerable to pandemics. Populations in closer proximity are at higher risk of passing a disease from one person to another. As the population of West Virginia is predominantly rural and less-densely populated than urban centers, there is a lower risk of pandemic compared to urbanized states.

Impacts on Socially Vulnerable Populations

The socially vulnerable are at the greatest risk due to pandemics and other disasters (Karaye IM 2020), partly due to disparities in income, education, transportation, housing, jobs, environment, psychosocial stresses, and healthcare. Lower household incomes result in diminished health care.

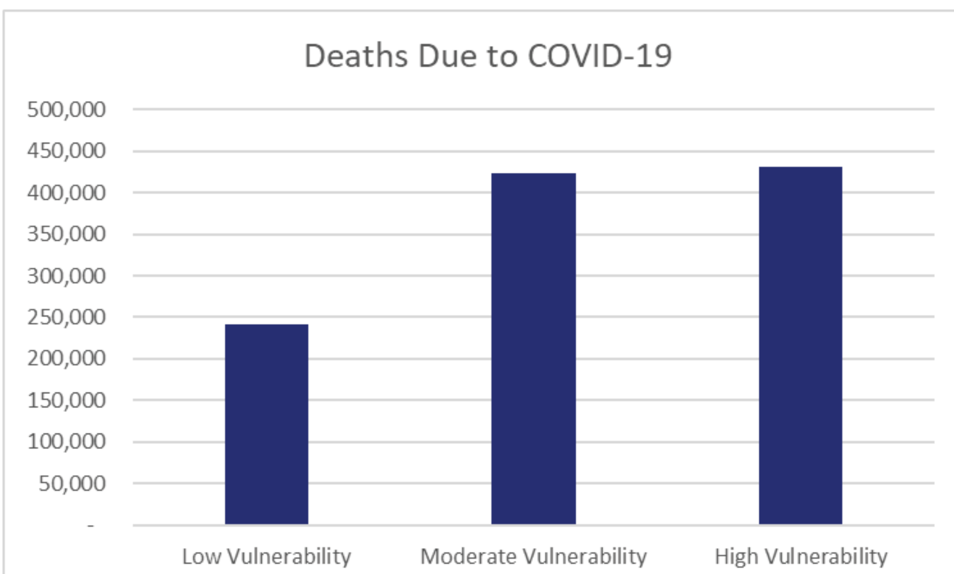
Depending on the characteristics of the disease or virus, certain population groups can be at higher risk of infection than others. For example, as shown in Figure 5.9-1, the vast majority of deaths (77.9 percent) from COVID in the State comprised people who were at least 65 years of age. Figure 5.9-2 shows that more individuals who are categorized as Moderately Vulnerable or Highly Vulnerable (according to the CDC's Social Vulnerability Index [SVI]) died from COVID-19 than other groups.

Figure 5.9-1. Count of COVID-19 Deaths by Age Group



Source: CDC 2023, as of 6/5/23

Figure 5.9-2. Count of COVID-19 Deaths by SVI Category



Source: CDC 2023, as of 6/5/23

Future Changes That May Impact State Vulnerability

Understanding future changes that impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of changing hazard conditions

Potential or Projected Development

As stated elsewhere in this SHMP, projected development in the State is currently related to redevelopment in developed areas rather than new development in areas that have not yet been developed. This could lead to concentrating people into smaller areas, increasing the risk of passing a transmissible disease among the population.

Projected Changes in Population

As population in the state continues to decrease, there is the potential that fewer people will be present to contract a disease. Additionally, as the population in the state ages (19.9% of the population is currently 65 years of age or older, and that number is expected to increase), more residents may face challenges health challenges related to pandemics and other diseases.

Other Factors of Change

Although future conditions may lead to scenarios that result in more diseases becoming a threat to the people of West Virginia, the projected decrease in population within the State means there will be fewer people exposed to the hazard.

5.9.3 Consequence Analysis

Impacts to the Public

Widespread sickness and loss of life can result from pandemics and vector-borne diseases. Disease outbreaks reaching pandemic proportions can cause social impacts on a global scale (Shang, Li and Zhang 2021). For example, civil disorder, protests, depression, and anxiety are a few of the social impacts of the COVID-19 pandemic.

Impacts to Responders

Burnout and workforce shortages among first responders and public health and healthcare workers may be seen. Pandemics and infectious diseases can also affect first responders in many ways, including the need for more personal protection equipment to keep them safe and able to perform job duties. There is also an added layer of complexity to triaging patient care and a higher patient volume during pandemics.

Impacts to Continuity of Operations

Health hazard events are not likely to result in any losses associated with damage or impairment to state assets. All losses from this hazard would be associated with impacts on operations and the economy.

Impacts to Property, Facilities, and Infrastructure

The most significant impact on critical facilitiesis the increase in hospitalization and emergency room visits resulting from a health hazard event. This would create a greater demand on these critical facilities, their staff, and resources.

Impacts to the Environment

Epidemics, pandemics, and vector-borne diseases can be directly or indirectly tied to environmental impacts. Demand for single-use plastics to mitigate the spread of disease and increased waste generated by hospitals has negative environmental impacts. Powerful disinfectants can contaminate up in water supplies. Microplastics from degrading personal protective equipment (e.g., masks, gloves) can contribute to high concentrations found in fish, water, sediments, soils, and the air (Hartman 2021).

Impacts to the Economic Condition of the State

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. In addition, given the importance of the poultry industry in the State, an avian influenza outbreak would have significant economic impacts.

Impacts to Public Confidence in State Governance

The State's management of response and recovery efforts will influence public trust. Timely and accurate distribution of public information and notification during these events will also positively impact public trust.

5.10. Radiological Incidents

2023 SHMP Update Changes

- This hazard was not included in the 2018 State Hazard Mitigation Plan (SHMP).
- The hazard profile includes a detailed description of the hazard, location, extent, previous occurrences, probability of future occurrence (including how future conditions may impact the hazard), vulnerability, and consequences.

5.10.1. Hazard Profile

The radiological exposure hazard focuses on the risk from releases of radiological material from the Beaver Valley Power Station (BVPS) in Pennsylvania.

Hazard Description

Radiological hazards and incidents generally refer to incidents involving (1) a release of significant levels of radioactive materials or (2) exposure of workers or the general public to radiation. Primary concerns following a radiological incident or accident are the impact on public health from (1) direct exposure to a radioactive plume; (2) inhalation of radioactive materials; (3) ingestion of contaminated food, water, and milk; and (4) long-term exposure to deposited radioactive materials in the environment that may lead to either acute (radiation sickness or death) or chronic (cancer) health effects (Centers for Disease Control and Prevention [CDC] 2019).

The nuclear industry has adopted pre-determined, site-specific Emergency Action Levels (EAL) defined by the U.S. Nuclear Regulatory Commission (U.S. NRC). The EALs provide the framework and guidance for observing, addressing, and classifying the severity of site-specific incidents and conditions that are communicated to off-site emergency response organizations (U.S. NRC 2021). Additional EALs specifically deal with issues of security, such as threats of airborne attack, hostile action within the facility, or attack on the facility. These EALs ensure that appropriate notifications of a security threat will occur in a timely manner.

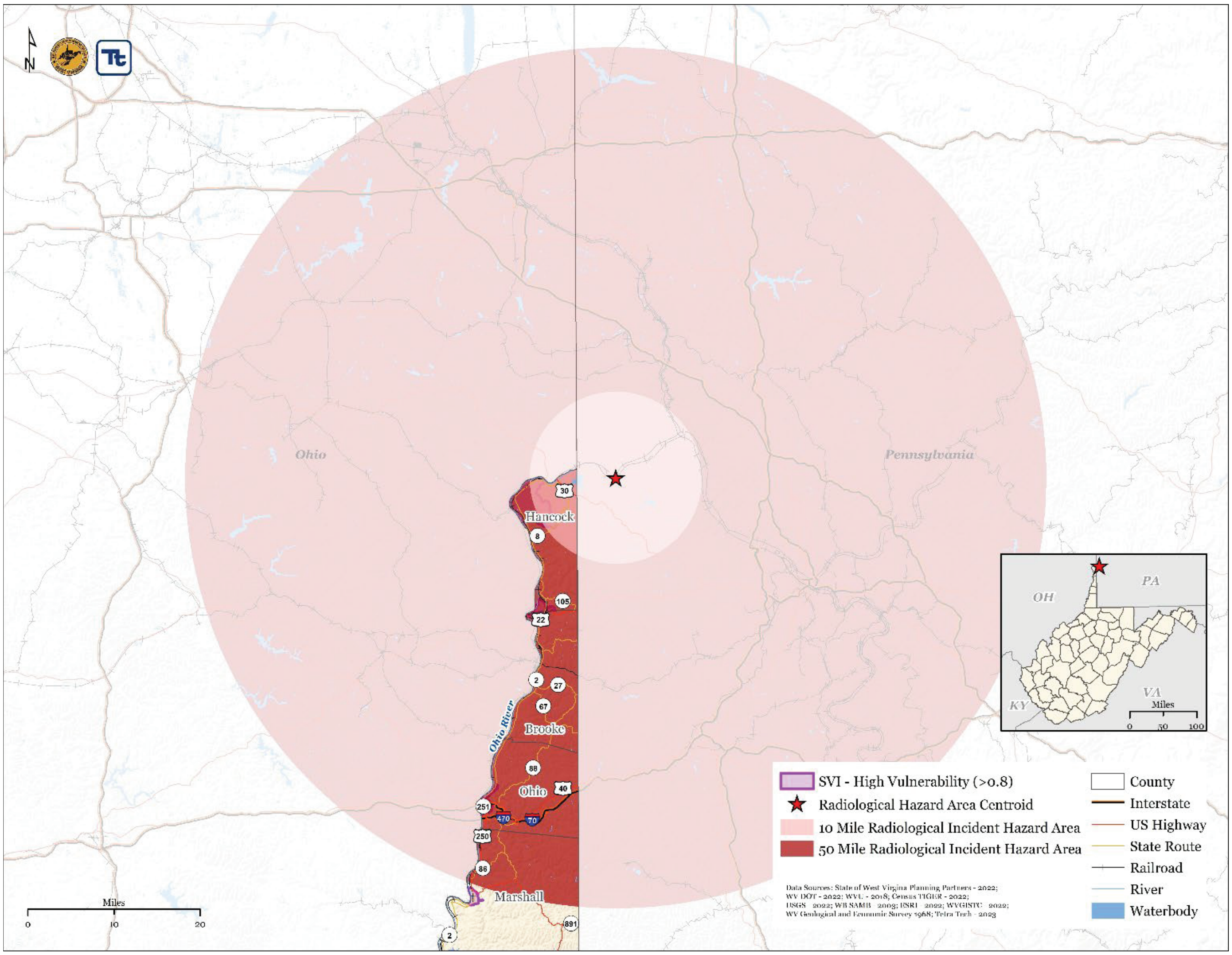
The NRC encourages the use of probabilistic risk assessments (PRA) to estimate quantitatively the potential risk to public health and safety considering the design, operations, and maintenance practices at nuclear power plants. PRAs typically focus on accidents that can severely damage the core and that may challenge containment. The Federal Emergency Management Agency (FEMA), West Virginia Emergency Management Division (WVEMD), and county governments have formulated radiological emergency response plans to prepare for radiological emergencies at the BVPS. These plans include a plume exposure pathway emergency planning zone (EPZ) (an area with a radius of 10 miles from the nuclear power facility) and an Ingestion Exposure Pathway EPZ (an area with a radius of 50 miles from the facility) (WVEMD 2019).

The wide use of radioactive and nuclear material in research, education, medicine, and industry, as well as the potential for terrorism, requires all levels of government to be prepared for response, mitigation, and recovery efforts should a radiological or nuclear emergency occur.

LOCATION

The BVPS is a two-unit nuclear power plant located in Shippingport, Pennsylvania, east of West Virginia. BVPS is owned and operated by Energy Harbor Corporation. The plant consists of two Westinghouse pressurized water reactors that started operation in July 1976 (Unit One) and August 1987 (Unit 2) (WVEMD n.d.). The location of the facility is shown in Figure 5.10-1.

Figure 5.10-1. BVPS Location



WVEMD and Hancock County coordinate emergency response plans and activities with BVPS, the State of Ohio and its Columbiana County, and the Commonwealth of Pennsylvania and its Beaver County. State of West Virginia (the State) and county agencies have the primary responsibility for the safety of the general public outside of the nuclear facility. Most of these protective actions center around a 10-mile Plume Exposure Pathway EPZ that includes parts of Hancock County, Ohio, and Pennsylvania (WVEMD n.d.), though there are protective actions to be taken to protect the food supply (i.e., the ingestion exposure pathway) in the area within 50 miles (the Ingestion Exposure Pathway EPZ) of the power plant. Table 5.10-1 lists the area of each county within the two EPZs. For brevity, only the counties affected are listed.

Table 5.10-1. Total Acres of Land Area Located in the Radiological Incidents Hazard Areas

County	Total Acres of Land Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Radiological Incidents Hazard Areas			
		Total Acres Within 10 Miles of the BVPS	Percent of Total	Total Acres Within 50 Miles of the BVPS	Percent of Total
Brooke	59,321	0	0.0%	59,321	100.0%
Hancock	56,222	22,668	40.3%	56,222	100.0%
Marshall	199,304	0	0.0%	57,651	28.9%
Ohio	69,666	0	0.0%	69,666	100.0%
Total	**15,466,796**	**22,668**	**0.1%**	**242,860**	**1.6%**

Source: USGS 2022; West Virginia University Geographic Information Systems (GIS) Technical Center (WVU GISTC) 2022

Extent

The Plume Exposure Pathway EPZ is designed to consider whole-body external exposure to radiation from a radioactive plume and deposited materials and inhalation exposure from the passing radioactive plume. The duration of primary exposures could range in length from hours to days. The 50-mile Ingestion Exposure Pathway EPZ considers exposure primarily from ingestion of water or foods such as milk and fresh vegetables that have been contaminated with radiation. This kind of exposure can stem from any of the three categories of nuclear accident listed below (U.S. NRC 2020).

- *Criticality accidents*: Involves loss of control of nuclear assemblies or power reactors.
- *Loss-of-coolant accidents*: Occurs whenever a reactor coolant system experiences a break or opening large enough that the coolant inventory in the system cannot be maintained by the normally operating make-up system.
- *Loss-of-containment accidents*: Involves the release of radioactivity from materials such as tritium; fission products; plutonium; and natural, depleted, or enriched uranium. Points of release have been containment vessels at fixed facilities or damaged packages during transportation accidents.

In accordance with regulations specified by FEMA and NRC, each facility is required to notify jurisdictional agencies of an incident or occurrence within that facility. NRC uses four classification levels for nuclear incidents (U.S. NRC 2021). Agencies involved in responding to radiological incidents use the following notification levels based on an internal trigger:

- *Unusual Event*: Incidents are occurring or have occurred that indicate potential degradation in the level of safety of the plant. No release of radioactive material requiring off-site response or monitoring is expected unless further degradation occurs.
- *Alert*: Incidents are in process or have occurred that involve actual or potential substantial degradation in the level of safety of the plant. Any releases of radioactive material from the plant are expected to be limited to a small fraction of the U.S. Environmental Protection Agency (U.S. EPA) Protective Action Guides (PAG).
- *Site Area Emergency*: Incidents are in process or have occurred that resulted in actual or likely major failures of plant functions needed for protection of the public. Any releases of radioactive material are not expected to exceed U.S. EPA PAGs except near the site boundary.

- *General Emergency*: Incidents are in process or have occurred that have caused actual or imminent substantial core damage or melting of reactor fuel with potential for loss-of-containment integrity. Radioactive releases during a General Emergency can reasonably be expected to exceed the U.S. EPA PAGs over more than the immediate site area (U.S. NRC 2021).

After a nuclear incident, the primary concern is the effect on the health of the population located near the incident. The duration of primary exposure could range in length from hours to months, depending on the proximity to the point of radioactive release. External radiation and inhalation and ingestion of radioactive isotopes can cause acute health effects (e.g., death, severe health impairment), chronic health effects (e.g., cancers), and psychological effects (U.S. EPA 2023).

Potential environmental impacts specific to the 50-mile Ingestion Exposure Pathway EPZ include the long-term effects of radioactive contamination in the environment and in agricultural products. The State can expect some radioactive contamination in very small amounts in the case of a radiological incident. This is not a significant concern in terms of external exposure and immediate health risks, but even a small amount of radiation will require the protection of the food chain, particularly milk supplies. Small amounts of radiation ingested over time could lead to future health issues. As a result, in the case of a radiological incident, foodstuffs, crops, milk, livestock feed and forage, and farm water supplies will need to be protected from and tested for contamination in accordance with State and local radiological emergency response procedures. Additionally, spills and releases of radiologically active materials from accidents can result in the contamination of soil and public water supplies (U.S. EPA 2023).

Warning Time

Warning time for radiological incidents will vary based on the nature of the incident. Incidents at the BVPS may start as minor issues and progress through the emergency classification levels over a period of days. Other incidents may cause a release of radiological materials immediately, bringing the site to General Emergency without first passing through the precursor levels.

PREVIOUS OCCURRENCES AND LOSSES

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, the State was not included in any disaster (DR) or emergency (EM) declarations for radiological incidents (FEMA 2023).

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was not included in any agricultural disaster declarations pertaining to radiological incidents nor were any declarations related to releases of radiological materials (USDA 2023).

Previous Events

There are no records of releases of radiological materials from the BVPS (U.S. NRC 2023).

PROBABILITY OF FUTURE HAZARD EVENTS

Overall Probability

Based on the history of events of the BVPS, and the low occurrence of events nationwide, the State has a low probability of events in the future.

Table 5.10-2. Probability of Future Radiological Incidents in West Virginia

Hazard Type	Number of Occurrences	Percent Chance of Occurrence in Any Given Year
Radiological	0	Cannot be determined based on past events

Source: U.S. NRC 2023

Projected Future Conditions

Radiological incidents can be caused by other hazards, including weather-related hazards. More frequent, more intense storms or flood events impacting BVPS could damage the infrastructure at the site, which could cascade into an incident that releases radioactive material into the State.

5.10.2. Vulnerability Assessment

Effects from a radiological incident at BVPS would vary depending on the product released (type of radiation), amount of radiation released, current weather conditions, and time of day. The priority following an incident at BVPS is the life safety of all individuals within the area impacted. Secondary to health and safety would be effects on critical infrastructure, environment, property, and the economy.

Contamination of agriculture, livestock, and production can lead to loss of commerce with other regions of the State, country, and even the world. In 2011, many countries halted imports of products from Japan for fear of contamination following the tsunami-related nuclear incident at the Fukishima Power Plant. This loss in revenue compounded losses that Japan and the region surrounding the power plant were already experiencing following the initial disaster.

Impacts within the affected area can include loss of utility service, contamination of local crops and livestock, loss of residential property due to measurable quantities of nuclear materials, and increased risk to health and well-being of individuals within the area.

STATE ASSETS

The spatial analysis for the radiological incidents hazard determined there are three State-owned or -leased buildings located in a 10-mile radius of BVPS (as shown in Table 5.10-3). All three of these facilities are located in Hancock County and have a replacement cost value of $3,470,052 for structures and contents. Two of the buildings within 10 miles of BVPS are used by the Department of Environmental Protection, and the other is used by the Division of Natural Resources - Parks, as shown in Table 5.10-4.

Table 5.10-3. State Buildings Within 10 Miles of the BVPS

State Facilities Within 10 Miles of BVPS		Replacement Cost Value for State Facilities Within 10 Miles of the BVPS		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Hancock	3	$2,853,152	$616,900	$3,470,052
Total	**3**	**$2,853,152**	**$616,900**	**$3,470,052**

Source: WVBRIM 2022

Table 5.10-4. State Buildings Within 10 Miles of the BVPS by Agency

State Facilities Within 10 Miles of BVPS		Replacement Cost Value for State Facilities Within the Radiological Incidents 10-Mile Buffer Hazard Area		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Environmental Protection, Department of State of West Virginia	2	$23,000	$45,700	$68,700
Parks, West Virginia State C/O Division of Natural Resources	1	$2,830,152	$571,200	$3,401,352
Total (WV State)	**3**	**$2,853,152**	**$616,900**	**$3,470,052**

Source: WVBRIM 2022

There are 47 State buildings located within 50 miles of BVPS, with the greatest number of buildings located in Ohio County (30 structures); those facilities have a replacement cost value of $28.7 million for structures and contents, as shown in Table 5.10-5. The majority of the State facilities within 50 miles of the BVPS are occupied by the Department of Health and Human Resources (5 buildings), Division of Highways (5 buildings), and the Department of Military Affairs and Public Safety – State Police (5 buildings), but the Northern Community and Technical College has the highest replacement cost value of State buildings ($10.9 million) within 50 miles of BVPS, as shown in Table 5.10-6.

Table 5.10-5. State Buildings Within 50 Miles of the BVPS by County

State Facilities Located Within the Radiological Incidents 50-Mile Buffer Hazard Area		Replacement Cost Value for State Facilities Within 50 Miles of the BVPS		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Brooke	4	$3,040,000	$140,000	$3,180,000
Hancock	11	$3,563,152	$2,336,900	$5,900,052
Marshall	2	$480,000	$34,600	$514,600
Ohio	30	$20,465,072	$8,195,209	$28,660,281
Total	**47**	**$27,548,224**	**$10,706,709**	**$38,254,933**

Source: WVBRIM 2022

Table 5.10-6. State Buildings Within 50 Miles of the BVPS by Agency

State Facilities Located Within 50 Miles of BVPS			Replacement Cost Value for State Facilities Within 50 Miles of the BVPS	
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Adjutant General's Office State of West Virginia	1	$140,000	$55,000	$195,000
Administration, Secretary of Department of Administration	0	$0	$0	$0
Agriculture, Department of State of West Virginia	0	$0	$0	$0
Air And Environmental Quality Boards State of West Virginia	0	$0	$0	$0
Alcohol Beverage Control Administration State of West Virginia	0	$0	$0	$0
Architects, Board of State of West Virginia	0	$0	$0	$0
Armory Board State of West Virginia	2	$3,691,000	$2,500,000	$6,191,000
Arts, Culture & History, Department of State of West Virginia	1	$4,384	$2,000	$6,384
Attorney General, Office of The State of West Virginia	0	$0	$0	$0
Aviation, Division of	0	$0	$0	$0
Bar, State State of West Virginia	0	$0	$0	$0
Barbers & Cosmetologists, Board of State of West Virginia	0	$0	$0	$0
Blue Ridge Community & Technical College	0	$0	$0	$0
Bluefield State College	0	$0	$0	$0
Board of Treasury Investments	0	$0	$0	$0
Bridgevalley Community & Tech College	0	$0	$0	$0
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	0	$0	$0	$0
Commission For National And Community Service, WV	0	$0	$0	$0
Concord University	0	$0	$0	$0
Conservation Agency, West Virginia State of West Virginia	1	$0	$9,600	$9,600
Consolidated Public Retirement Board Department of Administration	0	$0	$0	$0
Consumer Advocate, Division of WV Public Service Commission	0	$0	$0	$0
Corrections, Division of State of West Virginia	1	$0	$11,600	$11,600
Courthouse Facilities Improvement Authority	0	$0	$0	$0
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	0	$0	$0	$0
Dietitians, Board of Licensed	0	$0	$0	$0
Eastern Panhandle Instructional Coop	0	$0	$0	$0
Eastern WV Community & Tech. College	0	$0	$0	$0
Economic Development Authority State of West Virginia	0	$0	$0	$0

State Facilities Located Within 50 Miles of BVPS			Replacement Cost Value for State Facilities Within 50 Miles of the BVPS	
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Economic Development, WV Dept of	0	$0	$0	$0
Education, Department of State of West Virginia	2	$0	$173,000	$173,000
Educational Broadcasting Authority State of West Virginia	0	$0	$0	$0
Enterprise Resource Planning Board, WV	0	$0	$0	$0
Environmental Protection, Department of State of West Virginia	4	$37,000	$1,184,459	$1,221,459
Ethics Commission, West Virginia Department of Administration	0	$0	$0	$0
Examiners In Counseling, Board of State of West Virginia	0	$0	$0	$0
Fairmont State University	0	$0	$0	$0
Fire Commission State of West Virginia	0	$0	$0	$0
Fleet Management Office, Dept of Admin State of West Virginia	0	$0	$0	$0
Forestry, Division of State of West Virginia	0	$0	$0	$0
General Services Division Department of Administration	0	$0	$0	$0
Geological And Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	0	$0	$0	$0
Governor, Office of The State of West Virginia	0	$0	$0	$0
Health & Human Resources, Department of State of West Virginia	5	$4,060,000	$880,000	$4,940,000
Higher Education Policy Commission, WV	0	$0	$0	$0
Highways, Division of State of West Virginia	5	$401,800	$112,650	$514,450
Homeland Security & Emergency Management Division	0	$0	$0	$0
Insurance Commissioner, Office of The State of West Virginia	1	$0	$25,000	$25,000
Investment Management Board, WV State of West Virginia	0	$0	$0	$0
Joint Committee On Government & Finance State of West Virginia	0	$0	$0	$0
Justice & Community Services, Div. of	0	$0	$0	$0
Juvenile Services, Division of	1	$0	$50,000	$50,000
Labor, Division of State of West Virginia	0	$0	$0	$0
Land Division/Dept of Agriculture State of West Virginia	0	$0	$0	$0
Landscape Architects, Board of State of West Virginia	0	$0	$0	$0
Library Commission State of West Virginia	0	$0	$0	$0
Lottery Commission State of West Virginia	1	$0	$1,500,000	$1,500,000
Marshall University	0	$0	$0	$0
Military Affairs, Secretary of And Public Safety	0	$0	$0	$0

State Facilities Located Within 50 Miles of BVPS			Replacement Cost Value for State Facilities Within 50 Miles of the BVPS	
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Miner's Health Safety, Division of And Training, State of West Virginia	0	$0	$0	$0
Motor Vehicles, Division of State of West Virginia	0	$0	$0	$0
Mountain State Esc	0	$0	$0	$0
Mountwest Community & Technical College	0	$0	$0	$0
National Coal Heritage Area Authority	0	$0	$0	$0
Natural Resources, Department of State of West Virginia	0	$0	$0	$0
New River Community & Technical College	0	$0	$0	$0
Northern Community & Tech College, WV College Square	1	$8,900,000	$2,000,000	$10,900,000
Occupational Therapy Board State of West Virginia	0	$0	$0	$0
Office of Technology/Is&C Department of Administration	0	$0	$0	$0
Osteopathic Medicine, WV Board of State of West Virginia	0	$0	$0	$0
Osteopathic Medicine, WV School of	1	$0	$10,200	$10,200
Parks, West Virginia State C\O Division of Natural Resources	1	$2,830,152	$571,200	$3,401,352
Pharmacy, Board of State of West Virginia	0	$0	$0	$0
Physical Therapy, Board of State of West Virginia	0	$0	$0	$0
Pierpont Community And Technical College	0	$0	$0	$0
Practical Nurses, Board of State of West Virginia	0	$0	$0	$0
Prosecuting Attorneys Institute, WV	0	$0	$0	$0
Psychologists Examiners, Board of State of West Virginia	0	$0	$0	$0
Public Service Commission State of West Virginia	0	$0	$0	$0
Purchasing, Division of Department of Administration	0	$0	$0	$0
Rail Authority State of West Virginia	0	$0	$0	$0
Real Estate Commission State of West Virginia	0	$0	$0	$0
Regional Jail & Corr. Fac. Authority State of West Virginia	0	$0	$0	$0
Registered Nurses, Board of State of West Virginia	0	$0	$0	$0
Rehabilitation Services Division of Commerce	1	$0	$675,000	$675,000
Respiratory Care, WV Board of	0	$0	$0	$0
School Building Authority, West Virginia	0	$0	$0	$0
Schools For The Deaf And The Blind State of West Virginia	0	$0	$0	$0
Senior Services, Bureau of State of West Virginia	0	$0	$0	$0
Shepherd University	0	$0	$0	$0
Southern Educational Services Coop	0	$0	$0	$0

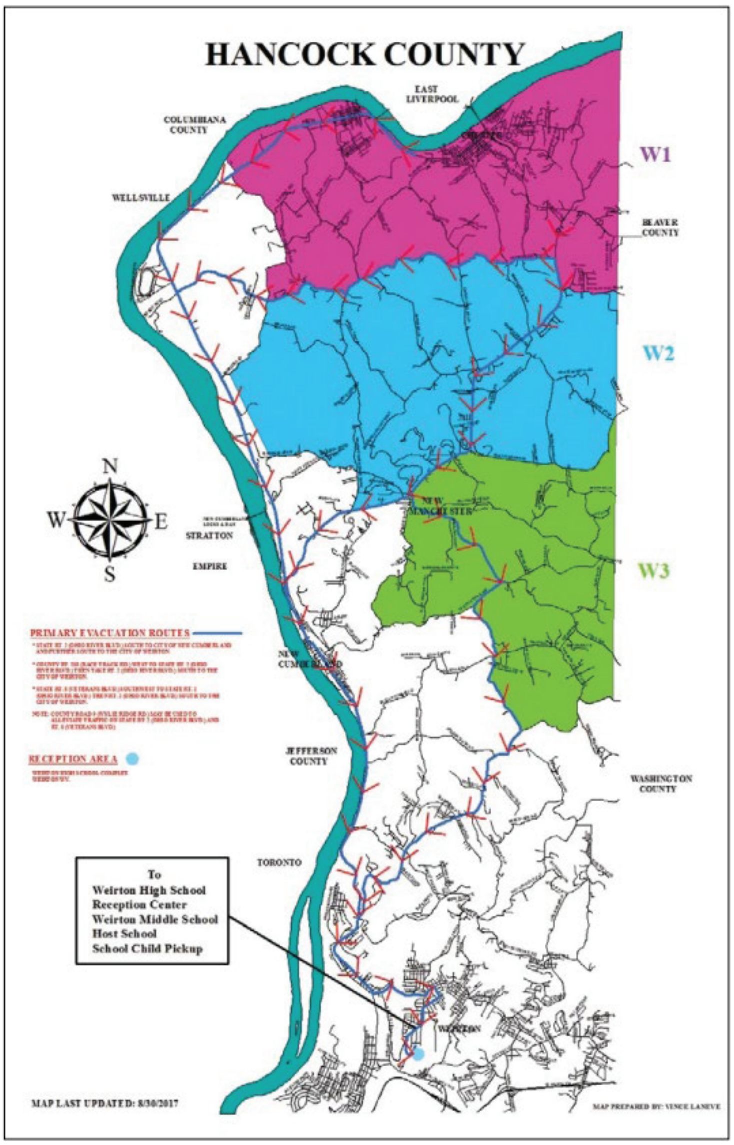
State Facilities Located Within 50 Miles of BVPS			Replacement Cost Value for State Facilities Within 50 Miles of the BVPS	
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Southern WV Community & Tech College	0	$0	$0	$0
Speech Pathology & Audiology Examiners West Virginia Board of	0	$0	$0	$0
State Police, West Virginia Dept of Military Affairs & Public Safety	5	$1,210,000	$80,000	$1,290,000
Supreme Court of Appeals State of West Virginia	4	$0	$266,000	$266,000
Tax Appeals, WV Office of	0	$0	$0	$0
Tax Department State of West Virginia	1	$0	$60,000	$60,000
Treasurer of State State of West Virginia	0	$0	$0	$0
University Physicians And Surgeons	0	$0	$0	$0
Unknown	4	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	1	$0	$10,000	$10,000
Veterinary Medicine, Board of State of West Virginia	0	$0	$0	$0
Water Development Authority State of West Virginia	0	$0	$0	$0
West Liberty University	3	$6,273,888	$531,000	$6,804,888
West Virginia Parkways Authority	0	$0	$0	$0
West Virginia State University - Institute	0	$0	$0	$0
West Virginia State University - Malden	0	$0	$0	$0
West Virginia University	0	$0	$0	$0
West Virginia University Arthurdale	0	$0	$0	$0
West Virginia University At Parkersburg	0	$0	$0	$0
West Virginia University Beckley	0	$0	$0	$0
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	0	$0	$0	$0
West Virginia University Fort Ashby	0	$0	$0	$0
West Virginia University Granville	0	$0	$0	$0
West Virginia University Jacksons Mill	0	$0	$0	$0
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	0	$0	$0	$0
West Virginia University Montgomery	0	$0	$0	$0
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	0	$0	$0	$0
West Virginia University Wardensville	0	$0	$0	$0
West Virginia University Weston	0	$0	$0	$0
Workforce West Virginia	0	$0	$0	$0
WV Public Employees Grievance Board	0	$0	$0	$0
WVsom Clinic Inc Dba Robert C Byrd Clinic	0	$0	$0	$0

State Facilities Located Within 50 Miles of BVPS			Replacement Cost Value for State Facilities Within 50 Miles of the BVPS	
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value
Total (WV State)	**47**	**$27,548,224**	**$10,706,709**	**$38,254,933**

Source: WVBRIM 2022

Roads provide a vital transportation link between populated areas. During a radiological incident, some roads will be closed to traffic while others will serve as vital evacuation routes for people leaving the affected areas. Figure 5.10-2 shows the designated evacuation routes in Hancock County for use during an incident at BVPS.

Figure 5.10-2. BVPS Evacuation Routes in Hancock County



Source: Hancock County Office of Emergency Management 2021

There are 10.26 miles of State-owned roads located within 10 miles of the BVPS, all of which are in Hancock County. There are 126.45 miles of State-owned roads within 50 miles of the BVPS, in Brooke, Hancock, Marshall, and Ohio Counties.

Table 5.10-7. State Roads Located in Areas Vulnerable to Radiological Incidents by County

County	State Roads Located Within the Radiological Incidents 10-Mile Buffer Hazard Area	State Roads Located Within the Radiological Incidents 50-Mile Buffer Hazard Area
	Mileage of Roadways	Mileage of Roadways
Brooke	0.00	52.01
Hancock	10.26	34.87
Marshall	0.00	12.91
Ohio	0.00	26.66
Total	**10.26**	**126.45**

Source: WVDOT 2022

Critical Facilities and Community Lifelines

It is important to determine the critical facilities and infrastructure within the State that may be at risk during a radiological incident. While damage to structures is not expected during radiological incidents, critical services during and after an event may not be available if transportation routes to access these critical facilities are impacted. Roads that are blocked or damaged can isolate residents and can prevent access throughout the State to many service providers needing to get to vulnerable populations or to make repairs.

The State has not identified critical facilities within 10 miles of BVPS (WVEMD 2022). Table 5.10-8 summarizes the total number of critical facilities by lifeline category located in areas within 50 miles of BVPS, by county. Ohio County has the greatest number of critical facilities (6) within 50 miles of BVPS, with the majority of the facilities being categorized as Safety and Security lifelines.

Table 5.10-8. Critical Facilities Within 50 Miles of the BVPS by County

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transport-ation	Total
Hancock	0	0	1	0	0	1	0	2
Ohio	0	0	1	0	0	5	0	6
Total	**0**	**0**	**2**	**0**	**0**	**6**	**0**	**8**

Source: WVEMD 2022

Though not included in the State's set of identified critical facilities, Table 5.10-9 lists the hospitals that are within 50 miles of BVPS. None of the hospitals listed are within 10 miles of BVPS.

Table 5.10-9. Hospitals Within 50 Miles of the BVPS

Hospital	City	County	Number of Beds
Select Specialty Hospital - Weirton	Weirton	Brooke	20
Weirton Medical Center	Weirton	Brooke	218
Reynolds Memorial Hospital - WVU Hospitals	Glen Dale	Marshall	94

Hospital	City	County	Number of Beds
Peterson Healthcare and Rehabilitation Hospital	Wheeling	Ohio	172
Select Specialty Hospital - Wheeling	Wheeling	Ohio	13
Wheeling Hospital - WVU Hospitals	Wheeling	Ohio	223

POPULATION

The population within 10 miles of the BVPS resides within Hancock County, as shown in Table 5.10-10. Table 5.10-11 shows similar details for populations within 50 miles of the BVPS. The tables show the total number of people exposed to radiological incidents, the number of those people identified as "highly vulnerable" in the CDC's Social Vulnerability Index (SVI) data, and the percentage of the exposed people who are considered highly vulnerable.

Table 5.10-10. 2020 U.S. Census Population Located Within 10 Miles of BVPS

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Exposed Population Highly Vulnerable
Hancock	1,995	7,913	25.21%
Total	1,995	7,913	25.21%

Source: CDC 2022

Table 5.10-11. 2020 U.S. Census Population Located Within 50 Miles of BVPS

County	Total Exposed Population	Highly Vulnerable Exposed Population	% Exposed Population Highly Vulnerable
Brooke	2,543	22,162	11.47%
Hancock	6,126	29,118	21.04%
Ohio	3,851	41,875	9.20%
Total	**12,520**	**93,155**	**13.4%**

Source: CDC 2022

Impacts on Socially Vulnerable Populations

Vulnerable populations are all populations within 10 miles of the BVPS that are incapable of escaping the area within an allowable time frame. This population includes the elderly, young, and individuals with disabilities, access, or functional needs who may be unable to get themselves out of the affected areas. The vulnerable population also includes those who would not have adequate warning from the emergency warning system (e.g., television or radio). To help identify the populations especially vulnerable to incidents at BVPS, Hancock County distributes an annual mailer to all residents within 10 miles of BVPS that includes an Access/Functional Needs Information Card (Hancock County Office of Emergency Management 2021). This card collects information on hearing impairments, visual impairments, mobility impairments, and lack of transportation to affect one's own evacuation.

Future Changes That May Impact State Vulnerability

Understanding future changes that impact vulnerability in the State can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of future hazard conditions

Potential or Projected Development

Any development within the areas of Hancock, Brooke, Ohio, or Marshall Counties that are within 10 miles or 50 miles of the BVPS could increase vulnerability to radiological incidents. This is particularly true for the portions of Hancock County within 10 miles of the nuclear power plant.

Projected Changes in Population

As shown in Section 2, the State is experiencing a net loss of population. This could lead to fewer people in areas within 10 or 50 miles of the BVPS, reducing overall vulnerability of the population to a radiological incident. As the population ages, more residents may face challenges quickly evacuating an area in the event of an emergency at BVPS.

Other Factors of Change

In February 2022, Governor Jim Justice signed a bill eliminating West Virginia’s ban on nuclear power. According to the Nuclear Energy Institute, coal currently provides 88 percent of West Virginia's energy needs, followed by 5 percent from natural gas, 3.3 percent from wind, 3.1 percent from hydroelectric, and 0.2 percent from other energy sources (NPR 2022). In coming years, the State is likely to diversify its electric power sources to include nuclear power. Construction of nuclear power facilities in West Virginia would increase the risk of a radiological incident.

5.10.3. Consequence Analysis

Impacts to the Public

WVEMD and the Hancock County Office of Emergency Management (OEM) are responsible for ensuring the safety of West Virginia residents during an incident at BVPS. Significant effort has been made to plan for the response to such incidents and minimize impacts on the general public. However, during an incident, thousands of people are at risk of being contaminated by radioactive material and will need to be evacuated, and a subset of those people will require temporary housing. Some portions of the population will be placed under shelter-in-place orders and unable to leave their residences for an undetermined period of time.

While only the population within 10 miles of the BVPS are considered vulnerable to being directly contaminated by radioactive material, multitudes of people become vulnerable to a radiological incident as radioactive material settles on farm and pastureland and contaminates the food chain. Should an incident occur, State and federal agencies would sample and monitor milk, livestock feed, storage crops, and water supplies within the Ingestion Exposure Pathway EPZ, and may issue public health advisories to avoid certain crops and foodstuffs.

Impacts to Responders

Emergency responders (e.g., police, firefighters, public works/highway crews) will be deployed to set up and staff access control and traffic control points, possibly putting them in danger of being contaminated by radioactive material. Radiation exposure can lead to leukemia, breast, bladder, colon, liver, lung, esophagus, ovarian, multiple myeloma, and stomach cancers (U.S. NRC 2020).

Impacts to Continuity of Operations

Staff from WVEMD, WVDEP, and WV Department of Health and Human Resources, among other departments and agencies, may be deployed to manage response operations. Daily operations of affected agencies would be impacted.

Impacts to Property, Facilities, and Infrastructure

A radiological incident at the BVPS would have very little direct impact on property, facilities, and infrastructure in the State. Facilities and infrastructure may require decontamination after a radiological release. Transportation infrastructure may also be impacted by restrictions (e.g., road closures) in and around the Plume Exposure Pathway EPZ.

Impacts to the Environment

The release of radioactive materials has a profound impact on animals. Radiation causes genetic anomalies, leading to decreased reproduction, deformities, and death. High levels of contamination can also appear in plants and last for decades. For instance, Cesium-137, a radioactive fission product of nuclear plants, still appears around the 1986 Chernobyl incident site (Wai 2020).

Impacts to the Economic Condition of the State

Contamination of agriculture, livestock, and production can lead to loss of commerce with other regions of the State, country, and even the world. In 2011, many countries halted imports of products from Japan for fear of contamination following the tsunami-related nuclear incident at the Fukishima Power Plant. This loss in revenue compounded losses that Japan and region surrounding the power plant were already experiencing following the initial disaster.

Impacts to Public Confidence in State Governance

A radiological incident would have a significant impact on the public's confidence in State governance. Whether that impact is good or bad depends on the efficiency and effectiveness of the response effort. Given the amount of time and financial resources spent on preparing for incidents at nuclear power plants, any errors or inefficiencies, whether actual or perceived, in the response will have cascading political impacts on local and State officials.

5.11 Radon Exposure

2023 SHMP Update Changes

- The 2023 State Hazard Mitigation Plan (SHMP) risk assessment was expanded to include this hazard. The hazard profile has been created to describe the hazard, location, extent, previous occurrences, and probability of future occurrence (including how future conditions may impact the hazard). Figures from federal and State of West Virginia (the State) agencies are incorporated.

5.11.1 Hazard Profile

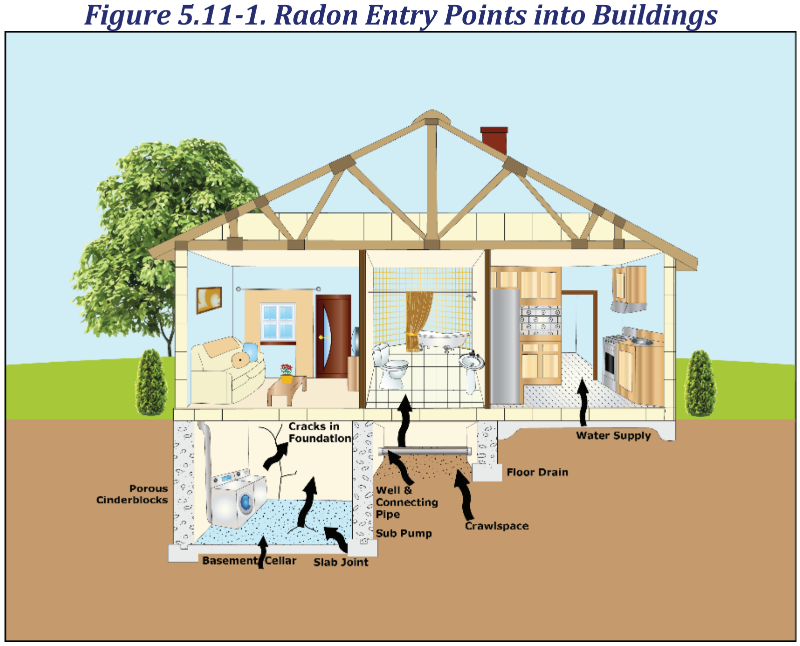
The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and projected future conditions) and vulnerability assessment for the radon exposure hazard in West Virginia.

Hazard Description

Radon is a natural gas that cannot be seen, smelled, or tasted. It is a noble gas that originates from natural radioactive decay of uranium and thorium. It is a large component of the natural radiation to which humans are exposed and can pose a serious threat to public health when it accumulates in poorly ventilated residential and occupation settings. According to the U.S. Environmental Protection Agency (U.S. EPA), radon is estimated to cause more than 20,000 lung cancer deaths per year, second only to smoking as the leading cause of lung cancer (U.S. EPA 2022). West Virginia is ranked as the 31st state with the highest radon levels, with an estimated 29% of homes having a high level of radon (American Lung Association n.d.).

The distribution of radon correlates with the distribution of radium, its immediate radioactive parent, and with uranium, its original ancestor. Because of the short half-life of radon, the distance radon atoms travel from their parent before they decay is generally limited to feet or tens of feet. Radon can enter a building in several ways, as described below and shown in Figure 5.11-1 (U.S. EPA 2023):

Figure 5.11-1. Radon Entry Points into Buildings



Sources: U.S. EPA 2023

- Radon in soil air flows into the building in the following ways: cracks in solid floors and walls, construction joints, gaps in suspended floors, gaps around service pipes, and cavities inside walls

- Radon dissolved in water from private wells and exsolved during water usage
- Radon emanating from uranium-rich building materials (such as concrete blocks or gypsum wallboard)

Location

Radon is detected across the entire United States, with some states experiencing higher levels than others. It is found in the atmosphere in trace amounts; however, it can enter buildings through cracks and holes in foundations (U.S. EPA 2022). The U.S. EPA developed a map of radon zones to identify areas in the United States that have the potential for elevated indoor radon levels. The map was developed using data on indoor radon measurements, geology, aerial radioactivity, soil parameters, and foundation types and uses three zones to show potential risk (U.S. EPA 2022). The three zones are described in Table 5.11-1.

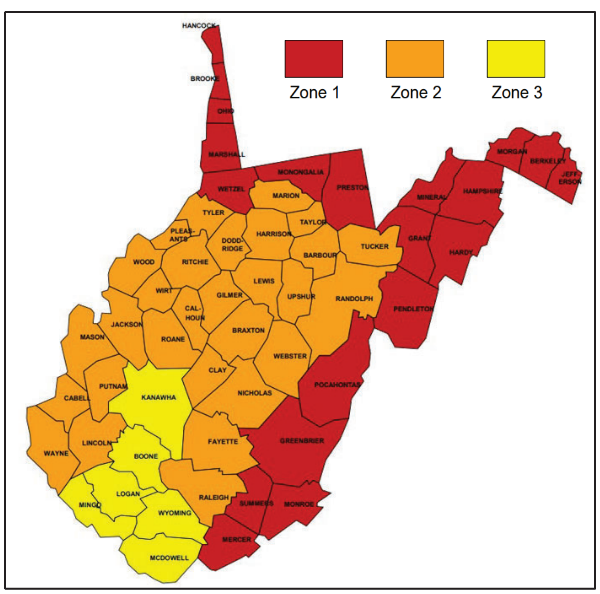
Table 5.11-1. Radon Zones

Zone	Description
Zone 1 (red zone)	Highest potential for elevated indoor radon levels; average indoor radon levels may be greater than 4 pCi/L (picocuries per liter)
Zone 2 (orange zone)	Moderate potential; average indoor radon levels may be between 2 and 4 pCi/L
Zone 3 (yellow zone)	Low potential; average indoor radon levels may be less than 2 pCi/L

Source: U.S. EPA 2014

Figure 5.11-2 illustrates the radon zones for West Virginia. A majority of the State is located in Zone 2, having moderate potential for elevated indoor radon levels. The northern and eastern portions of the State are shown as Zone 1, having the highest potential for elevated indoor radon levels. A small portion of the State is shown as Zone 3, having low potential for elevated indoor radon levels.

Figure 5.11-2. U.S. EPA Radon Zones in West Virginia



Source: U.S. EPA 2014

EXTENT

Radon levels are measured in units called picocurie per liter or pCi/L. A pCi/L is a unit of radioactivity corresponding to one decay every 27 seconds in a volume of one liter, or 0.037 decays per second in every liter of air (U.S. EPA 2012). The average radon concentration in the indoor air in homes in the United States is about 1.3 pCi/L (U.S. EPA 2022). The U.S. EPA recommends that homes be repaired if the radon level is 4 pCi/L or more. However, the U.S. EPA also recommends that Americans consider fixing their home if radon levels are between 2 and 4 pCi/L because there is no known safe level of exposure to radon.

The worst-case scenario for radon exposure would be caused by a large area of tightly sealed homes inducing high levels of exposure to residents over a prolonged period of time without awareness of this by the residents. The most likely scenario is a single household exposed to a very low concentration of radon with no adverse health effects.

Exposure can cause lung cancer. Lung cancer is the only known effect on human health from exposure to radon in air, and thus far, no evidence indicates that children are at greater risk of lung cancer than adults (U.S. EPA 2016). The main hazard is actually from the radon daughter products (polonium-218, lead-214, bismuth-214), which may become attached to lung tissue and induce lung cancer by their radioactive decay (U.S. EPA 2022). Table 5.11-2 lists (1) cancer risks from exposure to radon at various levels for smokers and non-smokers, (2) lung cancer risks from radon exposure compared to cancer risks from other hazards for smokers and non-smokers, and (3) action thresholds.

Table 5.11-2. Radon Risk for Smokers and Non-Smokers

Radon Level (picoCuries per liter [pCi/L])	Cancer Rate per 1,000 People with Lifetime Exposure	Comparative Cancer Risk of Radon Exposure	ACTION THRESHOLD
SMOKERS			
20	About 260 people could develop lung cancer	250 times the risk of drowning	Fix structure
10	About 150 people could develop lung cancer	200 times the risk of dying in a home fire	
8	About 120 people could develop lung cancer	30 times the risk of dying in a fall	
4	About 62 people could develop lung cancer	5 times the risk of dying in a car crash	
2	About 32 people could develop lung cancer	6 times the risk of dying from poison	Consider fixing structure between 2 and 4 pCi/L
1.3	About 20 people could develop lung cancer	(Average indoor radon level)	Reducing radon levels below 2 pCi/L is difficult
0.4	About 3 people could develop lung cancer	(Average outdoor radon level)	
NON-SMOKERS			
20	About 36 people could develop lung cancer	35 times the risk of drowning	Fix structure
10	About 18 people could develop lung cancer	20 times the risk of dying in a home fire	
8	About 15 people could develop lung cancer	4 times the risk of dying in a fall	
4	About 7 people could develop lung cancer	The risk of dying in a car crash	
2	About 4 people could develop lung cancer	The risk of dying from poison	Consider fixing structure between 2 and 4 pCi/L

Radon Level (picoCuries per liter [pCi/L])	Cancer Rate per 1,000 People with Lifetime Exposure	Comparative Cancer Risk of Radon Exposure	ACTION THRESHOLD
1.3	About 2 people could develop lung cancer	(Average indoor radon level)	Reducing radon levels below 2pCi/L is difficult
0.4	-	(Average outdoor radon level)	

Source: U.S. EPA 2022
Note: Risk may be lower for former smokers.
** Lifetime risk of lung cancer deaths from "EPA Assessment of Risks from Radon in Homes (EPA 402-R-03-003)".*
*** Comparison data calculated using the Centers for Disease Control and Prevention's 1999-2001 National Center for Injury Prevention and Control Reports.*

Warning Time

Due to the way radon is formed, there is no set warning time. However, it is recommended that homes are tested for radon, and actions are taken if the radon level is 4 pCi/L or higher. Living spaces below the third floor should be tested. New construction should be tested prior to permitting occupancy.

PREVIOUS OCCURRENCES AND LOSSES

The West Virginia Department of Health and Human Resources administers the State's radon program, which is responsible for radon testing reports and mitigation notifications. Radon testers and mitigation specialists within the State are required to report radon test results to the program's director on a monthly basis. However, this information is not available through an open source.

Federal Emergency Management Agency (FEMA) Disaster Declarations

There have been no disaster declarations as a result of radon exposure.

U.S. Department of Agriculture (USDA) Disaster Declarations

There have been no USDA disaster declarations as a result of radon exposure.

Previous Events

High radon levels can be present anywhere, but certain areas have a higher chance of falling into radon-heavy zones. Previous high radon occurrences can help predict that locations in proximity could also have concerning radon levels present. These previous radon measurements are organized by county, which classifies counties into radon zones.

A 2008–2017 study conducted by the American Lung Association provides additional insight on the previous occurrences of radon within the State. The highest average radon concentration was found in Morgan County, with an estimated mean radon level of 13.4 pCi/L; Fayette County had the lowest concentration with a mean radon level of 0.8 pCi/L (American Lung Association 2022).

PROBABILITY OF FUTURE HAZARD EVENTS

Overall Probability

Radon exposure is inevitable and may be exacerbated by other factors. Radon concentration in soil gas depends on a number of soil properties, the importance of which are still being evaluated. The radon content of soil gas clearly tends to be higher in soils containing higher levels of radium and uranium, especially if the radium occupies a site on or near the surface of a grain of soil from which the radon can easily escape. The amount of pore space in the soil and its permeability for airflow, including cracks and channels, are important factors determining radon concentration in soil gas and its rate of flow into a building. Soil depth and moisture content, mineral host and form for radium, and other soil properties may also be important.

Projected Future Conditions

Projected future conditions may create conditions that result in higher levels of radon being released into the atmosphere and water supplies. Variances in rainfall events may result in more high-intensity events, which may increase landslide frequency and result in releases of radon gases that were stored below the ground surface. While precipitation has been variable in West Virginia, winter and spring precipitation amounts are projected to increase (NOAA 2022). These rains have potential to create torrential floods, landslides, and mudslides, particularly in the mountainous regions of the State. As projected future conditions drive rain events to greater extremes, the risk of landslide increases as well.

If temperatures rise globally, permafrost may melt, which could result in more radon gas releasing into the atmosphere. Increased reliance on air conditioning and fans due to warmer temperatures leads to decreased air exchange rates in tightly sealed homes, increased radon concentrations on upper floors where residents spend greater amounts of time, and higher radon concentration and exposure (Duke University 2023).

5.11.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For radon exposure, the entirety of West Virginia has been identified as a potential hazard area. Therefore, all assets in the State (population, structures, critical facilities, and lifelines), as described in the State Profile, are vulnerable. The impacts on State assets, critical facilities and community lifelines, population, and socially vulnerable population is discussed below.

State Assets

All State assets are exposed to radon. This includes 1,117 State assets and all 185 critical facilities and community lifelines. The vulnerability to these assets from radon exposure is considered low; however, assets located in Zone 3 are more at risk for radon exposure.

Critical Facilities and Community Lifelines

While the entire general building stock and critical facility inventory in the State is exposed to the risk of radon, radon does not result in direct damage to structures and facilities. Critical facilities or lifelines with elevated radon levels will require remediation systems to be installed such as installing a gas permeable layer for new construction, sealing cracks or installing a vapor retarder for existing structures, installing vent pipes, and installing vent fans (U.S. EPA 2022).

Population

For the purposes of this assessment, the entire population of West Virginia (1,807,426) is exposed; however, populations living in Zone 3 have a higher probability of being exposed to elevated radon levels in their homes.

Exposure to radon is the second-leading cause of lung cancer after smoking and the leading cause of lung cancer among non-smokers. As stated earlier, radon is responsible for more than 20,000 lung cancer deaths every year. Lung cancer is the only known effect on human health from exposure to radon in air, and thus far, no evidence indicates that children are at greater risk of lung cancer than adults (U.S. EPA 2013).

Table 5.11-2 details additional cancer risks from radon exposure. The main hazard is from the radon daughter products (polonium-218, lead-214, and bismuth-214), which may become attached to lung tissue and induce lung cancer by their radioactive decay. (U.S. EPA 2022).

Impacts on Socially Vulnerable Populations

Radon exposure may have disproportionate impacts on socially vulnerable populations. Those residents facing economic hardships may not be able to afford to professional radon testing or subsequent mitigative measures. The concentration of individuals living within group quarters increases the number of individuals that may be exposed to radon gas within that building. Individuals experiencing homelessness may unknowingly take shelter in buildings with poor ventilation risking radon exposure.

Additionally, individuals who smoke and experience unsafe radon exposure are more at risk of lung cancer than those who do not smoke and experience unsafe radon exposure. The population over the age of 65 (19.9%) and under the age of 5 (5.2%) are more vulnerable to radon exposure due to their weakened immune systems.

Future Changes That May Impact State Vulnerability

Understanding future changes that impact vulnerability in the State can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of future conditions

Potential or Projected Development

Although West Virginia has not experienced significant growth, any areas of growth could be impacted by the radon exposure because the entire planning area is exposed and vulnerable. However, due to increased standards and codes, new development may be less vulnerable to the hazard, while aging infrastructure will become increasingly vulnerable. Implementing risk reduction measures can be incorporated during new construction, which will be more effective than retrofitting an existing structure.

Projected Changes in Population

As population in the State continues to decrease, there is the potential that fewer people will reside or work within the State's radon exposure area. Increased abandoned properties will become increasingly at risk for radon exposure and may affect the homeless population, as previously stated. Additionally, as the population in the State ages (19.9% of the population is currently 65 years of age or older, and that number is expected to increase) more residents may face challenges health challenges related to radon exposure.

Other Factors of Change

Although future conditions may lead to scenarios that result in more radon being released, the projected decrease in population and subsequently development within the State means there will not be a higher number of people exposed to the hazard.

5.11.3 Consequence Analysis

Impacts to the Public

For the purposes of this plan, the entire population of the county is assumed to the risk of radon exposure. As discussed previously, lung cancer is a known health risk due to radon exposure. Lung cancer from radon may lead to loss of life and increased health care costs. Individual households may incur costs due to taking mitigation measures to eliminate potential entry points for radon in their homes.

Impacts to Responders

Radon does not pose an immediate risk to emergency responders. However, emergency responders may still be exposed to radon in places where they spend long periods of time, such as their homes or places of work.

Impacts to Continuity of Operations

Discovering dangerous radon exposure can shut down buildings from being used, which affects day-to-day lives of people who depend on that building for shelter, work, etc. This could also slow down or halt supply chains that are reliant on the businesses located within these structures. Radon-exposed schools may prevent children from attending school in person, which may limit a child's social skill knowledge. Any business that is shut down would require people who are reliant on it for goods and services to travel to neighboring towns to be able to continue their day-to-day operations.

Impacts to Property, Facilities, and Infrastructure

According to the U.S. EPA, the average radon concentration in the indoor air of homes in the United States is about 1.3 pCi/L. The U.S. EPA recommends that homes implement mitigation measures if the radon level is 4 pCi/L or more. However, the U.S. EPA also recommends that residents consider repairing or renovating their homes if radon levels are between 2 and 4 pCi/L because there is no known safe level of exposure to radon (U.S. EPA 2022).

Impacts to the Environment

Radon typically does not cause harm to the environment or natural ecosystems, as it is naturally occurring outdoors in open ventilated areas.

Impacts to the Economic Condition of the State

Retrofitting radon systems to older buildings can be costly but is more cost-effective than rebuilding an entire building exposed to radon. Cost for mitigation measures can vary greatly dependent upon the scale (individual home, larger government buildings, etc.) and the type of mitigation measure. The State could experience significant economic impacts if there were a scenario that required multiple government-owned structures to be mitigated or reconstructed. If high levels are found, there could be a disruption to government services resulting in economic losses.

Impacts to Public Confidence in State Governance

The public confidence in State governance would mainly depend on how effective the State has been in the past at preparing for and responding to radon exposure. Public confidence also depends on the preparation the State is taking for increased radon exposure. In general, if the State is transparent in sharing relevant information with the public regarding radon exposure, then the public is more apt to trust the State and feel as if it has the capability to protect and assist the residents of West Virginia.

The West Virginia Department of Health and Human Resources administers the State's radon program, which is responsible for radon testing reports and mitigation notifications. The program provides information about how residents can protect their homes from radon exposure and provide free radon testing kits upon request.

5.12 Severe Storm

2023 SHMP Update Changes

- The hazard profile was reorganized and significantly enhanced to include detailed descriptions of the following: hazard definition, location, extent, previous occurrences, and probability of future occurrences (including how future conditions may impact the hazard).
- Information was updated regarding the current population affected by severe storms.
- Severe storm events that occurred in the State of West Virginia (the State) from January 1, 2018, through December 31, 2022, were researched and added for this 2023 State Hazard Mitigation Plan (SHMP) Update.
- New and updated figures from federal, State, and local agencies are incorporated.
- Analyzed State asset exposure to severe storm events and assessed local vulnerabilities.

5.12.1 Hazard Profile

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of future conditions) and vulnerability assessment for the severe storm hazard in West Virginia.

Hazard Description

Wind and severe storms pose risks to West Virginia. High winds, thunderstorms, lightning, hail, tornadoes, and tropical cyclones can cover vast areas of the State quickly and without significant warning, leading to flooding, lightning-initiated fires, and significant structural damage (West Virginia Emergency Management Division 2018). Severe storms can pose a major potential threat to the State's population because of their frequency, the size of devastated areas, the population affected, and the potential damage scale. Severe storms in West Virginia also have historically caused secondary hazards such as flooding, mudflows, landslides, electrical outages, and other impacts.

Key Terms

Thunderstorm - A thunderstorm is a rain shower during which you hear thunder. Since thunder comes from lightning, all thunderstorms have lightning (NOAA n.d.).

Hail - Hail is a form of precipitation consisting of solid ice that forms inside thunderstorm updrafts (NOAA n.d.).

Tornado - A tornado is a narrow, violently rotating column of air that extends from a thunderstorm to the ground (NOAA n.d.).

Tropical Cyclone - A large, warm-core cyclone, originating over tropical or subtropical waters with organized deep convection and a closed surface wind circulation about a well-defined center. Types of tropical cyclones include hurricanes (maximum sustained winds of 74+ mph), tropical storms (39 – 73 mph), and tropical depressions (below 39 mph) (NOAA 2022).

Thunderstorm

A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (National Weather Service [NWS] 2021). A thunderstorm forms from a combination of moisture, rapidly rising warm air, and a force capable of lifting air, such as a warm and cold front, a sea breeze, or a mountain. All thunderstorms contain lightning. Thunderstorms may occur singly, in clusters, or in lines. It is possible for several thunderstorms to affect one location over a few hours or for a single, slow-moving storm to affect one location for an extended period. Thunderstorms can contribute to other hazard events, such as flooding, strong straight-line winds, tornadoes, hail, and lightning, as well as the possibility of lightning-initiated fires. Severe thunderstorms are officially defined as thunderstorms that produce one or more of the following:

- Winds of 58 mph or higher
- Hail 1 inch in diameter (quarter-sized) or larger
- Tornadoes

Hailstorm

Hail forms inside a thunderstorm where there are strong updrafts of warm air and downdrafts of cold water. If a water droplet is picked up by the updrafts, it can be carried well above the freezing level. Water droplets freeze when temperatures reach 32°F or colder. As the frozen droplet begins to fall, it might thaw as it moves into warmer air toward the bottom of the thunderstorm or the droplet might be picked up again by another updraft and carried back into the cold air to re-freeze. With each trip above and below the freezing level, the frozen droplet adds another layer of ice. The frozen droplet, with many layers of ice, falls to the ground as hail (NSSL 2021).

Tornado

A tornado is a narrow, violently rotating column of air that extends from a thunderstorm to the ground. Because wind is invisible, it is hard to see a tornado unless it forms a condensation funnel made up of water droplets, dust, and debris (NOAA n.d.). They typically spawn from strong winds associated with thunderstorms and tropical cyclones. While roughly 1,000 tornadoes a year are generated by thunderstorms, relatively few fully touch the ground. As wind speeds increase, the level of destruction continues to increase as well.

High Wind

Wind begins with differences in air pressures. It is a rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the earth. High winds are often associated with other severe weather events such as thunderstorms, tornadoes, and tropical storms (NWS 2012). Different types of damaging winds include straight-line wind, downdraft, downburst, microburst, gust front, derecho, bow echo, and hook echo. Each wind type is described below (NOAA n.d.):

- **Straight-line wind** is a term used to define any thunderstorm wind that is not associated with rotation. Straight-line winds are the movement of air from areas of higher pressure to areas of lower pressure – the greater the difference in pressure, the stronger the winds. It is used mainly to differentiate from tornadic winds.
- A **downdraft** is a small-scale column of air that rapidly sinks toward the ground and usually results in a downburst.

- A **downburst** is a strong downdraft with horizontal dimensions larger than 2.5 miles, resulting in an outward burst or damaging winds on or near the ground. It is usually associated with thunderstorms but can occur with rain storms too weak to produce thunder.
- A **microburst** is a small, concentrated downburst that produces an outward burst of damaging winds near the surface. It is typically short-lived, lasting only 5 to 10 minutes, with maximum wind speeds of up to 168 miles per hour (mph).
- A **gust front** is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. It is characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm.
- A **derecho** is a long-lived windstorm associated with rapidly moving precipitation or thunderstorms. If wind damage swatch is more than 240 miles and includes gusts of wind that reach 58 mph or greater, then the event can be classified as a derecho.
- A **bow echo** is a radar echo that is linear but bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo (crest). A bow echo can be more than 300 kilometers long, last for several hours, and produce extensive swaths of wind damage at the ground (NOAA 2023).
- A **hook echo** is a radar echo that is the most recognized and well-known radar signature for tornadic supercells. This “hook-like” feature occurs when the strong counter-clockwise winds circling the mesocyclone (rotating updraft) are strong enough to wrap precipitation around the rain-free updraft area of the storm (NOAA 2022).

Tropical Cyclones

Tropical cyclones (which include tropical depressions, tropical storms, hurricanes, and their remnants and post-tropical phases) are fueled by a different heat mechanism than other cyclonic windstorms such as nor’easters and polar lows. The characteristic that separates a tropical cyclone from another cyclonic system is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings, a phenomenon called “warm core” storm systems (NOAA 2011). Tropical cyclones strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. Tropical cyclones begin as disturbed areas of weather, often referred to as tropical disturbances. As the storm organizes, it is designated as a tropical depression.

A tropical storm is characterized by a low-pressure center and numerous thunderstorms that produce strong winds of 39 to 73 mph and heavy rain. A hurricane is a tropical cyclone that attains hurricane status when its wind speed reaches 74 mph or higher. Tropical systems may develop in the Atlantic between the Lesser Antilles and the African coast or may develop in the warm tropical waters of the Caribbean and Gulf of Mexico. These storms may move up the Atlantic coast of the United States and impact the eastern seaboard or move into the United States through the states along the Gulf Coast, bringing wind and rain as far north as New England before moving offshore and heading east (NOAA 2011). By the time a storm is classified as a hurricane and arrives in West Virginia, it has most likely weakened into a tropical storm or depression. These storms still pose a danger from torrential rains and high winds.

Location

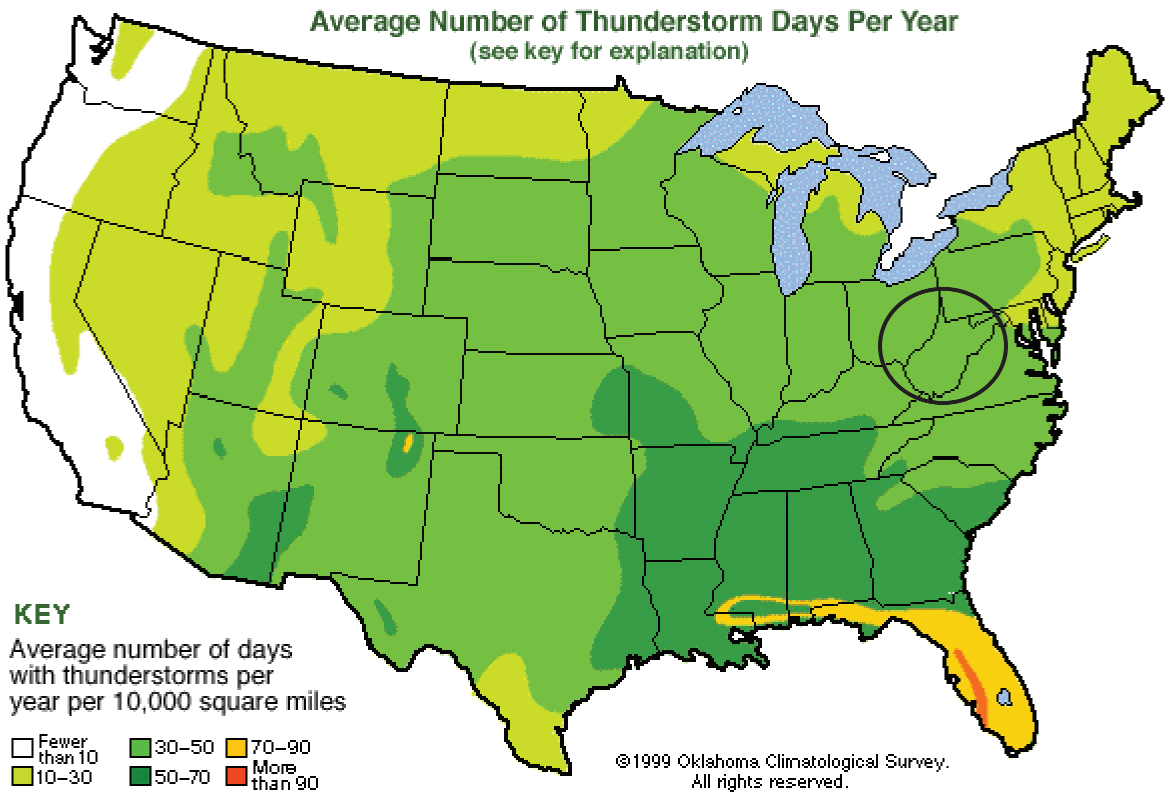
All communities within West Virginia are subject to impacts of severe storms. Areas that are subject to increased flooding and extreme winds are particularly vulnerable. Higher elevations in mountainous areas tend to experience severe storms as snowfall and winter weather. Flatter areas tend to be more ideal for tornado longevity, making those areas more at risk for that hazard.

Thunderstorm

Thunderstorms tend to take place during the spring and summer months and during the warmest times of the day, which tend to be late afternoon and early evening (NOAA n.d.).

Figure 5.12-1 displays thunderstorm days per year across the United States. According to the map, West Virginia is likely to have between 30-50 thunderstorms per year, which is similar to its surrounding states (University Corporation for Atmospheric Research 2023).

Figure 5.12-1: Average Number of Thunderstorms in the U.S.

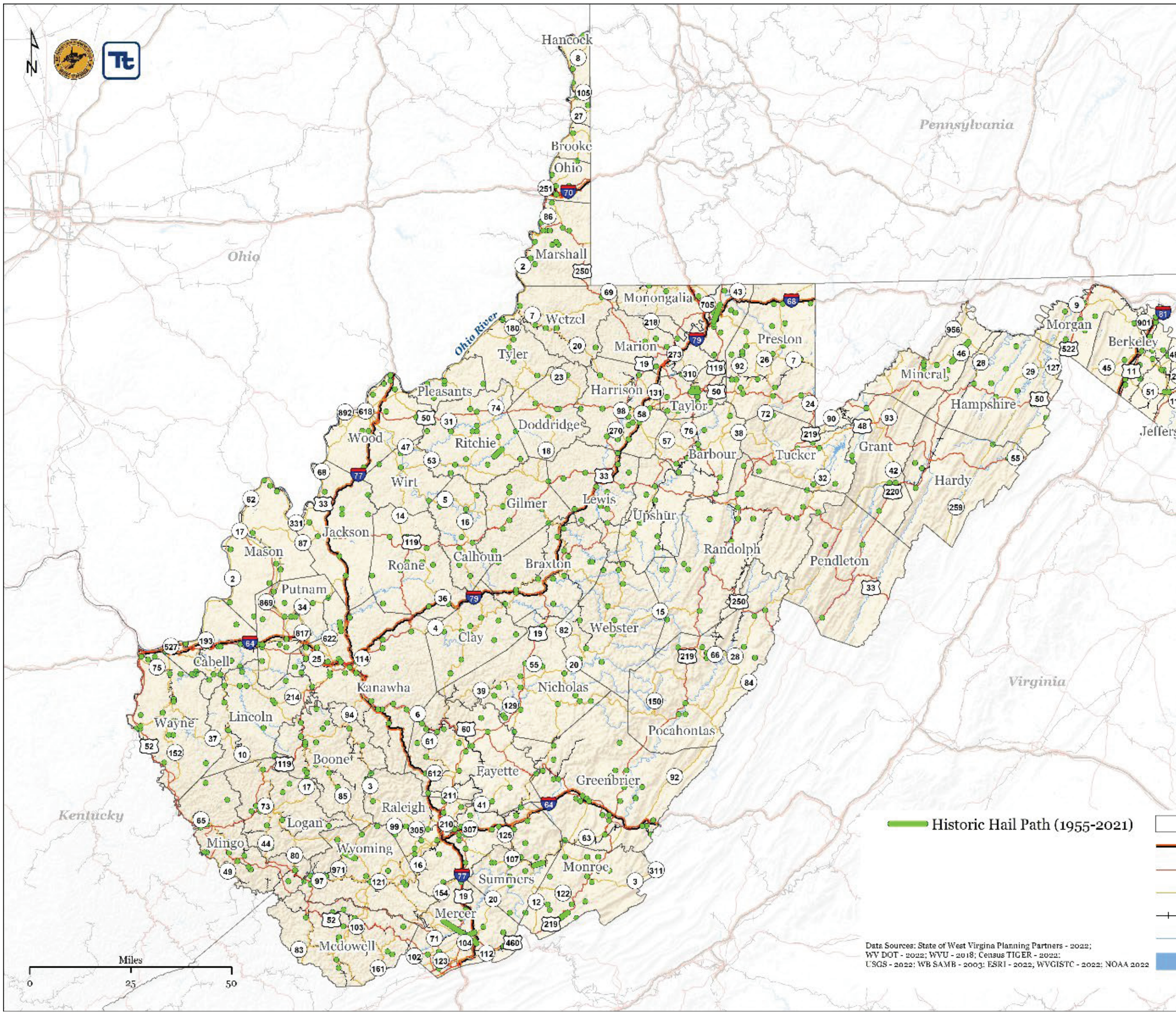


Source University Corporation for Atmospheric Research 2023
Note: West Virginia is identified within the black outlined circle

Hailstorm

Hailstorms can form anywhere; however, they are more likely to fall in areas that have the most thunderstorms (refer to Figure 5.12-1). The longer a hailstone spends in the clouds, the larger it becomes as more droplets continue to freeze. Hail falls when it becomes heavy enough to overcome the strength of the thunderstorm updraft and is pulled to the earth by gravity. Smaller hailstones may be blown away from the updraft by horizontal winds, so larger hail typically falls closer to the updraft than smaller hail (NOAA n.d.). Figure 5.12-2 pinpoints historic hail locations that have occurred in West Virginia.

Figure 5.12-2: Historic Hail Locations



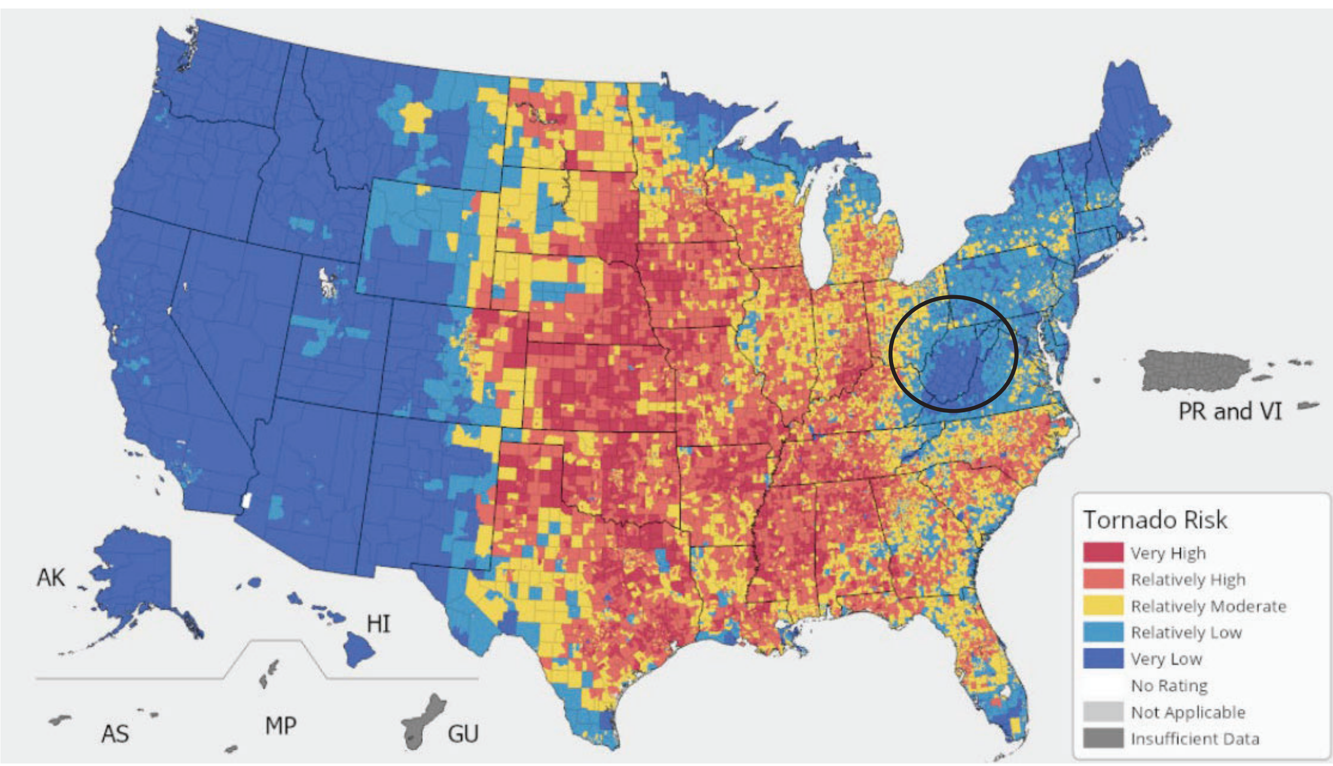
Tornado

Roughly 1,200 tornadoes hit the United States every year, with the majority located in Tornado Alley, which refers to the central United States; however, violent tornadoes have been experienced by all 50 states. While the extent of tornado damage is usually localized, the extreme winds of the tornado vortex can be among the most destructive on earth as they move through populated, developed areas and can affect nearby areas. The peak of tornado season is between June and July, and tornadoes typically strike during the warmer parts of the day, mainly between 4:00 pm and 9:00 pm (NOAA n.d.).

Tornado movement is characterized in two ways: direction and speed of the spinning winds and forward movement of the tornado and 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 0 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. The forward motion of the tornado path can be a few hundred yards or several hundred miles in length. The width of tornadoes can vary but generally range in size from less than 100 feet to more than a mile in width. Some tornadoes never touch the ground and are short-lived, while others may touch the ground several times.

Figure 5.12-3 displays the Tornado Risk Index for the United States (West Virginia displayed within the black circle). According to the National Risk Index, the majority of the State has between a very low to relatively low risk to tornadoes, with portions of the northern tip of the State having a relatively moderate risk.

Figure 5.12-3: National Risk Index, Tornado Risk Index Score

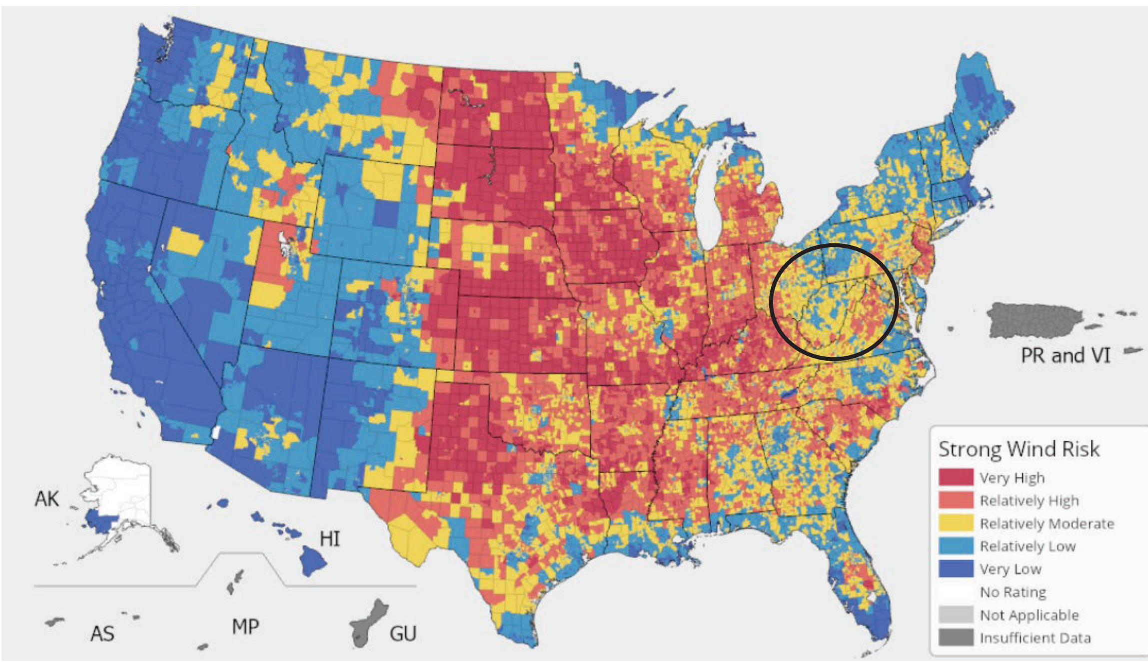


Source: FEMA 2023
Note: West Virginia is identified within the black outlined circle

High Wind

Severe storms have the power to produce powerful winds; therefore, strong, and powerful winds have a higher chance of occurring in locations that are more likely to experience these storms (NOAA n.d.). In addition, high wind events may occur without a thunderstorm, tornado, or tropical cyclone present and can be just as dangerous and destructive as those hazards. Figure 5.12-4 displays the Strong Wind Risk Index for the United States (West Virginia displayed within the black circle). According to the National Risk Index, the majority of the State has a relatively moderate risk to strong winds, with portions of the State having relatively low risk and relatively high risk.

Figure 5.12-4. National Risk Index, Strong Wind Risk Index Score

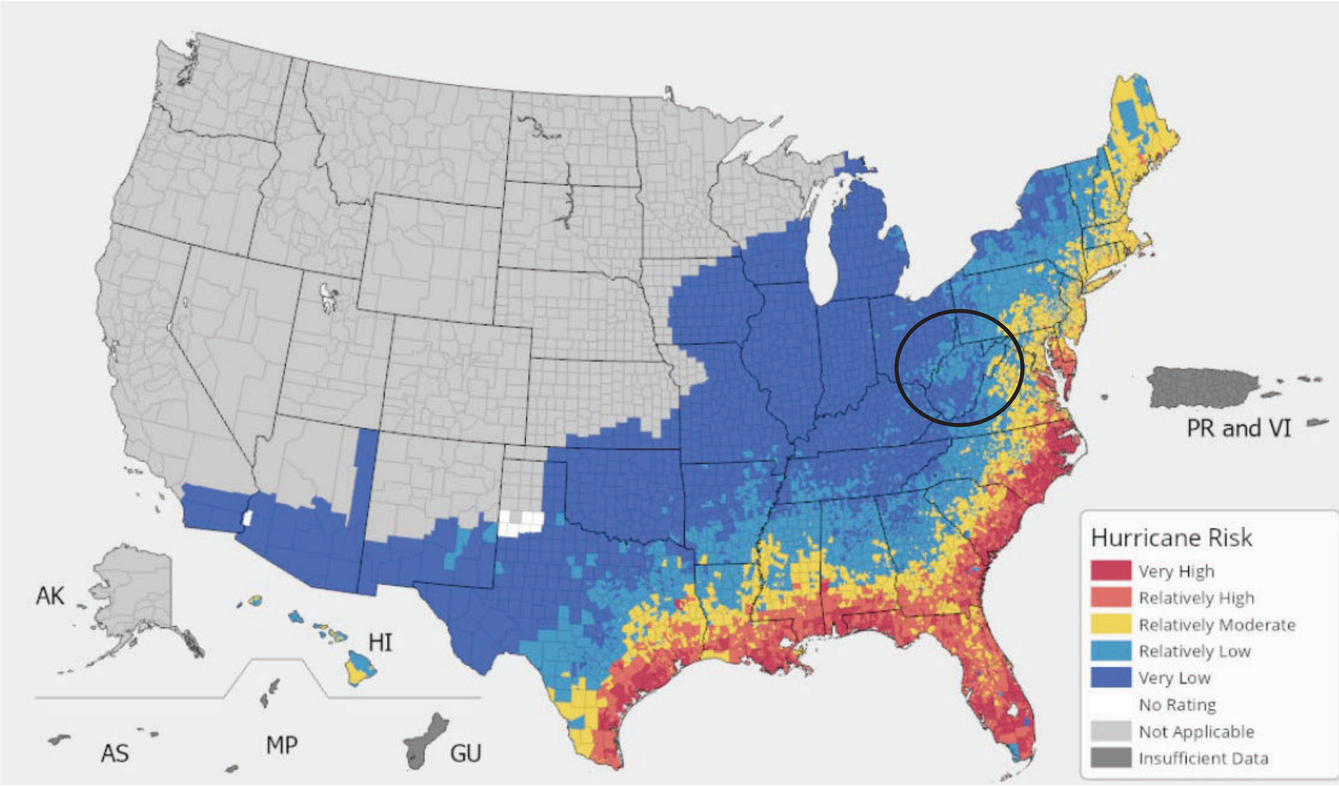


Source: FEMA 2023
Note: West Virginia is identified within the black outlined circle

Tropical Cyclones

Tropical cyclones are most likely to form from June to November each year. Each cyclone's path is predicted on a case-by-case basis which allows scientists to be able to consider information from the specific storm as well as what is known about the conditions of the atmosphere and the ocean (University Corporation for Atmospheric Research 2022). Figure 5.12-5 displays the Hurricane Risk Index for the United States (West Virginia displayed within the black circle), though this risk index is based solely on wind impacts. According to the National Risk Index, the State has between a very low to relatively low risk to hurricane winds. As stated above, the greatest danger posed in West Virginia by a tropical cyclone is from those winds and torrential rain, which may result in flooding throughout the State. The risk and vulnerability of the State to flooding from tropical cyclones is detailed in Section 5.5 (Flood).

Figure 5.12-5. National Risk Index, Hurricane Risk Index Score



Source: FEMA 2023
Note: West Virginia is identified within the black outlined circle

EXTENT

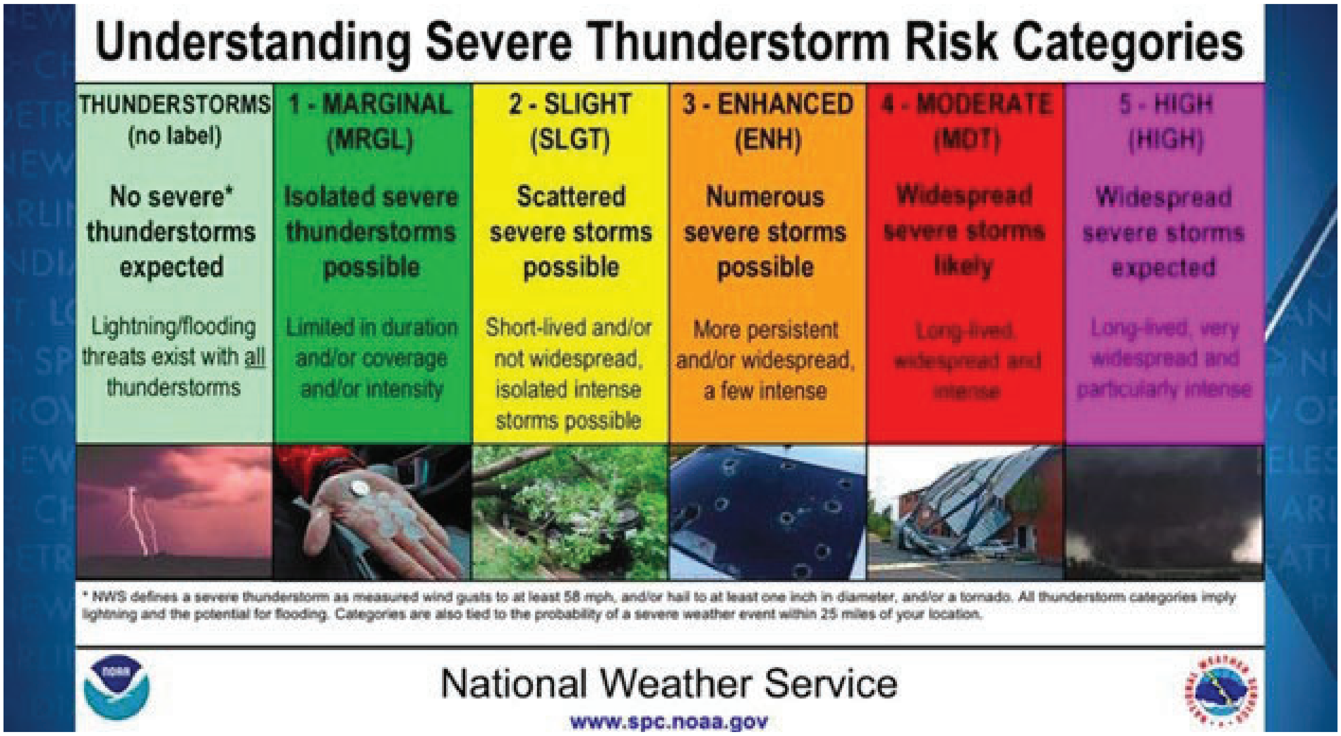
Thunderstorm

Severe thunderstorm watches and warnings are issued by the local NWS office and the Storm Prediction Center (SPC). The NWS and SPC will update the watches and warnings and notify the public when they are no longer in effect. NWS issues statements, watches, and warnings for thunderstorms:

- **Special Weather Statement:** Issued for strong storms that are below severe levels but may have impacts. Usually reserved for the threat of wind gust of 40–58 mph or small hail <1 inch.
- **Severe Thunderstorm Watch:** Severe thunderstorms with large hail, damaging winds, and/or tornadoes are possible, but the exact time and location of storm development is still uncertain. A watch means be prepared for storms.
- **Severe Thunderstorm Warning:** A severe thunderstorm is imminent or occurring; it is either detected by weather radar or reported by storm spotters. A severe thunderstorm is one that produces winds 58 mph or stronger and/or hail 1 inch in diameter or larger. A warning means to take shelter (NWS 2020).

The National Weather Service has five risk categories for severe weather: marginal, slight, enhanced, moderate, and high. The probabilistic forecast directly expresses the best estimate of a severe weather event occurring within 25 miles of a point (NWS 2022). Figure 5.12-6 details the thunderstorm risk categories.

Figure 5.12-6: Thunderstorm Risks



Source: NWS 2022

Hailstorm

Large hail size is said to be the greatest contributor to insured losses from a thunderstorm, making it one of the more expensive hazards. By using historic hailstone size and intensity data, it is easier to predict the full range of possible future outcomes in models (Grieser and Hill 2019).

The Torro Hailstorm Intensity Scale was developed to measure and categorize hailstorms. A member of the Tornado and Storm Research Organization (TORRO) in England created a 0 to 10 scale that begins at "no damage" and ends at catastrophic damage. More intense hailstorms cause lasting impacts on property, homes and have the ability to severely injure people and animals (TORRO n.d.). Table 5.12-1 breaks down the TORRO scale by category, and Table 5.12-2 shows hail size and diameter and how it may relate to common objects.

Table 5.12-1. The Torro Hailstorm Intensity Scale

Scale	Intensity Category	Typical Hail Diameter (mm)	Typical Damage Impacts
H0	Hard Hail	5	No Damage
H1	Potentially Damaging	5-15	Slight general damage to plants and crops
H2	Significant	10-20	Significant damage to fruit, crops, and vegetation
H3	Severe	20-30	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4	Severe	25-40	Widespread glass damage, vehicle body damage
H5	Destructive	30-50	Wholesale destruction of glass and damage to roofs, risk of injuries

Scale	Intensity Category	Typical Hail Diameter (mm)	Typical Damage Impacts
H6	Destructive	40-60	Bodywork of grounded aircraft dented; brink walls pitted
H7	Destructive	50-75	Severe roof damage, risk of serious injuries
H8	Destructive	60-90	Severe damage to aircraft bodywork
H9	Super Hailstorms	75-100	Extensive structural damage. Risk of severe or fatal injuries
H10	Super Hailstorms	>100	Extensive structural damage. Risk of severe or fatal injuries

Source TORRO n.d.

Table 5.12-2. Hail Size and Diameter

Size Code	Maximum Diameter (mm)	Description
0	5-9	Pea
1	10-15	Mothball
2	16-20	Marble, grape
3	21-30	Walnut
4	31-40	Pigeon’s egg
5	41-50	Golf ball
6	51-60	Hen’s egg
7	61-75	Tennis ball
8	76-90	Large orange
9	91-100	Grapefruit
10	>100	Melon

Source TORRO n.d.

Tornado

Wind speeds in tornadoes range from values below that of hurricane speeds to more than 300 mph. Unlike hurricanes, which produce wind speeds of similar values over relatively widespread areas (when compared to tornadoes), the maximum winds in tornadoes are often confined to extremely small areas and vary substantially over very short distances, even within the funnel itself.

The Fujita scale, introduced in 1971 by Dr. Ted Fujita, provided a way to characterize tornadoes based on the damage they produced and was able to relate that damage to the fastest quarter-mile wind at the height of a damaged structure. The Enhanced Fujita Scale or EF Scale, which became operational on February 1, 2007, is used to assign a tornado a 'rating' based on estimated wind speeds and related damage (refer to Figure 5.12-7). When tornado-related damage is surveyed, it is compared to a list of Damage Indicators (DIs) and Degrees of Damage (DoD) which help estimate better the range of wind speeds the tornado likely produced. From that, a rating (from EF0 to EF5) is assigned. Figure 5.12-7 describes the Enhanced Fujita Tornado Scale.

Tornado watches and warnings are issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly that little, if any, advance warning is possible (NOAA SPC 2018).

Figure 5.12-7: Enhanced Fujita Scale

EF Rating	Wind Speeds	Expected Damage
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.

Source NOAA n.d.

High Wind

Windstorms are generally defined as sustained wind speeds of 40 mph or greater, lasting for 1 hour or longer, or winds of 58 mph or greater for any duration. The Beaufort Wind Scale is one of the first scales to estimate wind speeds and effects. It was created by Britain's Admiral Sir Francis Beaufort; 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 (NOAA 2022).

Figure 5.12-8. Beaufort Scale

Beaufort Number	Wind Speed (miles/hour)	Wind Speed (km/hour)	Wind Speed (knots)	Description	Wind Effects on Land
0	< 1	< 1	< 1	Calm	Calm. Smoke rises vertically.
1	1-3	1-5	1-3	Light Air	Wind motion visible in smoke.
2	4-7	6-11	4-6	Light Breeze	Wind felt on exposed skin. Leaves rustle.
3	8-12	12-19	7-12	Gentle Breeze	Leaves and smaller twigs in constant motion.
4	13-18	20-28	11-16	Moderate Breeze	Dust and loose paper are raised. Small branches begin to move.
5	19-24	29-38	17-21	Fresh Breeze	Small trees begin to sway.
6	25-31	39-49	22-27	Strong Breeze	Large branches are in motion. Whistling is heard in overhead wires. Umbrella use is difficult.
7	32-38	50-61	28-33	Near Gale	Whole trees in motion. Some difficulty experienced walking into the wind.
8	39-46	62-74	34-40	Gale	Twigs and small branches break from trees. Cars veer on road.
9	47-54	75-88	41-47	Strong Gale	Larger branches break from trees. Light structural damage.
10	55-63	89-102	48-55	Storm	Trees broken and uprooted. Considerable structural damage.
11	64-72	103-117	56-63	Violent Storm	Widespread damage to structures and vegetation.
12	> 73	> 117	> 64	Hurricane	Considerable and widespread damage to structures and vegetation. Violence.

Source: NWS 2022

Tropical Cyclones

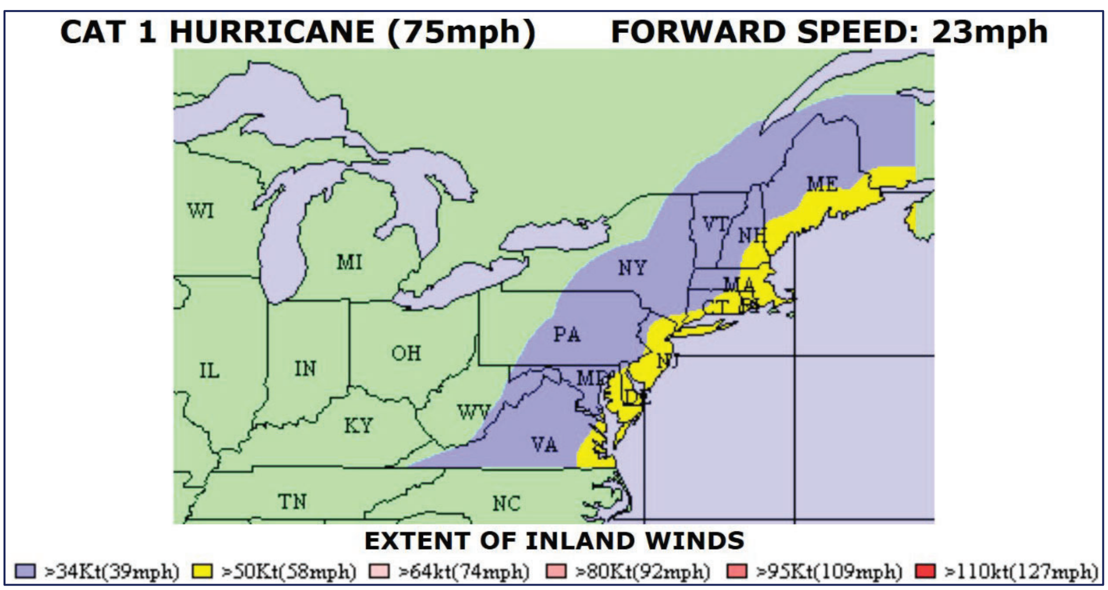
The extent of a tropical cyclone is commonly categorized in accordance with the Saffir-Simpson Hurricane Wind Scale, which assigns a designation of tropical storm for tropical cyclones with sustained wind speeds between 39–73 mph and a hurricane category rating of 1–5 based on a hurricane's increasing sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered *major hurricanes* because of their potential for significant loss of life and damage. Tropical storms and Category 1 and 2 storms are still dangerous and require preventative measures (NWS n.d.), though the probability of Category 2 or stronger winds ever impacting the State of West Virginia is extremely low. Table 5.12-3 below shows hurricane categories and the type of damage they produce, and Figure 5.12-9 shows the estimated extent of inland winds for a Category 1 hurricane moving at 23 miles per hour, the most basic and most likely hurricane scenario within FEMA Region III in a given year (FEMA 2023).

Table 5.12-3. Saffir-Simpson Hurricane Wind Scale

Category	Sustained Winds (miles per hour)	Types of Damage Due to Hurricane Winds
1	74-95	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (Major)	111-129	Devastating damage will occur: Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (Major)	130-156	Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (Major)	157 or higher	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
Other non-hurricane classifications are tropical storms (39-73 miles per hour) and tropical depressions (0-38 miles per hour)		

Source: NOAA n.d.

Figure 5.12-9: Extent of Inland Winds for a Weak Category 1 Hurricane



Source: FEMA 2023.

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. The MRP is the average period of time, in years, between occurrences of a particular hazard event, equal to the inverse of the annual frequency of exceedance.

The HAZUS 1,000-year recurrence hurricane analysis shows that the State is likely to experience tropical storm to Category 1 hurricane wind equivalents from a 1,000-year event. The 1,000-year event was chosen for this analysis to reflect changing hazard conditions- that the 1,000-year event of today may become the 500-year event of the future.

Warning Time

Thunderstorm

As described in the Extent section for thunderstorms, National Weather Service will issue a severe thunderstorm watch when conditions are favorable for the development of severe thunderstorms, and a warning when a severe thunderstorm is occurring, is detected by National Weather Service Doppler Radar, or a reliable report has been received. A severe thunderstorm watch lasts around 6 hours and covers a relatively large area; a watch means for individuals in the area to be alert. A severe thunderstorm warning is issued for smaller, more specific locations and generally last for less than one hour; a warning means for individuals to take action at that time (NWS 2023).

These warning times may also be applied to the hail, tornado, and high wind hazards, as these phenomena generally all occur during a severe thunderstorm. In addition to these warning times, a location may have a tornado siren to warn its residents and visitors of an actively occurring tornado; unfortunately, the timeframe for a tornado siren is only a few minutes until potential impacts are felt. An issuance for a severe thunderstorm watch or warning may occur during a tropical cyclone event as well.

Tropical Cyclone

The NWS issues hurricane and tropical storm watches and warnings. These watches and warnings are issued or will remain in effect after a tropical cyclone becomes post-tropical, when such a storm poses a significant threat to life and property. The NWS allows the National Hurricane Center (NHC) and the NWS Weather Forecast Offices (WFO) in Blacksburg, Virginia and Baltimore/Washington to issue advisories during the post-tropical stage. The following are the definitions of the watches and warnings:

- **Hurricane/Typhoon Warning** is issued when sustained winds of 74 mph or higher are expected somewhere within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm-force, the warning is issued 36 hours in advance of the anticipated onset of tropical storm-force winds. The warning can remain in effect when dangerously high water or combination of dangerously high water and waves continue, even though winds may be less than hurricane force.
- **Hurricane Watch** is issued when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm-force, the hurricane watch is issued 48 hours prior to the anticipated onset of tropical storm-force winds.

- **Tropical Storm Watch** is issued when sustained winds of 39 to 73 mph are possible within the specified area within 48 hours in association with a tropical, subtropical, or post-tropical storm. A severe thunderstorm watch or warning may occur simultaneously with a hurricane or tropical storm watch or warning.
- **Tropical Storm Warning** is issued when sustained winds of 39 to 73 mph are expected somewhere within the specified area within 36 hours in association with a tropical, subtropical, or post-tropical storm (NHC 2010).

It is possible for the counties on the southern end of the State along the Virginia border and the counties in the eastern West Virginia Panhandle to fall under watches and/or warnings related to tropical cyclones. The rest of the State would likely receive High Wind Warnings instead of Tropical Storm Warnings, though Hurricane Watches/Warnings are possible, though very unlikely, for the eastern counties.

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, the State was included in 55 disaster (DR) or emergency (EM) declarations for severe storm-related events. These events are classified as one or a combination of the following incident types: Flooding, Hurricane, and Severe Storm. Generally, these disasters cover a wide region of the State; therefore, they can impact many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2023).

Table 5.12-4. Severe Storm-Related Federal Declarations (1953 to 2022)

Date(s) of Event	Incident	Federal Designation	Counties Affected
March 9, 1962	Severe Storms, High Tides, Flooding	DR-125-WV*	Statewide
March 13, 1963	Severe Storms, Flooding	DR-147-WV*	Statewide
March 20, 1964	Severe Storms, Flooding	DR-165-WV*	Statewide
September 3, 1969	Severe Storms, Flooding	DR-278-WV	Greenbrier, Nicholas, Pocahontas
September 24, 1969	Severe Storms, Flooding	DR-279-WV	Greenbrier
February 27, 1972	Heavy Rains, Flooding	DR-323-WV	Boone, Kanawha, Lincoln, Logan, Mingo, Raleigh, Wyoming
July 3, 1972	Tropical Storm Agnes	DR-344-WV	Barbour, Berkeley, Brooke, Greenbrier, Hampshire, Hancock, Hardy, Jefferson, Marshall, Monongalia, Monroe, Morgan, Ohio, Preston, Wetzel
August 23, 1972	Heavy Rains, Flooding	DR-349-WV	Logan, McDowell, Mingo, Wyoming
January 29, 1974	Severe Storms, Flooding	DR-416-WV	Kanawha, Lincoln, Logan, Mingo, Wayne
April 11, 1974	Severe Storms, Flooding	DR-426-WV	Fayette, Greenbrier, Raleigh, Wyoming
September 12, 1975	Heavy Rains, Flooding	DR-481-WV	Marshall, Ohio
April 7, 1977	Severe Storms, Flooding	DR-531-WV	Cabell, Greenbrier, Lincoln, Logan, McDowell, Mercer, Mingo, Raleigh, Summers, Wayne, Wyoming
August 24, 1977	Severe Storms, Landslides and Flooding	EM-3052-WV	Boone, Logan, Mingo

Date(s) of Event	Incident	Federal Designation	Counties Affected
December 14, 1978	Severe Storms, Flooding	DR-569-WV	Cabell, Jackson, Lincoln, Mingo, Wayne
August 15, 1980	Severe Storms, Flooding	DR-628-WV	Fayette, Nicholas, Raleigh, Hancock, Harrison, Jackson, Kanawha, Marion, Marshall, Monongalia, Ohio, Preston, Putnam, Taylor, Webster
May 15, 1984	Severe Storms, Flooding	DR-706-WV	Logan, McDowell, Wayne, Mingo
November 7, 1985	Severe Storms, Flooding (Hurricane Juan)	DR-753-WV	Barbour, Berkeley, Braxton, Calhoun, Doddridge, Gilmer, Grant, Greenbrier, Hampshire, Hardy, Harrison, Jefferson, Lewis, Marion, Mineral, Monongalia, Monroe, Morgan, Nicholas, Pendleton, Pocahontas, Preston, Randolph, Summers, Taylor, Tucker, Tyler, Upshur, Webster
June 23-28, 1995	Severe Storm, Heavy Rains, Flooding, Mudslides	DR-1060-WV	Mercer, Mineral, Nicholas
September 5-8, 1996	Hurricane Fran	DR-1137-WV	Berkeley, Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan, Pendleton, Randolph, Tucker
March 7, 1997	Severe Storms/Flooding	DR-1168-WV	Braxton, Cabell, Calhoun, Clay, Gilmer, Jackson, Kanawha, Lincoln, Mason, Putnam, Roane, Tyler, Wayne, Wetzel, Wirt, Wood
June 26-July 27, 1998	Severe Storms, Flooding and Tornadoes	DR-1229-WV	Braxton, Cabell, Calhoun, Clay, Doddridge, Gilmer, Harrison, Jackson, Kanawha, Lewis, Marion, Marshall, Ohio, Pleasants, Ritchie, Roane, Tyler, Wetzel, Wood, Wirt
May 15-September 4, 2001	Severe Storms & Flooding	DR-1378-WV	Boone, Cabell, Calhoun, Clay, Doddridge, Fayette, Greenbrier, Kanawha, Lincoln, Logan, Marion, Mason, McDowell, Mercer, Mingo, Nicholas, Preston, Putnam, Raleigh, Roane, Summers, Taylor, Wayne, Wyoming
May 2-20, 2002	Severe Storms, Flooding, and Landslides	DR-1410-WV	Kanawha, Logan, McDowell, Mercer, Mingo, Raleigh, Summers, Wyoming
June 11-July 15, 2003	Severe Storms, Flooding and Landslides	DR-1474-WV	Berkeley, Boone, Cabell, Doddridge, Harrison, Kanawha, Lincoln, Logan, Marion, Mason, McDowell, Mingo, Monongalia, Nicholas, Preston, Putnam, Ritchie, Tucker, Wayne, Wyoming
September 18-30, 2003	Hurricane Isabel	DR-1496-WV	Berkeley, Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan, Pendleton, Randolph, Tucker
November 11-30, 2003	Severe Storms, Flooding, and Landslides	DR-1500-WV	Barbour, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Greenbrier, Harrison, Kanawha, Lewis, Logan, Marion, Marshall, McDowell, Mercer, Monongalia, Monroe, Nicholas, Pendleton, Pocahontas, Putnam, Raleigh,

Date(s) of Event	Incident	Federal Designation	Counties Affected
			Ritchie, Summers, Taylor, Upshur, Wayne, Webster, Wetzel, Wyoming
May 27-June 28, 2004	Severe Storms, Flooding and Landslides	DR-1522-WV	Boone, Braxton, Cabell, Clay, Fayette, Gilmer, Jackson, Kanawha, Lewis, Lincoln, Logan, Mason, McDowell, Mercer, Mingo, Nicholas, Putnam, Raleigh, Roane, Wayne, Webster, Wirt, Wyoming
July 22-September 1, 2004	Severe Storms, Flooding, and Landslides	DR-1536-WV	Fayette, Lincoln, Logan, Mingo
September 16-27, 2004	Severe Storms, Flooding and Landslides (Hurricane Ivan)	DR-1558-WV	Berkeley, Boone, Brooke, Cabell, Clay, Hancock, Jackson, Kanawha, Lincoln, Logan, Marshall, Mason, Mingo, Morgan, Ohio, Pleasants, Putnam, Tyler, Wayne, Wetzel, Wirt, Wood
January 4-25, 2005	Severe Storms, Flooding, and Landslides	DR-1574-WV	Brooke, Hancock, Marshall, Ohio, Tyler, Wetzel
August 29-October 1, 2005	Hurricane Katrina Evacuation	EM-3221-WV	All Counties
April 14-18, 2007	Severe Storms, Flooding, Landslides, and Mudslides	DR-1696-WV	Barbour, Boone, Cabell, Gilmer, Grant, Hardy, Lewis, Lincoln, Logan, McDowell, Mingo, Pendleton, Pocahontas, Putnam, Upshur, Wayne, Webster, Wyoming
June 3-7, 2008	Severe Storms, Tornadoes, Flooding, Mudslides, and Landslides	DR-1769-WV	Barbour, Braxton, Calhoun, Clay, Doddridge, Gilmer, Harrison, Jackson, Jefferson, Lewis, Marion, Ritchie, Taylor, Tucker, Tyler, Webster, Wetzel, Wirt
May 3-June 8, 2009	Severe Storms, Flooding, Mudslides, and Landslides	DR-1838-WV	Calhoun, Gilmer, Lewis, McDowell, Mercer, Mingo, Raleigh, Roane, Upshur, Wirt, Wyoming
March 12-April 9, 2010	Severe Storms, Flooding, Mudslides, and Landslides	DR-1893-WV	Fayette, Greenbrier, Kanawha, Mercer, Raleigh, Summers
June 24, 2010	Severe Storms, Flooding, Mudslides, and Landslides	DR-1918-WV	Lewis, Logan, McDowell, Mingo, Wyoming
February 29-March 5, 2012	Severe Storms, Tornadoes, Flooding, Mudslides, and Landslides	DR-4059-WV	Doddridge, Harrison, Lincoln, Marion, Mingo, Monongalia, Preston, Ritchie, Roane, Taylor, Wayne
March 15-31, 2012	Severe Storms, Flooding, Mudslides, and Landslides	DR-4061-WV	Lincoln, Logan, Mingo
June 29-July 10, 2012	Severe Storms	EM-3345-WV	All Counties
June 29-July 8, 2012	Severe Storms and Straight-line Winds	DR-4071-WV	Boone, Cabell, Clay, Fayette, Greenbrier, Jackson, Kanawha, Lincoln, Mason, McDowell, Mercer, Mingo, Monroe, Nicholas, Pocahontas, Raleigh, Roane, Tyler, Webster, Wood
October 29-November 8, 2012	Hurricane Sandy	EM-3358-WV	All Counties
October 29-November 8, 2012	Hurricane Sandy	DR-4093-WV	Barbour, Boone, Braxton, Clay, Fayette, Kanawha, Lewis, Nicholas, Pendleton,

Date(s) of Event	Incident	Federal Designation	Counties Affected
			Pocahontas, Preston, Raleigh, Randolph, Taylor, Tucker, Upshur, Webster, Wyoming
July 26, 2013	Severe Storms and Flooding	DR-4132-WV	Mason, Roane
March 3-14, 2015	Severe Winter Storm, Flooding, Landslides, and Mudslides	DR-4210-WV	Barbour, Boone, Braxton, Cabell, Doddridge, Fayette, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Marshall, McDowell, Mercer, Mingo, Monongalia, Putnam, Raleigh, Ritchie, Roane, Summers, Taylor, Tucker, Tyler, Upshur, Wayne, Webster, Wetzel, Wirt, Wood, Wyoming
April 3-5, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4219-WV	Boone, Cabell, Lincoln, Logan, Mingo, Wayne
May 18, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4220-WV	Braxton, Brooke, Doddridge, Gilmer, Jackson, Lewis, Marshall, Ohio, Pleasants, Ritchie, Tyler, Wetzel
May 21, 2015	Severe Storms, Flooding, Landslides, and Mudslides	DR-4221-WV	Cabell, Calhoun, Greenbrier, Jackson, Pleasants, Roane, Summers, Wirt
July 10-14, 2015	Severe Storms, Straight-line Winds, Flooding, Landslides, and Mudslides	DR-4236-WV	Braxton, Clay, Jackson, Lincoln, Logan, Nicholas, Roane, Webster, Wood
June 25, 2016	Severe Storms, Flooding, Landslides, and Mudslides	DR-4273-WV	Braxton, Gilmer, Lewis, Randolph, Upshur, Wayne, Clay, Fayette, Greenbrier, Jackson, Kanawha, Lincoln, Monroe, Nicholas, Pocahontas, Roane, Summers, Webster
July 28-29, 2017	Severe Storms, Flooding, Landslides, and Mudslides	DR-4331-WV	Doddridge, Harrison, Marion, Marshall, Monongalia, Ohio, Preston, Randolph, Taylor, Tucker, Tyler, Wetzel
April 17, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4359-WV	Brooke, Cabell, Calhoun, Doddridge, Hancock, Harrison, Lincoln, Logan, Marshall, Mason, Monongalia, Ohio, Pleasants, Preston, Ritchie, Taylor, Tyler, Wayne, Wetzel, Wirt, Wood
July 12, 2018	Severe Storms, Flooding, Landslides, and Mudslides	DR-4378-WV	Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan, Pendleton
August 2, 2019	Severe Storms, Flooding, Landslides, and Mudslides	DR-4455-WV	Grant, Pendleton, Preston, Randolph, Tucker
February 27-March 4, 2021	Severe Storms and Flooding	DR-4605-WV	Boone, Kanawha, Lincoln, Logan, Mingo, Wayne
July 12-13, 2022	Severe Storms, Flooding, Landslides, and Mudslides	DR-4678-WV	McDowell
August 14-15, 2022	Severe Storms, Flooding, Landslides, and Mudslides	DR-4679-WV	Fayette

Source: FEMA 2023
** For this event, as per the FEMA website, no additional information was filed for this event*

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was included in three agricultural disaster declarations pertaining to severe storms, as shown in Table 5.12-5.

Table 5.12-5. Severe Storm-Related USDA Declarations (2012 to 2022)

Date(s) of Event	Designation Number	Description of Disaster	Counties Declared
March 1-August 25, 2015	USDA-S3934	Hail, Wind, Lightning	Cabell, Hancock, Jackson, Marshall, Mason, Ohio, Pleasants, Tyler, Wayne, Wetzel, Wood
April 1-December 31, 2018	USDA-S4480	Hurricane	Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Greenbrier, Jackson, Kanawha, Lewis, Mason, Nicholas, Pleasants, Pocahontas, Putnam, Randolph, Ritchie, Roane, Tyler, Upshur, Webster, Wirt, Wood
April 15, 2018-continuing	USDA-S4493	Hail	Hardy, Pendleton

Source: USDA 2022

Previous Events

Many sources provided flooding information regarding previous occurrences and losses associated with severe storm events throughout the State. The 2018 SHMP discussed specific severe storm events that occurred in the State through 2018. For this 2023 SHMP update, severe storm events were summarized between January 1, 2018, and December 31, 2022.

Table 5.12-6 includes details of severe storm events that occurred in the State between 2018 and 2022. Major events include those that resulted in losses or fatalities, as reported by the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI), events that led to a FEMA disaster declaration, and/or event that led to a USDA declaration. Due to over 2,000 events having been recorded between 2018 and 2022, the following criteria was used to narrow the events shown in Table 5.12-6:

- FEMA-declared disasters are not included in the below table and can instead be found in Table 5.12-4
- USDA-declared disaster are not included in the below table and can instead be found in Table 5.12-5
- Only events from the NOAA NCEI Storm Events Database were used in Table 5.12-6
- Events searched for in the NOAA NCEI Storm Events Database included hail, high wind, hurricane, lightning, strong wind, thunderstorm wind, tornado, and tropical storm
- Episode narratives are used for the event description
- Event narratives are not included in the event description
- Events with less than $75,000 in property and/or crop damages are not included in Table 5.12-6
- Events with a fatality are included in Table 5.12-6

Table 5.12-6. Severe Storm Events in the State of West Virginia (2018 to 2022)

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
July 30-31, 2018	Thunderstorm Wind, Lightning	N/A	Braxton, Cabell, Calhoun, Kanawha, Putnam, Wayne	A slow-moving thunderstorm produced excessive rai Central West Virginia. An area of low pressure moved Valley on the 31st crossing through West Virginia tha to severe thunderstorms. $115,500 of property dama this event.
September 10, 2018	Strong Wind	N/A	Monongalia	Moisture from the decaying Tropical Storm Gordon i low and frontal boundary, spreading widespread hea region over a 3-day period. 72-hour totals across nor ranged from 2 inches to about 5.5 inches. Small-strea widespread as in areas to the north and east in Penn issues reported in Marshall County. However, winds with the saturated ground to cause a tree to fall on a killing a woman who was sleeping in an upstairs bedr property damages were incurred from this event.
October 20, 2018	Strong Wind	N/A	Boone, Cabell, Fayette, Kanawha, Lincoln, Mason, Putnam, Raleigh, Taylor, Wayne	A strong cold front brought a round of gusty winds w tree damage and power outages. One of the hardest Kanawha, where over 14,000 customers lost power. Airport measured a wind gust of 45 mph. A home alo Kanawha City has some siding blown off due to the w South Charleston had a punctured roof after a tree fe two days for all the power outages to be fixed. Sever outages also occurred in Cabell, Logan, Lincoln, Maso Wayne Counties. The ASOS at Raleigh County Airport knots. AEP reported a total of 17 transmission lines w Virginia, knocking multiple substation offline. $340,0 were incurred from this event.
February 24-25, 2019	High Wind, Strong Wind	N/A	Barbour, Berkeley, Boone, Braxton, Brooke, Calhoun, Clay, Doddridge, Fayette, Gilmer, Grant, Greenbrier, Hampshire, Hancock, Hardy, Harrison, Jackson, Jefferson,	A cold front rushed across the region during the late afternoon hours of the 24th, bringing a prolonged pe gusts that followed the frontal passage. This resulted of 40-60 mph wind gusts across the region. Several re 60 mph or greater were received. The highest record Mesonet sensor east of Canaan Heights in Tucker Co

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
			Kanawha, Lewis, Lincoln, Logan, Marshall, Mason, McDowell, Mercer, Mineral, Mingo, Monongalia, Monroe, Morgan, Nicholas, Ohio, Pendleton, Pleasants, Pocahontas, Preston, Putnam, Raleigh, Randolph, Ritchie, Roane, Summers, Taylor, Tucker, Tyler, Upshur, Wayne, Webster, Wetzel, Wirt, Wood, Wyoming	wind gusts in excess of 60 mph were observed as we widespread reports of downed trees, power lines, an across the entire region, with some examples noted i Thankfully, no injuries were reported from wind effe widespread as well. A peak of 91,000 outages were r on the night of the 24th. Full restoration took multip extent of damage and the initially unsafe working co ongoing wind. $1,920,500 of property damages were event.
April 14, 2019	Thunderstorm Wind, Hail	N/A	Barbour, Boone, Braxton, Cabell, Clay, Fayette, Greenbrier, Harrison, Kanawha, Lewis, McDowell, Ohio, Pocahontas, Preston, Raleigh, Randolph, Summers, Upshur	For this event, the tornado risk was perceived to be r Storm Prediction Center forecasting numeric probabi the Ohio River that were of an unusually high level. N confirmed in West Virginia from this event, with only reports received overall. $122,000 of property damag this event.
May 2-3, 2019	Thunderstorm Wind, Hail	N/A	Berkeley, Cabell, Calhoun, Kanawha, Putnam	A very localized microburst in Kanawha County result property damages.
May 23, 2019	Thunderstorm Wind, Hail	N/A	Clay, Fayette, Jackson, Kanawha, Marion, Mason, Nicholas, Preston, Roane	Thunderstorms developed in the middle Ohio River V of the 23rd. These storms quickly grew to severe leve hail and sporadic wind damage as they moved across $765,000 of property damages were incurred from th
May 25-26, 2019	Thunderstorm Wind, Lightning	N/A	Gilmer, Harrison, Jackson, Logan, Mason, Mercer, Monongalia, Ritchie, Roane, Taylor, Tyler, Webster, Wirt, Wood, Wyoming	Thunderstorms produced minor flash flooding, along some hail. Lightning is believed to be the cause of a f condensate storage tank owned by Dominion Energy million-gallon tank was holding roughly 640,000 gallo about 12 hours to extinguish. The community of Ben a time due to concerns of explosion. $1,152,000 of p incurred from this event.

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
May 29, 2019	Thunderstorm Wind, Hail	N/A	Brooke, Fayette, Greenbrier, Jackson, Logan, Mason, McDowell, Mercer, Mingo, Monongalia, Monroe, Raleigh, Roane, Summers, Webster, Wirt, Wood, Wyoming	Storms produced hail up to the size of quarters and p winds that blew down numerous trees and power lin damaged several structures. $437,500 of property da from this event.
June 24, 2019	Thunderstorm Wind, Hail, Lightning, Tornado	N/A	Barbour, Braxton, Brooke, Cabell, Clay, Greenbrier, Hancock, Kanawha, Lewis, Mercer, Mingo, Putnam, Randolph, Upshur, Wayne, Wetzel	A line of severe thunderstorms stretched across Cent 24th, resulting in widespread wind damage as well as touching down near the City of Charleston. Lightning then fell on top of a house. A limb from the tree injur $693,400 of property damages were incurred from th
June 30, 2019	Severe Storm, Flood, Flash Flood	DR-4455-WV	Grant, Pendleton, Preston, Randolph, Tucker	An unstable environment, plus residual outflow bour convection, helped to expand thunderstorm coverag the 29th and into the early morning hours of the 30th cold front. Storms pushed across Preston and Tucker 10 PM on the 29th. Periods of moderate to heavy rai 5 AM the following morning as back building storms c night. Rainfall totals of 2 to 4 inches were observed o of Preston County and over much of Tucker County, r reports of flash flooding. A few water rescues were m Campground, as well as in Jenningston. Heavy amour period of time fell in areas near the Appalachian Mou The heavy amounts of rain caused creeks and stream their banks. $1.053 million of property damages were event.
October 31, 2019	Thunderstorm Wind, Strong Wind, High Wind	N/A	Boone, Braxton, Fayette, Grant, Kanawha, Logan, Mingo, Monroe, Morgan, Ohio, Pocahontas, Tucker, Wyoming	A cold front led to a period of high winds across the r to 50 mph were observed, with a high gust of 64 mph Tucker County, WV. Many reports of tree and power received, and power outages numbered into the thou Wind impacts were likely more widespread than repo property damages were incurred from this event.

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
November 27, 2019	Strong Wind, High Wind	N/A	Berkeley, Cabell, Fayette, Grant, Greenbrier, Hampshire, Hardy, Jackson, Kanawha, Mason, Mercer, Mineral, Monroe, Morgan, Pendleton, Pocahontas, Preston, Putnam, Raleigh, Randolph, Roane, Summers, Tucker, Wayne	A cold front resulted in widespread wind gusts of 40 measured gust was near Snowshoe in Pocahontas Co station measured at 67 mph gust. Most damage was power lines; however, a column at the front of the W Church in Huntington was toppled by the wind. $691 damages were incurred from this event.
January 11-12, 2020	Strong Wind, Thunderstorm Wind, High Wind	N/A	Barbour, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Marion, Mason, McDowell, Mingo, Nicholas, Pleasants, Pocahontas, Putnam, Raleigh, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Webster, Wirt, Wood, Wyoming	A strong storm system moved through the Great Lak Gusts ahead of this system were regularly measured A line of showers and thunderstorms developed in th Valley along a cold front and quickly raced eastward afternoon and evening. By the time these got to the and central Appalachians, no lightning was present, b showers were still packing gusty outflow winds, with damage reported. The actual cold front surged throu another round of 45-55 mph winds, causing more po after noon on the 11th, a tree fell onto a side-by-side Boone County. A 14-year-old boy was fatally wounde sister were injured. The ASOS at Charleston's Yeager 13 miles from the incident site, measured gusts of 30 time of the incident. These were driven by the synop activity. $511,000 of property damages were incurre
April 7-13, 2020	Strong Wind, Thunderstorm Wind, High Wind, Hail	N/A	Berkeley, Boone, Braxton, Cabell, Clay, Doddridge, Fayette, Gilmer, Hardy, Harrison, Jefferson, Kanawha, Lewis, Lincoln, Logan, Marshall, Mason, McDowell, Mercer, Mingo, Monongalia, Monroe, Nicholas, Pocahontas, Putnam, Raleigh, Randolph,	A strong low-pressure system crossing through the st rounds of severe weather across West Virginia. Starti front draped across the Ohio Valley was the primary develop that evening. These storms produced large h northern West Virginia. A brief lull in storms during t primed the atmosphere once more for severe thunde of a cold front which passed through late that night. another round of thunderstorm wind damage, hail, a occurred late that evening and into the early mornin cooperative observers reported 1 to 2 inches of rainf

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
			Ritchie, Roane, Tucker, Tyler, Upshur, Upshur, Wayne, Webster, Wood	second round of convection. Strong synoptic winds o backside of the disturbance remained in place before built into the region. An intense low-pressure system Valley during the early morning hours on the 13th, w thunderstorms aligned along a surface cold front. Mu and structural damage with these storms. A tightene formed over the state, inflicting strong synoptic wind thunderstorms. Numerous trees were blown down, k multiple areas. Near Mt. Hope in NW Fayette County brick wall collapsed at the municipal stadium. Other damage around Mt. Hope. Nearby, the Beckley ASOS Many personal and DOT weather stations measured across the region. $1,478,000 of property damages w event.
April 21, 2020	Strong Wind	N/A	Barbour, Harrison, Kanawha, Logan, Raleigh, Randolph, Tyler, Upshur, Wayne, Wood	In the wake of a frontal passage, strong synoptic win afternoon of the 21st into the evening before taperin wind gusts of 40 to 50 mph were measured in the sta was at Yeager airport in Kanawha County where the mph gust. Isolated power outages were caused by fa $90,000 of property damages were incurred from thi
July 6-7, 2020	Thunderstorm Wind, Hail	N/A	Grant, Greenbrier, Harrison, Jefferson, Kanawha, Mineral, Mingo, Taylor	An upper-level disturbance triggered numerous show The very unstable lower-level air mass resulted in an to downburst winds, some of which were significant. showers and storms formed each day, with some of t hail and strong winds, along with heavy rainfall. $88, damages were incurred from this event.
August 1, 2020	Thunderstorm Wind	N/A	Calhoun, Harrison, Kanawha, Lincoln, Morgan, Raleigh, Roane	A warm front pushed through the central Appalachia River Valley, kicking off strong to severe thunderstor early evening. $137,000 of property damages were in
August 25, 2020	Thunderstorm Wind, Hail	N/A	Barbour, Boone, Cabell, Clay, Fayette, Grant, Greenbrier, Hampshire, Harrison, Jackson, Kanawha, Marion, Marshall, Mason, Mineral,	Severe storms were able to take advantage of a front towards I-70. Shear and increasing instability favored bowing segments initially. Damage in northern West limited to trees and power lines from the thundersto instance of roof damage was reported. Also, an insta

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
			Monongalia, Morgan, Preston, Putnam, Ritchie, Roane, Taylor, Upshur, Wetzel, Wirt, Wyoming	observed in Preston County. $322,500 of property da from this event.
November 15, 2020	Thunderstorm Wind	N/A	Berkeley, Brooke, Hancock, Hardy, Jefferson, Lewis, Mineral, Monongalia, Morgan, Ohio, Preston, Tucker	A cold front brought strong winds to the region. Wid least 45-55 mph were observed, with several higher r Along the convective line, gusts of 55-65 mph likely c widespread reports of wind damage to trees and pow instances of mostly minor structural damage. $173,0 were incurred from this event.
February 27-March 2, 2021	Flood, Flash Flood, Heavy Rain	DR-4605-WV	Barbour, Boone, Braxton, Cabell, Clay, Fayette, Greenbrier, Hampshire, Kanawha, Jackson, Jefferson,Lincoln, Logan, Mason, McDowell, Mercer, Mineral, Mingo, Morgan, Pocahontas, Putnam, Raleigh, Randolph, Ritchie, Roane, Summers, Tyler, Wayne, Webster, Wirt, Wood, Wyoming	Rainfall amounts ranging generally from 1.25 to near Mercer County. Most of the rain fell across a 4- to 5-l morning. Waves of rain, heavy at times, moved acros afternoon of February 26th through the morning of M streams rose out of their banks by the final day of Fe flooded roadways across West Virginia. Several wate conducted in Putnam County on the 28th due to veh submerged by rapidly rising water. An additional inch February 28th, along with partial melting of snowpac to some isolated flooding across eastern West Virgini fell across West Virginia from the final few days of Fe morning of Monday, March 1st. Multiple disturbance state during this time and caused periods of heavy ra this event fell south of the I-64 corridor, but the entir least 1 to 2 inches of rain over the span of four days. notable flooding across West Virginia as local creeks and spilled onto local roadways. Moderate river floo the first few days of March, with some river gauges r including the Coal, Elk, and Tug Fork Rivers. $554,560 were incurred from this event.
May 3-4, 2021	Thunderstorm Wind, Tornado	N/A	Berkeley, Jefferson, Marion	An isolated, cyclic supercell thunderstorm tracking al produced sporadic straight-line wind damage and spa tornadoes. $118,000 of property damages were incu

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
June 13-14, 2021	Thunderstorm Wind, Tornado, Hail	N/A	Barbour, Boone, Brooke, Calhoun, Clay, Doddridge, Fayette, Gilmer, Grant, Greenbrier, Hardy, Harrison, Kanawha, Lewis, Lincoln, Marion, Marshall, Monongalia, Monroe, Nicholas, Ohio, Pleasants, Preston, Putnam, Raleigh, Ritchie, Taylor, Tyler, Upshur, Webster, Wetzel, Wood	A strong cold front in accordance with a passing low- pressed into West Virginia on the evening of June 13 thunderstorms accompanied the front, resulting in m downed trees and power lines due to damaging wind combination of heavy downpours and multiple storm that day, several counties observed flash flooding. Th occurred in Gilmer County, where a large shed on a g away by the rushing high water, and Pocahontas Cou water rescue was conducted in the town of Frost. An developed ahead of an advancing boundary and quic near Pleasant Valley, WV. $261,000 of property dama this event.
June 21, 2021	Thunderstorm Wind	N/A	Barbour, Berkeley, Brooke, Doddridge, Gilmer, Hampshire, Hancock, Harrison, Jefferson, Kanawha, Lewis, Lincoln, Logan, Marion, Mineral, Monongalia, Nicholas, Preston, Putnam, Ritchie, Taylor, Tyler, Upshur, Wirt, Wood, Wyoming	Thunderstorms flourished across West Virginia on th of June 21st as a cold front glided through the region became severe and caused damaging winds to knock the front's passage. Early in the afternoon, a Mesone County measured a 52 mile per hour wind gust as the thunderstorms propagated eastward. Later that even storms arrived, with a 48 mile per hour wind gust bei Clarksburg airport. With saturated grounds already p storms, an instance of flash flooding was observed in several roads became impassible for a brief period. $ damages were incurred from this event.
July 29, 2021	Thunderstorm Wind	N/A	Monongalia, Ohio, Preston, Tucker	A shortwave passage during the morning of July 29th severe showers and thunderstorms across the region and midday hours. However, a discrete cell along the morning activity was able to develop a tornado along Westmoreland County border in Pennsylvania. This w was to follow. In the wake of this morning activity, ad were able to develop. A cross-boundary component discrete supercells to form during the mid and late a motions were favorable for the ingestion of streamw for rotating storms. While eight tornadoes formed du eastern Ohio and southwest Pennsylvania, the severe

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
				were limited to straight-line wind damage to mainly t thunderstorms also led to reports of numerous flood County. $107,000 of property damages were incurre
August 13, 2021	Thunderstorm Wind	N/A	Boone, Clay, Hancock, Hardy, Jefferson, Kanawha, Lincoln, Pendleton, Summers, Wayne	Thunderstorms developed across West Virginia on Au trees and power lines were blown down that afterno damage observed near Wallace in Kanawha County a trailer and a car. Minor flooding was also observed n Danville. $173,500 of property damages were incurre
May 1, 2022	Thunderstorm Wind, Hail	N/A	Clay, Monongalia	Showers and thunderstorms, mainly in broken lines, front across the region during the afternoon and eve Moderate shear and instability, as well as mid-level d development of several instances of severe thunders wind gusts being the primary impact. One storm grev produce half-dollar-sized hail in Clay County. $197,00 were incurred from this event.
May 3, 2022	Thunder Storm Wind	N/A	Grant, Hampshire, Hardy, Harrison, Monongalia, Ohio, Taylor, Wood	Numerous thunderstorms impacted the region durin evening hours of May 3rd. Several wind damage repo northern West Virginia. Although a tornado watch wa funnel cloud was spotted, no tornadoes were reporte $116,000 of property damages were incurred from th
June 8, 2022	Thunderstorm Wind, Hail	N/A	Greenbrier, Hampshire, Harrison, Jackson, Kanawha, Lewis, Marion, Marshall, Mason, Mineral, Monongalia, Monroe, Morgan, Preston, Putnam, Randolph, Taylor, Tyler, Wetzel, Wood	Storms that produced large hail and high winds deve River Valley on the evening of June 8th. Numerous su hours before reaching eastern Ohio along an advanci main threat occurred between 6pm and 10pm. The v storms was south of I-70 where the moisture bounda dry and strong deep wind shear helped the developn hail (up to 2 inches). $132,750 of property damages a damages were incurred from this event.
June 13-14, 2022	Thunderstorm Wind	N/A	Boone, Cabell, Clay, Doddridge, Fayette, Greenbrier, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Mason, Mercer, Ohio, Putnam,	A line of thunderstorms crossed through the Ohio Va afternoon of June 13th, moving into West Virginia in temperatures during the day aided with providing aft storms to thrive. Damaging winds were the main con storms as it persisted across the Ohio Valley; howeve also accompanied these storms. As this first line was

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
			Raleigh, Upshur, Wayne, Wirt, Wood, Wyoming	West Virginia, a second line of storms formed along t boundary and pushed into the northern portion of th night of the 13th. Damaging winds were the main thr line of storms. Following this line, another round of s winds entered along the northwestern portions of th morning of June 14th as enough instability continued the area. A fourth line passed through by the later m 14th. The main impacts from these storms were the power lines that were blown down across the region outages occurred across West Virginia as a result. Fo rounds of storms, rises occurred on a few rivers acros Isolated high water issues occurred along local roadw Harrison Counties, with a few roads becoming impas $95,500 of property damages were incurred from thi
June 16-17, 2022	Thunderstorm Wind, Hail	N/A	Gilmer, Greenbrier, Jefferson, Kanawha, Lewis, Logan, Mercer, Monroe, Nicholas, Pleasants, Pocahontas, Putnam, Ritchies, Roane, Summers, Tyler, Upshur, Wayne	On June 16th, the strongest storms resided across th West Virginia, where numerous trees were blown do hail fell. A few instances of heavy downpours within t leading to high water along local roadways in Tyler ar June 17th, numerous trees were blown down across West Virginia from strong wind gusts in the early afte more trees down in the southeastern portions of the The most significant damage caused by these storms off a home in Lincoln County. Heavy downpours and conditions also resulted in one instance of flash flood Route 129 and 39 in the town of Poe. $171,750 of pr incurred from this event.
July 12, 2022	Thunderstorm Wind, Hail, Tornado, Lightning	DR-4678-WV	Fayette, Grant, Greenbrier, Hampshire, Hardy, Harrison, Kanawha, Logan, Mason, Mineral, Pocahontas, Preston, Putnam, Raleigh, Summers, Taylor, Tucker	An outbreak of significant severe weather occurred c evening hours of Tuesday, July 12th, 2022. Swaths of winds were observed, much of which was considerab tornadoes were also confirmed, along with some sign of over 100 mph was measured in one of the most po eastern West Virginia. $1,426,250 of property damag damages were incurred from this event.

Date(s) of Event	Event Type	Disaster Declaration (if applicable)	Counties Affected	Description
July 23-24, 2022	Thunderstorm Wind, Hail	N/A	Doddridge, Grant, Greenbrier, Hancock, Hardy, Harrison, Jackson, Lewis, Mason, Mineral, Morgan, Nicholas, Ohio, Ohio, Pendleton, Pocahontas, Preston, Roane, Taylor, Tyler, Upshur, Webster, Wetzel	A widespread wind damage event occurred on July 2 crossed northern West Virginia during the early to m Although damage was more widespread to the north wind damage to trees and power lines resulted from of instability, ample shear, and pre-frontal disturbanc thunderstorm clusters producing widespread damagi of which occurred further north, but one instance of reported in Ohio County. $171,750 of property dama this event.
August 1, 2022	Thunderstorm Wind, Tornado	N/A	Braxton, Marshall	Low pressure drew in a cold front on the afternoon o contributing to the development of scattered shower Antecedent rainfall ahead of this event resulted in su conditions, which coupled with heavy rainfall led to a Two tornadoes spun up from a single supercell. $600 damages and $5,000 in crop damages were incurred
August 15-16, 2022	Heavy Rain, Flash Flood	DR-4679-WV	Fayette, Greenbrier, Kanawha	A narrow band of heavy rain fell across the I-64 corri morning hours of August 15th. The Charleston airpor of rain had fallen since the previous evening, with rac from 2 to 5 inches from Putnam to Fayette Counties. area of Kanawha County observed significant damage with damage costs extending close to one million dol also observed in the Scrabble Creek area of Fayette C West Virginia declared a State of Emergency for Kana Counties due to the flooding, and recovery and clean weeks after the event occurred. Another round of showers and storms transpired on 16th, which once again caused high water issues with Roughly $10 million of property damages were incurr

Sources: NOAA NCEI 2023; FEMA 2023

Probability of Future Hazard Events

Overall Probability

According to FEMA's disaster declaration, the USDA disaster declarations, the NOAA NCEI Storm Events Database, and the 2018 SHMP, the State experienced over 9,000 events between 1996 and 2022, as summarized in Table 5.12-7.

Table 5.12-7: Probability of Future Severe Storm Events in West Virginia

Hazard Type	Number of Occurrences Between 1996 and 2022	Percent Chance of Occurrence in Any Given Year
High Wind / Strong Wind	1,254	100
Lightning	90	100
Thunderstorm Wind	5,520	100
Hail	2,416	100
Tornado	79	100
Tropical Cyclone	0	0
Total	**9,359**	**100**

Sources: FEMA 2023; USDA 2023; NOAA NCEI 2023

Projected Future Conditions

Future conditions have the potential to make storms such as thunderstorms, tropical cyclones, and tornadoes more severe. Tornado activity in the United States has become more variable, particularly over the 2000s, with a decrease in the number of days per year with tornadoes and an increase in the number of tornadoes on particular days (U.S. Global Change Research Program 2018). West Virginia historically averages only two to five tornadoes per year, but any increase in that number could have severe impacts upon life safety and property, particularly in the State's poorer areas.

Although West Virginia is not a coastal state, it is not immune from the impacts of coastal storms. As these storms are projected to intensify in frequency and extent, it is safe to assume that tropical cyclone-related winds will increase in West Virginia. In West Virginia, an increase in both the number and intensity of severe storms could have devastating impact upon public utilities such as power grids, internet, and stormwater/wastewater systems. See the Utility Failure section below for further detail (U.S. Global Change Research Program n.d.) (NOAA 2022) (MetroNews 2021).

5.12.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For severe storms, the entirety of West Virginia has been identified as the hazard area. Therefore, all assets in the State (population, structures, critical facilities, and lifelines), as described in the State Profile, are vulnerable. The impacts on population, existing structures, critical facilities, and the economy are presented below.

State Assets

For the purposes of this risk assessment, an asset is considered potentially vulnerable if it is in an identified hazard area. As stated previously, for the severe storm hazard the entire area of West Virginia is the hazard area. Therefore, all State facilities and State roadways are vulnerable to severe storms.

Critical Facilities and Community Lifelines

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.

Table 5.12-8 summarizes wind impacts on critical facilities. Overall, the 1,000 year mean return period hurricane event is only expected to result in one lost school day and fairly minor to low-end moderate probabilities of sustaining damages.

Table 5.12-8. 1,000 Year Mean Return Period Hurricane Wind Impacts on Critical Facilities

Facility Type	1000-Year Mean Return Period Hurricane				
	Loss of Days	Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
Medical Care Facilities	0	0% - 2.3%	0% - 0.2%	0.00%	0.00%
Police Stations	0	0% - 10.6%	0% - 3%	0% - 0.2%	0.00%
Schools	1	0% - 10%	0% - 9.3%	<0.1%	0.00%
Other	N/A	0.0% - 12.7%	0% - 4.1%	0.0% - 0.5%	0.00%

Source: Hazus 6.0

Population

For the purpose of this SHMP, the entire population of West Virginia (1,807,426) is exposed to the severe storm hazard. Residents may be displaced or require temporary and long-term housing and sheltering. In addition, damages caused by severe storms can lead to severe injuries and loss of life.

Impacts on Socially Vulnerable Populations

Socially vulnerable populations are most susceptible due to their physical and financial ability to react and respond during extreme severe storms. 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 are 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. Section 2 (State Profile) provides statistics of these populations. 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 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 storms 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.

Future Changes That May Impact State Vulnerability

Understanding future changes that may impact vulnerability in the State can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors in examining potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including impacts of future conditions

Potential or Projected Development

Although West Virginia has not experienced significant growth, any areas of growth could be impacted by the severe storm hazard because the entire State is exposed and vulnerable. However, due to increased standards and codes, new development may be less vulnerable to the hazard, while aging infrastructure will become increasingly vulnerable.

Projected Changes in Population

West Virginia is losing population faster than recent forecasts, which do not account for county-by-county increases. According to population projections in 2022 from the West Virginia University (WVU) Bureau of Business and Economic Research, West Virginia's population was projected to fall from 1,793,716 in 2020 to 1,705,509 in 2040 (West Virginia University 2022). As of July 1, 2019, according to estimates by the U.S. Census Bureau, West Virginia's total population is 1,792,147, representing a 3.3 percent decline since 2010 (approximately 60,487 fewer residents). West Virginia lost population both naturally, with 19,000 more deaths than births, and through migration, with 27,000 more people leaving the State than moving in (WVDOT 2020). Refer to Section 2 (State Profile), which includes a discussion on population trends for the State.

As population in the State continues to decrease, there is the potential that fewer people will reside or work within the State's severe storm area. Increased abandoned properties that will be more vulnerable to the elements are more likely to occur within a declining population. Additionally, as the population in the State ages, more residents may face challenges quickly evacuating an area in the event of an intense hazard event.

Other Factors of Change

As the world warms, the frequency and severity of these events are likely to increase due to increasing evaporation and higher atmospheric water vapor levels in the atmosphere. It is anticipated by scientists that the intensity of hurricanes, tropical storms, and other coastal storms will increase. However, since tornadoes and severe thunderstorms occur over much shorter timeframes and smaller areas, the trends and future projections and trends are more difficult to predict. Compared to damages from other types of extreme weather, those occurring due to thunderstorm-related weather hazards have increased the most since 1980, and there is some indication that, in a warmer world, the number of days with conditions conducive to severe thunderstorm activity is likely to increase (CSSR 2018).

5.12.3 Consequence Analysis

Impacts to the Public

Severe weather impacts will impact some communities harder than others. Phenomena like tornadoes, hailstorms, and severe storms can cause damage to property, leaving low-income individuals with few options to repair their properties. In addition, impoverished and homeless populations are more vulnerable than others to severe storms due to potential lack of shelter, or building materials that are not made to withstand severe storms. In some cases, severe storms can trap people from downed powerlines, flooding, and fallen trees. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. This endangers those that may need assistance evacuating, as well as those that need to call for help when injured. Some severe events may call for shutting down air and rail transportation which could disrupt medical and emergency services as well as the transportation of emergency supplies, endangering those that are in need of help even more.

People who spend a lot of time outside, such as agricultural workers and the unhoused, are vulnerable to exposure and injury from events like severe storms, hailstorms, and/or tornadoes. Some weather has the ability to damage or destroy agricultural fields, which can affect livelihoods of the people that depend on the fields for economic purposes.

Impacts to Responders

Intense storms can immobilize a region and paralyze a city by shutting down air and rail transportation, stopping flow of supplies, and disrupting medical and emergency services. Lack of power to emergency facilities, such as police stations, fire stations, emergency medical services, and hospitals, will inhibit a community's ability to effectively respond to an event and maintain the safety of its citizens. Speed of wind and accumulations of rain can collapse buildings and knock down trees, communication, and power lines, making it difficult for responders to be able to pinpoint who needs help and where they may be. In rural areas, homes and farms may be isolated for days, due to communication failure and impassable roads.

Impacts to Continuity of Operations

Heavy winds can bring down trees, electrical wires, telephone poles and lines, and communication towers. This can impact continuity of operations statewide and can also affect neighboring states due to supply chain shortages. Severe storms can obstruct and slow transportation from knocked down trees and utility lines which causes structural collapse in buildings not designed to withstand intense wind and rain events. Strong tornadoes and tropical cyclones impact airports and roadways, sometimes even closing them completely, which stops the flow of supplies and disrupting emergency and medical services. The flooding and high winds associated with severe storms may also disrupt the distribution of gasoline, kerosene, diesel fuel, fuel oils, propane, and other petroleum products. This disruption could cause major problems for organizations and businesses that rely on such supplies. Additionally, such a disruption could affect backup power generation.

Impacts to Property, Facilities, and Infrastructure

Severe storms can damage and destroy infrastructure through wind speeds, hail size, flooding, etc., making the facility or infrastructure unsafe or impractical to use. Even well-constructed buildings are vulnerable to the effects of a stronger (generally EF-2 or higher) tornado. Due to the relatively low incidence and risk for tornado, traditional "Tornado Alley" mitigation methods such as tornado-safe rooms may not be economically feasible in West Virginia.

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.

Impacts to the Environment

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.

Impacts to the Economic Condition of the State

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 singular event.

Infrastructure at risk from severe storms also include roadways that could be damaged by tornadoes, hail, and increased precipitation. Costs to repair roads from severe storm impacts can drain local financial resources quickly. A quick thunderstorm or prolonged tropical cyclone event can cause substantial flooding, especially along small streams and in urban areas, which can become expensive to mitigate. Potential secondary impacts from severe storms also impact the local economy, including the interruption of transportation corridors and loss of business function for the duration of the event. Finally, extensive damage to forests can affect timber values and create flammable woody debris, exacerbating wildfire vulnerability.

IMPACTS TO PUBLIC CONFIDENCE IN STATE GOVERNANCE

The public confidence in state governance primarily depends on how effective the State has been in the past at preparing for and responding to sever storm events. Public confidence also depends on the size of the event and the preparation the State takes for each potential event. In general, if the State is transparent in sharing relevant information with the public regarding sever storm events, then the public is more apt to trust the State and feel as if it has the capability to support the residents of West Virginia if a severe storm event occurs. The State also demonstrates its reliability to the public through availability of programs and services relevant to severe storm assistance (Chew, et al. 2021).

5.13 Subsidence

2023 SHMP Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, and probability of future occurrence (including how future conditions may impact the hazard). New and updated figures from federal and state agencies are incorporated.
- Subsidence events that occurred in the State of West Virginia (the State) from January 1, 2018, through December 31, 2022, were researched for this 2023 State Hazard Mitigation Plan (SHMP) Update.
- Information was updated regarding the current population affected by subsidence.
- Analyzed state asset exposure to subsidence events and assessed vulnerabilities.

5.13.1 Hazard Profile

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of future conditions) and vulnerability assessment for the land subsidence hazard in West Virginia.

Hazard Description

Land subsidence is a gradual settling or sudden sinking of the earth's surface due to removal and displacement of subsurface earth materials. Subsidence is one of the most diverse forms of ground failure, ranging from small or local collapses to broad regional lowering of the earth's surface. The principal causes are mostly due to human activities and include but are not limited to:

- Aquifer-system compaction associated with groundwater withdrawals
- Drainage of organic soils
- Fracking and underground mining
- Earthquakes and erosion
- Natural compaction or collapse
- Expansive soils
- Mining activities (USGS 2019)

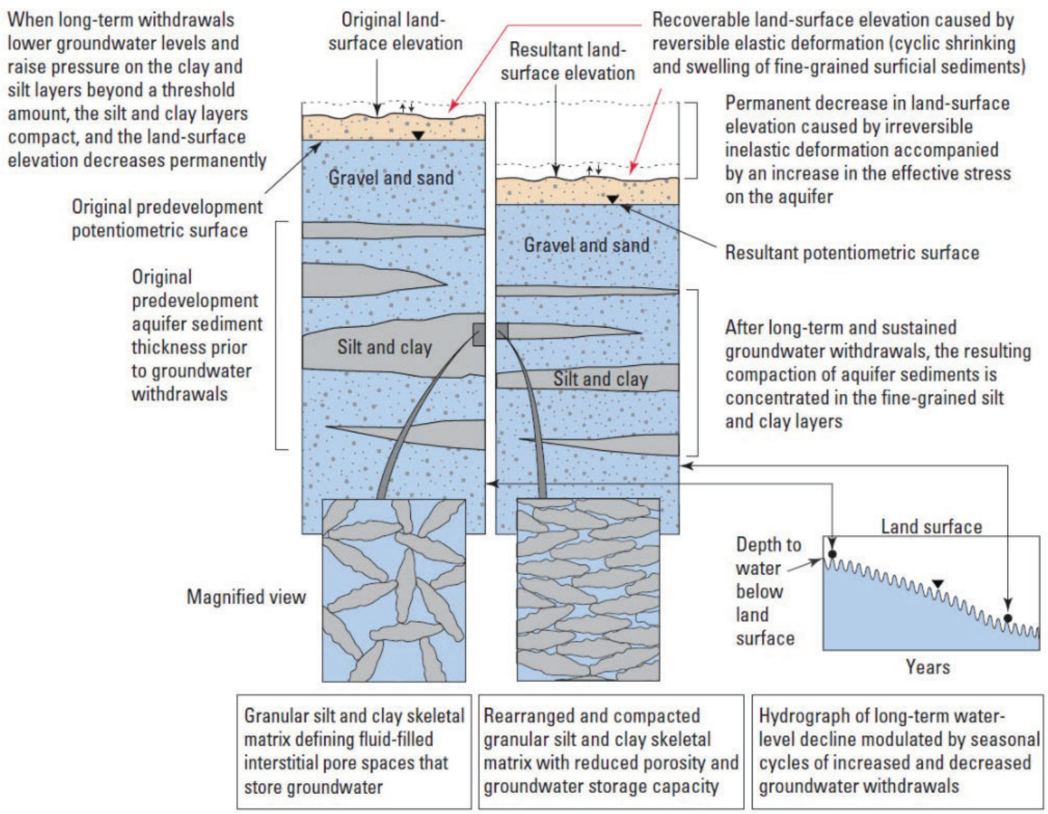
Consequences of land subsidence include:

- Reduces the ability to store water in an aquifer
- Partially or completely submerges land
- Collapses water well casings
- Disrupts collector drains and irrigation ditches
- Alters the flow of creeks and bayous, which may increase the frequency and severity of flooding
- Damages roadways, bridges, building foundations, and other infrastructure

Land subsidence occurs on karst terrain, which is generally underlain by limestone or dolomite, in which the topography is formed chiefly by the dissolving of rock which may be characterized by sinkholes, sinking streams, closed depressions, subterranean drainage, and caves (USGS 2018).

Figure 5.13-1 below illustrates the land subsidence process, wherein soil layers become compacted and unstable due to the loss of groundwater.

Figure 5.13-1. The Subsidence Process



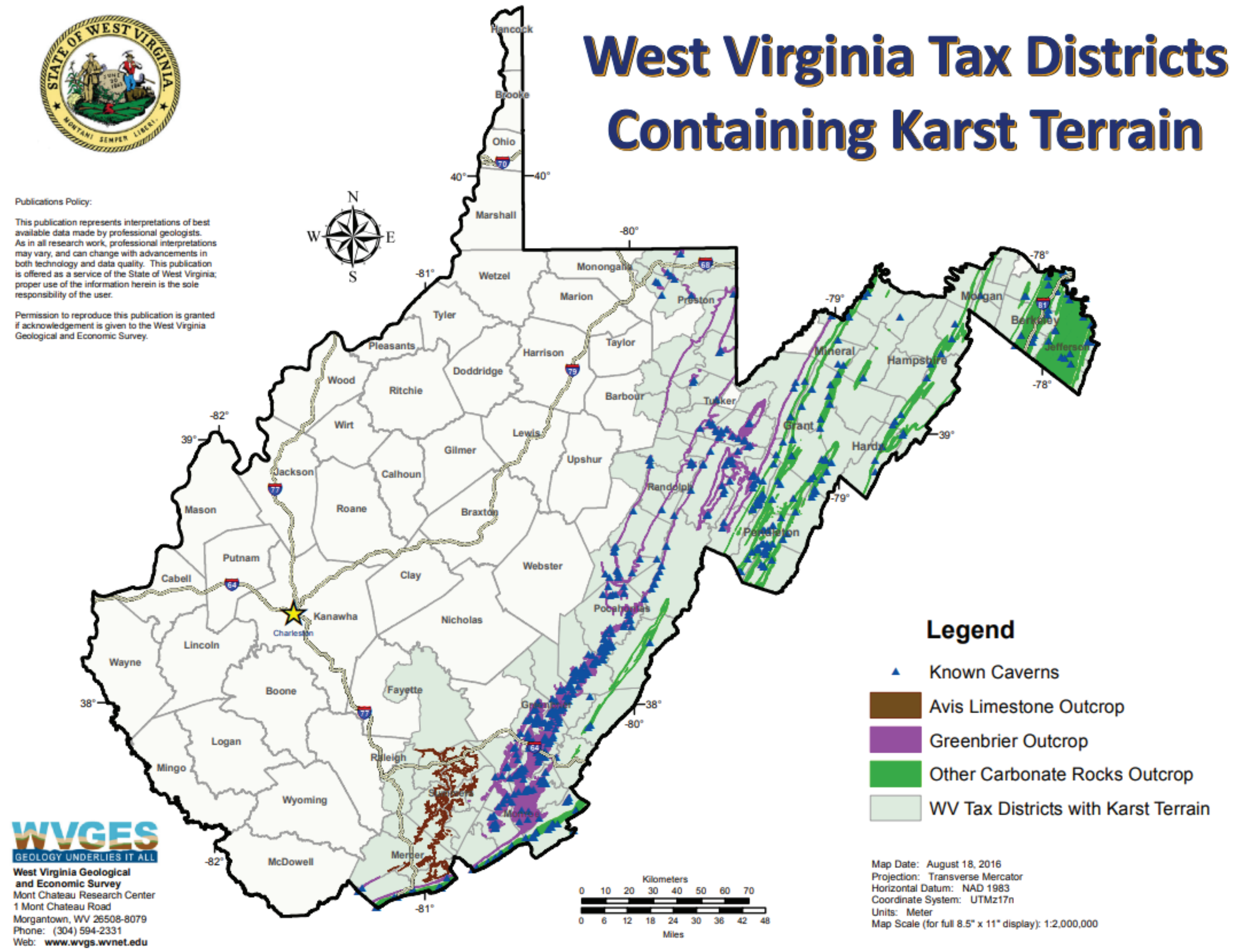
Source: USGS n.d.

Location

The U.S. Geological Survey (USGS) notes that “subsidence is a global problem and, in the United States, more than 17,000 square miles in 45 states, an area roughly the size of New Hampshire and Vermont combined, have been directly affected by subsidence” (USGS 2018).

In West Virginia, karst topography exists primarily in the eastern counties. Land subsidence can also occur in developed areas as a result of subsurface erosion caused by leaking water lines or changes in groundwater flow caused by pumping associated with dewatering excavations, especially in karst areas (West Virginia Emergency Management Division 2018). Figure 5.13-2 illustrates karst terrain areas located throughout the state by tax district.

Figure 5.13-2. Karst Terrain Areas



Source: West Virginia Geological and Economic Survey (WVGES) 2016

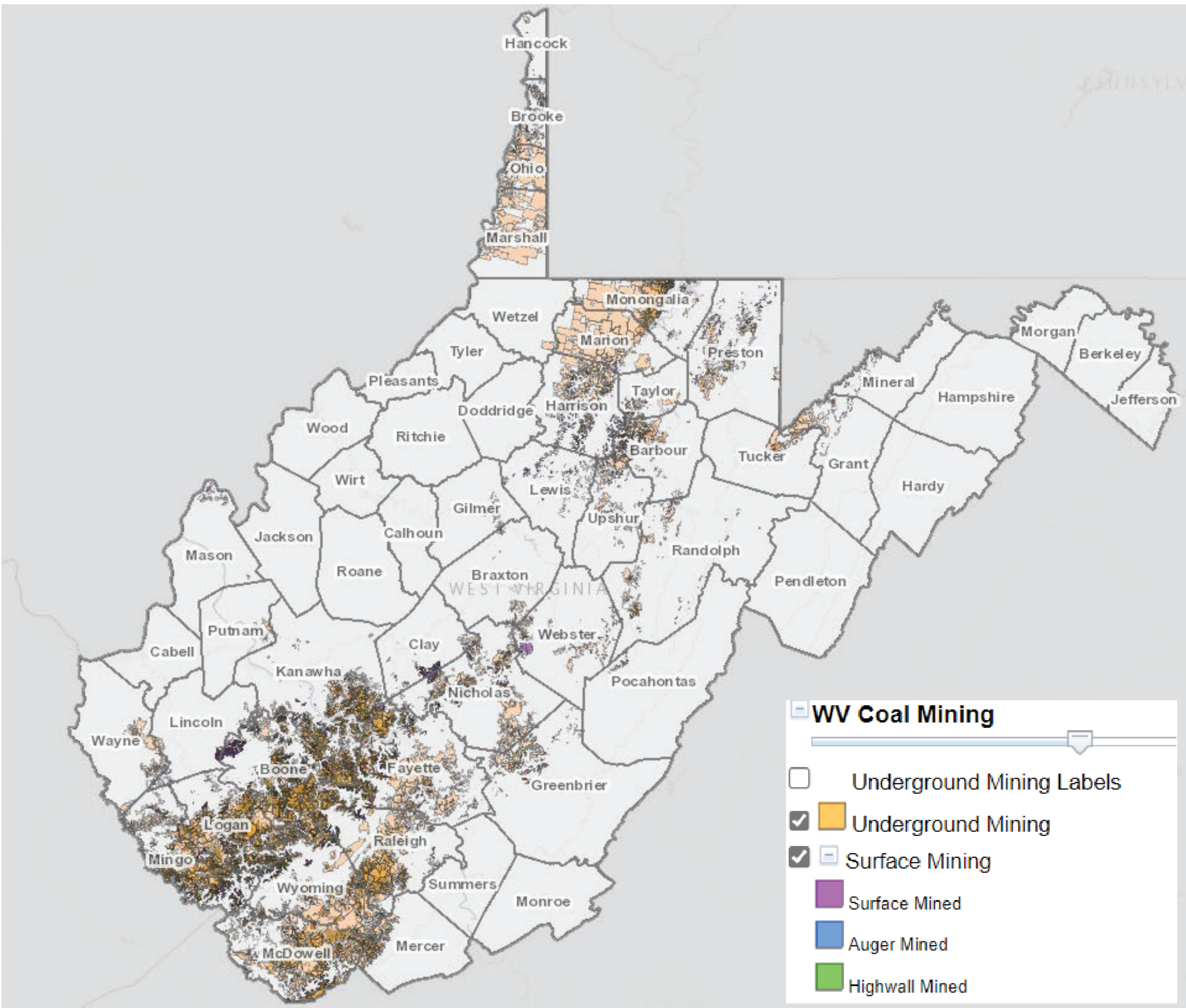
The principal karst-forming carbonate rocks in West Virginia are within the Mississippian Greenbrier Group; Devonian and Silurian Helderberg Group and Tonoloway Limestone; and Ordovician and Cambrian Black River Group, Saint Paul Group, Beekmantown Group, Conococheague Formation, Elbrook Formation, Tomstown Dolomite, and the Mississippian Avis Limestone (WVGES 2016).

Based on Figure 5.13-2, 17 of the state's 55 counties are susceptible to subsidence risk in karst areas:

- Barbour
- Berkeley
- Fayette
- Grant
- Greenbrier
- Hampshire
- Hardy
- Jefferson
- Mercer
- Mineral
- Monongalia
- Monroe
- Morgan
- Pendleton
- Pocahontas
- Preston
- Raleigh

As previously mentioned, subsidence events may also occur from mining activities, especially in areas where the cover of a mine is thin or in areas where bedrock is not necessarily conducive to their formation. Figure 5.13-3 below displays the underground and surface coal mines in the State.

Figure 5.13-3. Underground and Surface Coal Mines in West Virginia



Source: WVGES 2023

Based on Figure 5.13-3, 38 of the state's 55 counites are susceptible to mine subsidence:

- Barbour
- Boone
- Braxton
- Brooke
- Clay
- Harrison
- Kanawha
- Lewis
- Lincoln
- Logan
- Mineral
- Mingo
- Monongalia
- Nicholas
- Ohio
- Summers
- Taylor
- Tucker
- Upshur
- Wayne

- Fayette
- Gilmer
- Grant
- Greenbrier
- Hancock
- Marion
- Marshall
- Mason
- McDowell
- Mercer
- Preston
- Putnam
- Pocahontas
- Raleigh
- Randolph
- Webster
- Wetzel
- Wyoming

Table 5.13-1 details the number of acres and percentage of lands located in the subsidence karst hazard areas and subsidence abandoned mine hazard areas by county. 4.6 percent of West Virginia's total land is located in karst subsidence areas and 0.4 percent of land is located in mine subsidence areas. Jefferson County has the highest percentage (79.4 percent) of land in the karst subsidence area, followed by Berkeley County at 40.8 percent. Logan and McDowell Counties both have the largest percentage of land in mine subsidence areas at 2.4 percent.

Table 5.13-1: Total Acres of Land Area Located in the Subsidence Hazard Areas

County	Total Acres of Land Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Subsidence Hazard Areas			
		Total Acres Located in the Subsidence Karst Hazard Area	Percent of Total	Total Acres Located in the Subsidence Abandoned Mine Lands hazard area	Percent of Total
Barbour	218,598	161	0.1%	572	0.3%
Berkeley	205,141	83,765	40.8%	0	0.0%
Boone	321,687	0	0.0%	2,791	0.9%
Braxton	328,023	0	0.0%	184	0.1%
Brooke	59,321	0	0.0%	1,202	2.0%
Cabell	184,109	0	0.0%	0	0.0%
Calhoun	179,487	0	0.0%	0	0.0%
Clay	219,951	0	0.0%	1,257	0.6%
Doddridge	205,051	0	0.0%	0	0.0%
Fayette	427,276	0	0.0%	4,775	1.1%
Gilmer	217,274	0	0.0%	383	0.2%
Grant	305,479	38,933	12.7%	226	0.1%
Greenbrier	654,360	98,135	15.0%	116	0.0%
Hampshire	412,248	29,843	7.2%	0	0.0%
Hancock	56,222	0	0.0%	2	0.0%
Hardy	373,689	37,139	9.9%	0	0.0%
Harrison	266,023	0	0.0%	2,808	1.1%
Jackson	300,968	0	0.0%	0	0.0%
Jefferson	134,920	107,101	79.4%	0	0.0%
Kanawha	582,312	0	0.0%	1,924	0.3%
Lewis	246,359	0	0.0%	257	0.1%
Lincoln	280,594	0	0.0%	432	0.2%
Logan	291,325	0	0.0%	6,946	2.4%
Marion	199,006	0	0.0%	1,712	0.9%
Marshall	199,304	0	0.0%	270	0.1%
Mason	284,059	0	0.0%	1,910	0.7%
McDowell	342,174	0	0.0%	8,180	2.4%
Mercer	268,828	14,596	5.4%	348	0.1%
Mineral	210,134	19,479	9.3%	51	0.0%
Mingo	270,756	0	0.0%	4,062	1.5%
Monongalia	232,200	1,434	0.6%	1,220	0.5%
Monroe	302,704	91,122	30.1%	0	0.0%

County	Total Acres of Land Area	Total Acres of Land Area (Excluding Waterbodies) Located in the Subsidence Hazard Areas			
		Total Acres Located in the Subsidence Karst Hazard Area	Percent of Total	Total Acres Located in the Subsidence Abandoned Mine Lands hazard area	Percent of Total
Morgan	146,880	6,573	4.5%	0	0.0%
Nicholas	415,482	0	0.0%	585	0.1%
Ohio	69,666	0	0.0%	159	0.2%
Pendleton	446,485	76,296	17.1%	0	0.0%
Pleasants	85,837	0	0.0%	0	0.0%
Pocahontas	601,520	54,664	9.1%	0	0.0%
Preston	415,612	8,342	2.0%	1,612	0.4%
Putnam	223,706	0	0.0%	2,164	1.0%
Raleigh	388,484	0	0.0%	2,365	0.6%
Randolph	664,970	26,872	4.0%	413	0.1%
Ritchie	290,396	0	0.0%	0	0.0%
Roane	309,410	0	0.0%	0	0.0%
Summers	233,898	1,566	0.7%	21	0.0%
Taylor	110,892	0	0.0%	307	0.3%
Tucker	265,897	18,470	6.9%	378	0.1%
Tyler	166,857	0	0.0%	0	0.0%
Upshur	226,613	0	0.0%	452	0.2%
Wayne	325,702	0	0.0%	833	0.3%
Webster	355,637	84	0.0%	292	0.1%
Wetzel	231,289	0	0.0%	2	0.0%
Wirt	150,356	0	0.0%	0	0.0%
Wood	241,020	0	0.0%	0	0.0%
Wyoming	320,602	0	0.0%	3,126	1.0%
Total	**15,466,796**	**714,575**	**4.6%**	**54,337**	**0.4%**

Source: WVDEP 1996; USGS 2022; West Virginia GIS Technical Center (WVU GISTC) 2022

Extent

Human activity can often be the cause of a subsidence area. Leaking water pipes or structures that convey stormwater runoff may also result in areas of subsidence as the water dissolves substantial amounts of rock over time. In some cases, construction, land grading, or earth-moving activities that cause changes in stormwater flow can trigger subsidence events. Subsidence events may occur during mining activities, especially in areas where the cover of a mine is thin or in areas where bedrock is not necessarily conducive to their formation. Subsurface (i.e., underground) extraction of materials such as oil, gas, coal, metal ores (i.e., copper, iron, and zinc), clay, shale, limestone, or water may result in slow-moving or abrupt shifts in the ground surface (Whittaker and Reddish 1989).

The occurrence of subsidence is not as obvious as other geologic hazards. The detection of subsidence is gradual and is typically from the identified movement of key benchmarks or landmarks, such as a statue or tree appearing to have moved or sunk into the ground. Scientists will use radar images from Earth-orbiting satellites to monitor subsidence by mapping the land-surface deformation. This tool is called InSAR or interferometric synthetic aperture radar. Once subsidence is identified and mapped, assessments of the InSAR data can be done to improve our understanding of the subsidence processes (USGS 2019).

Warning Time

Signs that subsidence is occurring include slumping or falling fence posts, trees, or foundations; sudden formation of small ponds; wilting vegetation; discolored well water; and/or structural cracks in walls and floors. These signs tend to appear over time, and may not be noticed. The ground giving way due to the collapse of the roof of a sinkhole or underground mine shaft may occur suddenly without any warning.

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1954 and 2022, the State was not included in any disaster (DR) or emergency (EM) declarations for land subsidence-related events. Generally, these disasters cover a wide region of the state; therefore, they can impact many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2023).

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, the State was not included in any land subsidence-related agricultural disaster declarations (USDA 2023).

Previous Events

For the 2023 SHMP update, known land subsidence events that impacted the State between 2018 and 2022 were researched. While numerous sources, including the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) events that led to a FEMA disaster declaration and/or event that led to a USDA declaration were researched during this plan update, information regarding occurrences and losses associated with land subsidence hazard events in the state was limited.

For events prior to 2018, refer to the 2018 SHMP.

Probability of Future Hazard Events

Overall Probability

Although subsidence events will continue to be a possibility in West Virginia, the probability of an occurrence is difficult to predict due to the low number of recorded previous events. Future development and mining activities in the state can lead to a higher probability of subsidence occurring in the hazard area.

Projected Future Conditions

Periods of drought and flooding are likely to increase in frequently in severity. Impacts from drought and flood events may exacerbate the likelihood of a subsidence event due to soil expansion and contraction. As drought levels increase, the need to pump water from aquifers also increases, which increase the likelihood of subsidence.

5.13.2 Vulnerability Assessment

A statewide assessment was conducted based on areas underlain by karst geology and areas of abandoned mines, with data provided by West Virginia Department of Environmental Protection, U.S. Geological Survey, and West Virginia GIS Technical Center (WVU GISTC). For this plan, subsidence hazard areas are identified as karst areas and areas of abandoned mines.

State Assets

Table 5.13-2 and Table 5.13-3 summarize the number and replacement cost value of state assets located in the subsidence karst hazard area. Table 5.13-2 reflects only the counties with state facilities. All other counties not shown in the table do not have state facilities within the subsidence karst hazard area. Table 5.13-3 reflects only the agencies with structures located in the subsidence karst hazard area.

The spatial analysis for the subsidence hazard determined there are 95 state facilities located in the subsidence karst hazard area with the greatest number of state buildings located in Berkeley County (37 buildings) while Jefferson County has the highest replacement cost value ($279 million). Out of all State agencies, the Division of Natural Resources – Parks, Department of Health and Human Resources, and Department of Military Affairs and Public Safety – State Police have the most facilities (9 each) located in the subsidence karst hazard area, while Shepherd University has the highest replacement cost value ($273.6 million).

Table 5.13-2. State Facilities Located in the Subsidence Karst Hazard Area by County

State Facilities Located Within the Subsidence Karst Hazard Area		Replacement Cost Value for State Facilities Within the Subsidence Karst Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Berkeley	37	$46,485,286	$14,542,092	$61,027,378
Greenbrier	23	$74,124,458	$15,055,143	$89,179,601
Jefferson	13	$250,331,187	$28,709,213	$279,040,400
Mercer	2	$0	$130,400	$130,400
Monroe	6	$944,818	$519,027	$1,463,845
Morgan	7	$73,264,366	$11,120,000	$84,384,366
Pendleton	1	$0	$125,000	$125,000
Pocahontas	1	$0	$25,000	$25,000
Preston	1	$760,000	$40,000	$800,000
Tucker	1	$0	$0	$0
Webster	3	$0	$275,000	$275,000
Total	95	$445,910,115	$70,540,875	$516,450,990

Source: WVEMD; WV Geological and Economic Survey 1968

Table 5.13-3: State Facilities Located in the Subsidence Karst Hazard Area by Agency

State Facilities Located Within the Subsidence Karst Hazard Area		Replacement Cost Value for State Facilities Within the Subsidence Karst Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Armory Board State of West Virginia	5	$7,848,637	$3,017,500	$10,866,137

State Facilities Located Within the Subsidence Karst Hazard Area		Replacement Cost Value for State Facilities Within the Subsidence Karst Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Attorney General, Office of The State of West Virginia	1	$0	$40,000	$40,000
Blue Ridge Community & Technical College	3	$17,395,660	$8,206,792	$25,602,452
Conservation Agency, West Virginia State of West Virginia	3	$0	$184,645	$184,645
Corrections, Division of State of West Virginia	3	$12,065,260	$1,052,500	$13,117,760
Department of Transportation	1	$0	$0	$0
Eastern Panhandle Instructional COOP	8	$800,000	$1,655,000	$2,455,000
Education, Department of State of West Virginia	4	$5,403,548	$1,006,500	$6,410,048
Environmental Protection, Division of State of West Virginia	1	$14,000	$23,000	$37,000
Forestry, Division of State of West Virginia	1	$15,000	$8,000	$23,000
Health & Human Resources, Department of State of West Virginia	9	$7,571,000	$2,245,000	$9,816,000
Highways, Division of State of West Virginia	5	$1,510,500	$325,000	$1,835,500
Insurance Commissioner, Office of The State of West Virginia	1	$0	$20,000	$20,000
Juvenile Services, Division of	3	$0	$180,000	$180,000
Motor Vehicles, Division of State of West Virginia	4	$0	$645,000	$645,000
New River Community & Technical College	1	$1,058,000	$530,000	$1,588,000
Osteopathic Medicine, WV Board of State of West Virginia	2	$66,788,139	$8,193,198	$74,981,337
Parks, West Virginia State C\O Division of Natural Resources	9	$73,556,281	$11,199,600	$84,755,881
Rehabilitation Services Division of Commerce	2	$0	$773,100	$773,100
Shepherd University	1	$246,443,250	$27,131,195	$273,574,445
State Police, West Virginia Dept of Military Affairs & Public Safety	9	$1,400,000	$550,000	$1,950,000
Supreme Court of Appeals State of West Virginia	7	$0	$461,100	$461,100
Tax Department State of West Virginia	1	$0	$100,000	$100,000
Unknown	4	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	2	$0	$18,000	$18,000
West Virginia University Kearneysville	1	$3,587,937	$539,318	$4,127,255
West Virginia University Union	1	$452,903	$53,427	$506,330
Workforce West Virginia	2	$0	$133,000	$133,000
WVsom Clinic Inc Dba Robert C Byrd Clinic	1	$0	$2,250,000	$2,250,000
Total (WV State)	95	$445,910,115	$70,540,875	$516,450,990

Source WVEMD; WV Geological and Economic Survey 1968

Table 5.13-4 and Table 5.13-5 summarize the number and replacement cost value of state assets located in the abandoned mind lands hazard area. Table 5.13-4 reflects only the counties with state facilities; all other counties not shown in the table do not have state facilities within the abandoned mind lands hazard area. Table 5.13-5 reflects only the agencies with structures located in abandoned mind lands hazard areas.

The spatial analysis for the subsidence hazard determined there are 10 state facilities located in the abandoned mine lands hazard area with the greatest number of state buildings located in Marion County (5 buildings with a replacement cost value of $2.5 million). Out of the state agencies, the Department of Health and Human Resources has the most facilities (3) located in the abandoned mine lands hazard area with a replacement cost value of approximately $2.5 million).

Table 5.13-4: State Facilities Located in the Abandoned Mine Lands Hazard Area by County

State Facilities Located Within the Abandoned Mine Lands Hazard Area		Replacement Cost Value for State Facilities Within the Abandoned Mine Lands Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Barbour	1	$0	$255,000	$255,000
Clay	2	$0	$243,100	$243,100
Marion	5	$2,055,000	$460,000	$2,515,000
Ohio	1	$680,000	$10,000	$690,000
Tucker	1	$129,600	$4,300	$133,900
Total	10	$2,864,600	$972,400	$3,837,000

Source: WVEMD; WVDEP 1996

Table 5.13-5: State Facilities Located in the Abandoned Mine Lands Hazard Area by Agency

State Facilities Located Within the Abandoned Mine Lands Hazard Area		Replacement Cost Value for State Facilities Within the Abandoned Mine Lands Hazard Area by County		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Education, Department of State of West Virginia	2	$0	$20,000	$20,000
Health & Human Resources, Department of State of West Virginia	3	$680,000	$475,000	$1,155,000
Highways, Division of State of West Virginia	2	$2,055,000	$440,000	$2,495,000
Parks, West Virginia State C\O Division of Natural Resources	1	$129,600	$4,300	$133,900
State Police, West Virginia Dept of Military Affairs & Public Safety	1	$0	$0	$0
Supreme Court of Appeals State of West Virginia	1	$0	$33,100	$33,100
Total (WV State)	10	$2,864,600	$972,400	$3,837,000

Source: WVEMD; WVDEP 1996

Critical Facilities and Community Lifelines

Transportation routes are vulnerable to subsidence and have the potential to be inaccessible, creating isolation issues. Those that are in poor condition are the most vulnerable; however, roads and bridges in good condition could fault as well. Utility infrastructure is also vulnerable; the interruption of services may impact vulnerable populations and facilities that need to be in operation during a disaster. Full functionality of critical facilities such as police, fire, and medical services is essential for response during and after a subsidence event.

Critical facilities are crucial to continuity of operations statewide and are sorted into lifeline categories. Table 5.13-6 summarizes the critical facilities located in the subsidence karst hazard area and reflects only the counties with state facilities. All other counties not shown in the table do not have state facilities within the subsidence karst hazard area. There are no critical facilities located in the abandoned mind lands hazard area.

Table 5.13-6: Critical Facilities Located in the Subsidence Karst Hazard Area by County

County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Berkeley	0	0	0	0	0	3	0	3
Greenbrier	0	0	0	0	0	2	0	2
Jefferson	0	0	1	0	0	1	0	2
Pendleton	0	0	0	0	0	1	0	1
Webster	0	0	0	0	1	0	0	1
Total	**0**	**0**	**1**	**0**	**1**	**7**	**0**	**9**

Source: WV Emergency Management Division; WV Geological and Economic Survey 1968

Population

Subsidence has the potential to impact human health and life of residents and responders, structures, infrastructure, and natural resources. Based on the analysis, an estimated 131,102 West Virginian residents are located in the subsidence karst hazard area, and 22.9 percent are highly vulnerable. Berkely County accounts for nearly half of the population, with 57,798 people being located within the karst hazard area. In addition, an estimated 15,528 West Virginian residents are located in the abandoned mine hazard area, with 40.3 percent being highly vulnerable. Marion County has nearly a third of the population, with 5,131 people being located within the abandoned mine hazard area. Table 5.13-7 and Table 5.13-8 list the estimated total population and highly vulnerable population living in both karst and abandoned mine subsidence hazard, respectively; only counties with populations in the two hazards areas are shown.

Table 5.13-7: Population Located in the Subsidence Karst Hazard Area by County

County	Total Population Located in the Subsidence Karst Hazard Area	Highly Vulnerable Population Located in the Subsidence Karst Hazard Area	% Population Highly Vulnerable Located in the Subsidence Karst Hazard Area
Barbour	7	0	0.0%
Berkeley	57,798	17,110	29.6%
Grant	1,475	673	45.7%
Greenbrier	7,886	3,348	42.5%
Hampshire	1,775	446	25.1%
Jefferson	45,663	2,389	5.2%
Mercer	6,556	5,649	86.2%
Mineral	2,281	4	0.2%
Monongalia	76	0	0.0%
Monroe	2,861	0	0.0%
Morgan	953	0	0.0%
Pendleton	1,209	0	0.0%
Pocahontas	1,023	0	0.0%
Preston	307	45	14.5%
Randolph	599	304	50.7%
Summers	55	55	100.0%
Tucker	563	0	0.0%
Webster	15	0	0.0%
Total	**131,102**	**30,024**	**22.9%**

Source: Centers for Disease Control and Prevention (CDC) 2020; WV Geologic and Economic Survey 1968

Table 5.13-8: Population Located in the Subsidence Abandoned Mine Lands Hazard Area by County

County	Total Population Located in the Subsidence Abandoned Mine Lands Hazard Area	Highly Vulnerable Population Located in the Subsidence Abandoned Mine Lands Hazard Area	% Population Highly Vulnerable Located in the Subsidence Abandoned Mine Lands Hazard Area
Barbour	74	23	30.7%
Boone	205	15	7.5%
Braxton	14	0	0.0%
Brooke	239	0	0.0%
Clay	24	21	86.9%
Doddridge	0	0	0.0%
Fayette	754	444	58.9%
Gilmer	39	0	0.5%
Grant	5	0	0.0%
Greenbrier	6	1	23.5%
Harrison	2,538	928	36.6%
Kanawha	351	141	40.2%
Lewis	61	1	2.2%
Lincoln	46	0	0.0%
Logan	1,075	908	84.4%
Marion	5,131	1,414	27.6%
Marshall	435	356	81.8%
Mason	243	0	0.0%
McDowell	754	611	81.0%
Mercer	16	2	13.1%
Mineral	7	7	100.0%
Mingo	753	683	90.7%
Monongalia	523	0	0.0%
Nicholas	8	0	0.0%
Ohio	216	58	26.8%
Preston	185	0	0.0%
Putnam	711	0	0.0%
Raleigh	859	624	72.6%
Randolph	21	0	0.4%
Taylor	7	7	100.0%
Tucker	2	0	0.0%
Upshur	92	0	0.0%
Wayne	76	0	0.0%
Webster	5	0	0.0%
Wyoming	53	8	14.4%
Total	**15,528**	**6,253**	**40.3%**

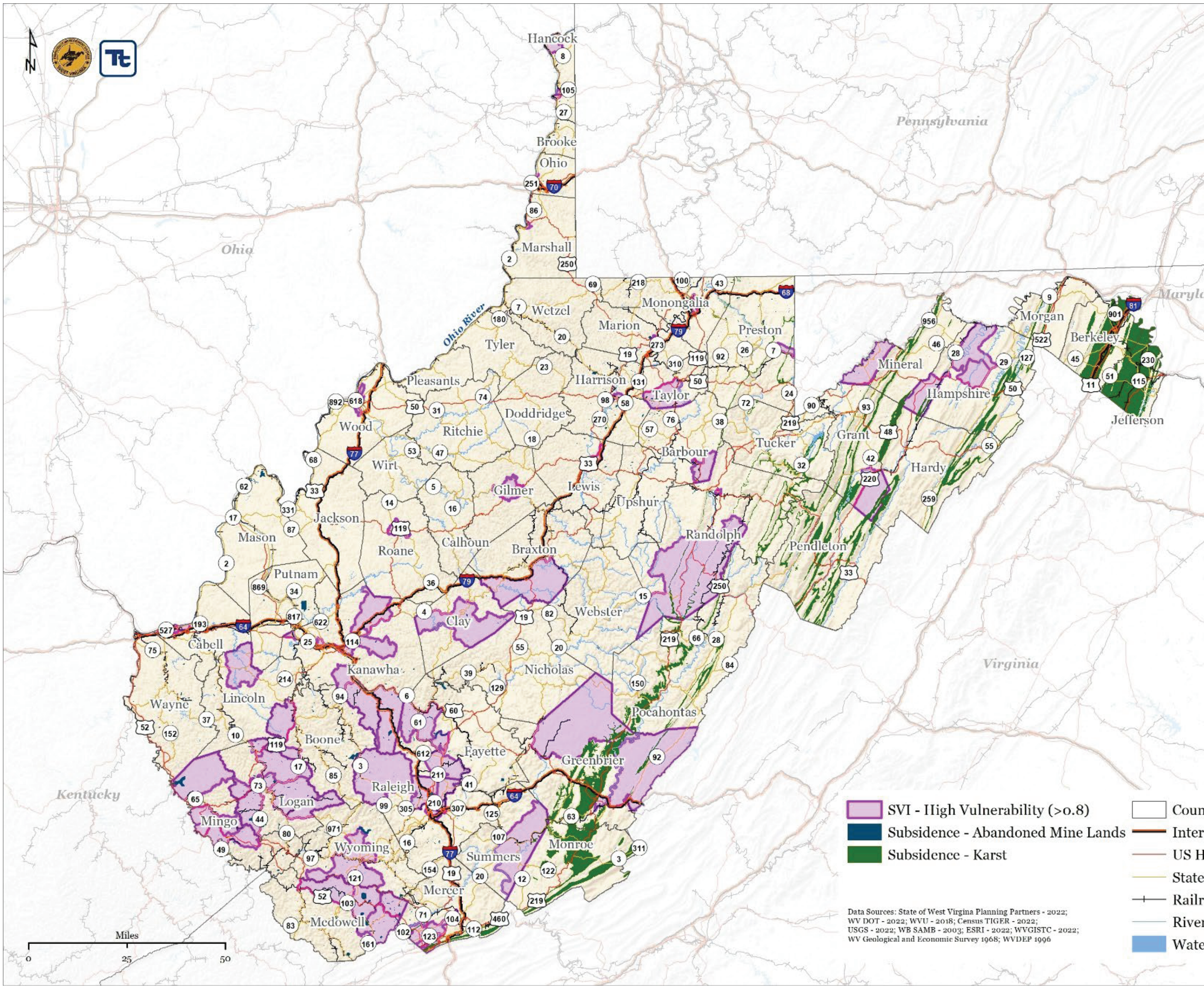
Source CDC 2020; WVDEP 1996

Impacts on Socially Vulnerable Populations

The risk assessment for subsidence found that 22.9 percent of people in the karst subsidence hazard areas are identified as being in the highly vulnerable population (30,024), and 40.3 percent of people in the subsidence abandoned mine hazard areas are identified as being in the highly vulnerable population (6,253) (refer to Table 5.13-7 and Table 5.13-8, respectively). Figure 5.13-4 depicts the social vulnerability index overlayed with the hazard areas.

A subsidence event would be an isolated incidence and impact the populations within the immediate area of the incident. Socially vulnerable populations in those areas who are economically disadvantaged may face the brunt of the impacts as subsidence can damage or destroy structures and property.

Figure 5.13-4. Social Vulnerability Index for Subsidence



Future Changes That May Impact State Vulnerability

Understanding future changes that impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of future conditions

Potential or Projected Development

It is anticipated that any new development in the subsidence hazard areas will be exposed to the hazard. Table 5.13-1 identifies that 768,914 acres of land are located within the total subsidence hazard area. Further development in the hazard area would expose the population and structures to the subsidence hazard.

Chapter 33, Article 30, Section 6 of the State of West Virginia Code identifies that every insurance policy issued or renewed must include, at a separately stated premium, insurance for loss occurring on or after October 1, 1982, caused by mine subsidence unless waived by the insured. However, in the counties listed below, the coverage may only be provided if it is requested by the insured (State of West Virginia 2022).

- Berkeley
- Cabell
- Calhoun
- Hampshire
- Hardy
- Jackson
- Jefferson
- Monroe
- Morgan
- Pendleton
- Pleasants
- Ritchie
- Roane
- Wirt
- Wood

Projected Changes in Population

West Virginia is losing population faster than recent forecasts, which do not account for county-by-county increases. According to population projections in 2022 from the West Virginia University (WVU) Bureau of Business and Economic Research, West Virginia's population was projected to fall from 1,793,716 in 2020 to 1,705,509 in 2040 (West Virginia University 2022). As of July 1, 2019, according to estimates by the U.S. Census Bureau, West Virginia's total population is 1,792,147, representing a 3.3 percent decline since 2010 (approximately 60,487 fewer residents). West Virginia lost population both naturally, with 19,000 more deaths than births, and through migration, with 27,000 more people leaving the state than moving in (WVDOT 2020). Refer to Section 2 (State Profile), which includes a discussion on population trends for the state.

Increased abandoned mines and potential subsidence areas that are more vulnerable to the elements are more likely to experience subsidence events. However, as population in the state continues to decrease, there is the potential that fewer people will reside or work within the state's land subsidence hazard areas.

Other Factors of Change

Projections may alter the stability of land in the subsidence hazards areas. Karst soils are easily erodible by rains as the water seeps into the rock, which can alter the landscape (National Geographic 2022). Eroded landscapes can lead to unstable ground above, making the area at increased risk. The alteration of these landscapes should be factored into future land use regulations to avoid an increased risk to population and property.

More frequent and intense rain and storms can increase chemical leaching from degraded lands and increase the risk of mine blowouts and landslides, which can be devastating and deadly for people and wildlife. Reclaiming these abandoned mines could produce an increase in jobs and revenue in the state; the RECLAIM (Revitalizing the Economy of Coal Communities by Leveraging Local Activities and Investing More) Act has been introduced on the federal level and encourages reclamation of abandoned mine lands for recreation, community development, and wildlife habitat, all while creating good jobs (NWF 2021). Performing these actions could improve and address environmental, health, and economic issues.

5.13.3 Consequence Analysis

Impacts to the Public

Subsidence events caused by karst terrain or abandoned mines are isolated and impact the population within the immediate area. In some cases, subsidence can damage or destroy homes, which forces the homeowners or renters to find temporary or permanent shelters. Loss of property can also leave individuals homeless, which can be detrimental for vulnerable populations, particularly those who rely on medical equipment or home-health care. Subsidence may also affect the amount of water in which an aquifer can hold, which would adversely affect those dependent on the aquifer for potable water (USGS 2019).

An analysis performed on the population of the State revealed that an estimated 131,102 West Virginian residents are located in the subsidence karst hazard area, and 22.9 percent are highly vulnerable. In addition, an estimated 15,525 West Virginian residents are located in the abandoned mine hazard area, with 40.3 percent being highly vulnerable. Please reference Table 5.13-7 and Table 5.13-8 for more information regarding populations in the subsidence hazard areas.

Impacts to Responders

Significant subsidence events may hinder the delivery of emergency services. Subsidence can cause delays or impair rail transportation, halt supply chains, and disrupt medical and emergency services that provide lifesaving support. Intense subsidence events can collapse buildings and knock down trees and power lines, making it difficult for responders to get to reach an impacted area and maintain communications with one another. Communications may also be impacted for the public if any communication towers are impacted by the subsidence event.

Responders, especially those in search and rescue or recovery operations, should maintain situational awareness when entering a structure with damage from subsidence. Unstable ground may cause the structure to collapse, as subsidence has been known to cause the support and stability of a structure's foundation to collapse or sink.

Impacts to Continuity of Operations

Subsidence events have the potential to bring down trees, electrical wires, telephone poles and lines, and communication towers. Communication and power can be disrupted for extended periods of time while utility companies repair damages, impacting day-to-day operations. Larger events may interrupt transportation flow in communities as damages could include downed trees, utility line, and structural collapses near major roadways. If damages are along major throughways, airports and roadways may be impacted for an undetermined amount of time, stopping the flow of supplies and disrupting emergency and medical services.

Impacts to Property, Facilities, and Infrastructure

Roads provide a vital transportation link between populated areas through West Virginia. Subsidence incidents can result in damages to roadways and road closures, leading to traffic congestion, longer commuting times, and prevention of emergency personnel from responding to incidents. More specifically, the state's network of roadways provide access to local and federal roadways. The state roadways located in hazard areas are more susceptible to damages and closures. West Virginia has over 215 miles of state roads that run through karst terrain and over 49 miles of state roads running through abandoned mining areas. Jefferson County has the greatest number of road miles (65.87 miles) exposed in the subsidence karst hazard area and McDowell County has the greatest number of road miles (12.82 miles) exposed in the subsidence abandoned mine lands hazard area. Table 5.13-9 displays the state roads in both karst and abandoned mine subsidence hazard areas; only counties with populations in the two hazard areas are shown.

Table 5.13-9: State Roads Located Within the Subsidence Karst and Abandoned Mine Lands Hazard Areas by County

County	State Roads Located Within the Subsidence Karst Hazard Area	State Roads Located Within the Subsidence Abandoned Mine Lands hazard area
	Mileage of Roadway	Mileage of Roadway
Barbour	0.00	0.12
Berkeley	33.58	0.00
Boone	0.00	1.42
Brooke	0.00	0.28
Clay	0.00	9.11
Fayette	0.00	1.71
Gilmer	0.00	0.49
Grant	7.17	0.48
Greenbrier	18.12	0.91
Hampshire	4.49	0.00
Hardy	0.49	0.00
Harrison	0.00	0.47
Jefferson	65.87	0.00
Kanawha	0.00	0.08
Lincoln	0.00	0.95
Logan	0.00	7.17
Marion	0.00	0.67
Marshall	0.00	0.55
Mason	0.00	2.14
McDowell	0.00	12.82
Mercer	6.56	0.09
Mineral	8.80	0.00
Mingo	0.00	0.82
Monongalia	3.41	0.51
Monroe	37.41	0.00
Morgan	0.55	0.00
Nicholas	0.00	2.71
Ohio	0.00	0.54

County	State Roads Located Within the Subsidence Karst Hazard Area Mileage of Roadway	State Roads Located Within the Subsidence Abandoned Mine Lands hazard area Mileage of Roadway
Pendleton	5.11	0.00
Pocahontas	6.88	0.00
Preston	1.01	1.08
Raleigh	0.00	0.87
Randolph	2.12	0.00
Summers	3.64	0.00
Taylor	0.00	0.02
Tucker	9.97	0.25
Upshur	0.00	0.41
Wayne	0.00	0.18
Webster	0.29	0.00
Wyoming	0.00	3.01
Total	**215.47**	**49.86**

Source: WVDEP 1996; WVDOT – 2021

Impacts to the Environment

As displayed in Table 5.13-1, there are just under 769,000 acres of land within the subsidence hazard areas in West Virginia. 54,338 acres of the subsidence area are located above or near abandoned mines. Subsidence caused by abandoned mines poses threats to water quality and wildlife. Nearby bodies of water can experience loss of riparian habitat, biodiversity, and groundwater contamination. Wildlife suffer losses by being forced out of their habitat and losing a safe source of drinking water (NWF 2021). 714,576 acres of the subsidence area is located on karst soils. Karst landscapes may feature caves, underground streams, and sinkholes on the surface. One primary concern with karst is that due to its geologic makeup, the porous nature of the rock allows water to flow through it without much filtration, which could allow contaminants to enter a karst aquifer and cause water quality problems (NPS 2022).

Impacts to the Economic Condition of the State

Subsidence events can impose direct and indirect impacts on the state's economy. Direct costs include actual damage sustained to buildings, property, and infrastructure. Indirect costs, such as cleanup costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity, are difficult to measure. Despite only having 104 state facilities located throughout West Virginia, the total replacement value for these structures and the contents within them is over $177 million (refer to Table 5.13-2 through Table 5.13-5). While subsidence can cause significant damage to state assets, there are no standard formulas for estimating associated losses.

Impacts to Public Confidence in State Governance

The public confidence in state governance primarily depends on how effective the State has been in the past at preparing for and responding to subsidence events. Public confidence also depends on the size of the event and the preparation the State takes for each potential event. In general, if the State is transparent in sharing relevant information with the public, proves that it has the capability to support the residents of West Virginia if subsidence events occur, and demonstrates its reliability to the public through availability of programs and services relevant to subsidence, then the public will remain confident in the State's governance (Chew, et al. 2021).

The State has governmental offices dedicated to abandoned mine lands and the reclamation of those lands. The Office of Abandoned Mine Lands and Reclamation oversees and facilitates the resolving of public safety issues as mine fires and subsidence, hazardous highwalls, mining-impacted water supplies, open shafts and portals, and other dangers resulting from mining before 1977. This office oversees the Abandoned Mine Lands Economic Revitalization (AMLER) Program, which administers federal funding for economic development projects on abandoned mine lands (WVDEP 2023).

5.14 Utility Failure

2023 SHMP Update Changes

- The 2023 State Hazard Mitigation Plan (SHMP) risk assessment was expanded to include human-caused hazards. The hazard profile has been created to enhance the hazard description, location, extent, previous occurrences, and probability of future occurrence (including how future conditions may impact the hazard). New and updated figures from federal and state agencies are incorporated.
- Utility failure events that occurred in the State of West Virginia (the State) from January 1, 2010, through December 31, 2022, were researched for this 2023 SHMP update.
- Information was updated regarding the current population affected by utility failure.

5.14.1 Hazard Profile

A utility interruption includes power failure, potable water service outage, telecommunication infrastructure failure, natural gas infrastructure failure, or sewer infrastructure failure. Interruptions to basic utilities (such as data/telecommunications, water, natural gas, or sewer) can have a detrimental impact on West Virginia in terms of day-to-day function. Utilities that employ aboveground wiring (power and data/telecommunications) are vulnerable to the effects of other hazards, such as high wind, heavy snow, ice, rain, and vehicular accidents to name a few.

Hazard Description

Utility failure is defined as any disruption or loss of a public service which includes but is not limited to electrical service, potable water, wastewater, and natural gas caused by disruption of power transmission which can be caused by an accident, sabotage, natural hazards, or equipment aging/failure (also referred to as a utility interruption or utility outage). A significant utility interruption is defined as any incident of a long duration, which would require the involvement of the local and/or state emergency management organizations to coordinate provision of food, water, heating, cooling, and shelter.

Failure of utilities, such as wastewater and potable water, may occur as a result of a power failure or due to equipment failure. These critical utilities are essential to community continuity, emergency services, and recovery, and their interruption of service may have cascading economic, environmental, and emergency response impacts. Interruption of utilities also leads to disruption in daily life for residents (i.e., loss of potable water for cooking) and can also have serious impacts on firefighting and emergency response capabilities.

Power failures lead to the inability to use electric-powered equipment, such as lighting; heating, ventilation, and air conditioning; communication equipment (telephones, computers, etc.); fire and security systems; appliances such as refrigerators, sterilizers, etc.; and medical equipment. This all can lead to food spoilage, loss of heating and cooling, basement flooding due to sump pump failure, and loss of water due to well pump failure. In addition, utility gas failures can lead to the widespread inability for West Virginia residents to heat their homes, as 91 percent of natural gas customers in the state are residential (U.S. DOE 2021). Current procedures of shutting off utility gas distribution before severe weather events could also hinder the ability to provide backup power if residents have generators power by utility gas.

Location

Utility failure can take place anywhere within the state where utilities have been installed and at any time. These events are usually small-scale, localized occurrences and a secondary impact of other hazards such as serve storms or ice storms. Local outages and interruptions may be caused by traffic accidents or wind damage. However, utility failure can also be widespread, as often is the case with blackouts caused by heat waves, snowstorms, and ice storms in West Virginia. During these hazard events, the critical infrastructure supporting these utilities is impacted.

Some utility facilities are especially vulnerable to failure, including ones that rely on aging infrastructure to support them. Utilities located in hazard-prone areas are also vulnerable to those hazard impacts. For instance, potable water interruption is possible when water intakes and water control facilities are located in the floodplain.

Extent

The extent and severity of a utility interruption depends on the cause, location, duration, and time of year. It can range from a small, localized event to a regional power outage. Impacts can be significant to the State and its residents. Utility interruptions typically occur because of, or in combination with, aging infrastructure, other emergencies, or disaster incidents, such as severe weather and flooding, and can be exacerbated by such emergencies. In 2012, a heat wave caused a 6-hour power outage that impacted approximately 940,090 people in West Virginia; a 2008 power outage lasted for 59 hours, impacting 50,780 people (U.S. DOE 2021). Impacts such as these demonstrate how the scale and subsequent impacts of utilities failures can impact the state.

Warning Time

Widespread utility failure can occur without warning. Generally warning times will be short in the case of technological failure, such as a fire at a sub-station, traffic accident, human error, or terrorist attack. In cases where a power failure is caused by natural hazards, greater warning time is possible. For example, high wind events such as tornadoes and hurricanes often cause widespread power failure and are often forecasted before they affect a community. Additionally, severe winter weather conditions such as ice storms, blizzards, and snowstorms often cause power failure and are often forecasted in advance. Incidents such as these often provide an opportunity for advanced notification regarding the potential for utility failure during the hazard event. In these scenarios, utility response crews can stage resources to prepare for utility failure, and residents can make preparations.

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1954 and 2022, West Virginia was not included in any major disaster (DR) or emergency (EM) declarations specific to utility failure events. However, the state has been impacted by numerous natural hazard events, such as severe storms and winter weather, that received declarations that involved utility failures (FEMA

2023). For a listing of FEMA disaster declarations for each natural hazard, visit the respective hazard profiles in Section 5.

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas. However, utility failure is not a potential cause of agricultural disasters (USDA 2023).

Previous Events

For this SHMP update, utility failure events were summarized between 2010 and 2022. Every year, West Virginia is susceptible to minor and major utility interruptions either through technological failure or as the result of natural hazard events.

Table 5.15-1. Utility Failure Events in the State – 2010 to 2022

Date(s) of Event	Event Type	FEMA/USDA Declarations	Counties Affected	Description
April 16, 2010	Thunderstorm Wind	N/A	Brooke, Hancock, Ohio	Severe thunderstorms led to at least 150,000 home
August 4, 2010	Thunderstorm Wind	N/A	Statewide	Thunderstorms produced widespread wind damage without power across Pennsylvania and West Virgin
October 26, 2010	Thunderstorm Wind	N/A	Boone, Cabell, Jackson, Hancock, Kanawha, Lincoln, Mason, Mingo, Putnam	A strong Autumn front created severe wind gusts w homes without power due to knocked-over power l
April 4, 2011	Thunderstorm Wind	N/A	Braxton, Cabell, Gilmer, Kanawha, Lincoln, Logan, Summers	Wind gusts hit up to 60 mph and led to 29,000 hom Kanawha County.
Jul 8, 2012	Thunderstorm Wind	N/A	Statewide	Large temperature fluctuations led to strong storms of 25,000 in Kanawha County.
October 29-31, 2012	Blizzard/High Winds	EM-3358-WV DR-4093-WV	Statewide	Blizzard-like conditions developed from a heavy sno Superstorm Sandy, leaving over 200,000 people wit outages lasted over a week in many areas. The Nati activated to help set up shelters and distribute food
November 1, 2013	Thunderstorm Wind	N/A	Statewide	Severe storm and wind damage left nearly 50,000 p across Ohio, Pennsylvania, and West Virginia.
November 17, 2013	Thunderstorm Wind	N/A	Statewide	A line of isolated thunderstorms produced severe w power in 25,000 homes.
January 6, 2014	Wind Chill/ Extreme Cold	N/A	Statewide	Snowstorm brings extreme cold temperatures with even lower. Temperatures led to frozen pipes, pow difficulties.
June 10, 2014	Thunderstorm Wind	N/A	Braxton, Cabell, Gilmer, Jackson, Monroe, Wayne	Storms produced severe wind, which knocked out p
March 4, 2015	Flood	N/A	Statewide	Mixed precipitation led to prolonged power outage to 60 hours for their electricity to be restored. Cour shelters for their affected residents.
July 12, 2015	Thunderstorms	DR-4236-WV	Statewide	Clusters of snow and thunderstorms caused power gubernatorial state of emergency was declared for
March 1, 2016	Strong Wind	N/A	Statewide	A storm produced wind gusts up to 55 mph and kno 11,000 people, mostly in Kanawha and Jackson Cou

Date(s) of Event	Event Type	FEMA/USDA Declarations	Counties Affected	Description
June 23, 2016	Strong Wind	DR-4273-WV	Statewide	Wind damage and flash flooding knocked out electr days. The American Red Cross was called in to help and provide shelters.
November 6, 2018	Strong Wind	N/A	Cabell, Kanawha, Lincoln, Putnam, Wayne (Zones)	Showers created strong wind gusts which blew dow 10,000 power outages across the southwestern par
February 24, 2019	Strong Wind	N/A	Statewide	Isolated storms led to downed trees and powerline 91,000 residents of West Virginia without power.
February 10, 2021	Winter Storm	N/A	Statewide	A wintry mix led to significant tree damage and mac residents in West Virginia lose power.
February 17, 2021	Heavy Snow and Ice	DR-4603-WV	Cabell, Lincoln, Mason, Putnam, Wayne	A winter storm produced heavy snow and ice accum over 500 broken power poles and yards of wire in n This caused significant power outages.

Sources: FEMA 2023; NOAA NCEI 2023
EOC Emergency Operations Center

PROBABILITY OF FUTURE HAZARD EVENTS

Overall Probability

While the probability of future utility failure incidents in West Virginia is difficult to predict, the historic record indicates that significant failures have occurred because of extreme temperatures, high winds, lightning, severe weather, winter weather, technological failures, and age of utility infrastructure. Minor utility interruptions may occur several times a year throughout the state with varying duration. As infrastructure ages beyond its intended lifespan, it is likely to become less reliable, leading to a higher likelihood of failure. In addition, new infrastructure designed to withstand hazardous weather will have a higher likelihood of success.

Projected Future Conditions

As described in earlier sections, future conditions are making hazardous weather more extreme and exacerbating storm impacts. This trend can be expected to continue as the global climate continue to warm throughout the 21st century. Heat waves tend to present challenges to the electrical grids of West Virginia. The temperature in West Virginia has increased by 1°F since the beginning of the 20th century, with more variability in precipitation (NCEI 2022). As conditions continue to evolve over time, projected longer periods of intense heat will result in more residents running air conditioning and fans for longer periods of time which increases the strain on electrical utilities and possibly resulting in widespread outages or brownouts. An additional strain on water utilities may be caused as a result of an increase in the intensity of naturally occurring droughts due to temperature-caused increases and moisture loss in soil during dry spells (NCEI 2022).

Increased wind from thunderstorms, tornadoes, and other wind events threatens aboveground utilities such as power lines. As these severe storms increase in occurrence and intensity, outages to residents and businesses can be expected more frequently, particularly in areas where the average age of the infrastructure is greatest.

5.14.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For utility failure, the entirety of West Virginia has been identified as the hazard area. Therefore, all assets in the state (population, structures, critical facilities, and lifelines), as described in the State Profile, are vulnerable. The impacts on population, existing structures, critical facilities, and the economy are presented below.

STATE ASSETS

For the purposes of this risk assessment, an asset is considered potentially vulnerable if it is in an identified hazard area. As stated previously, utility failure impacts and affects the entire area of West Virginia is the hazard area; therefore, a total of 1,117 State facilities are vulnerable to utility failure. The total replacement cost value for all 1,117 structures is $6,103,990,956. Kanawha County has the most structures (200) while Monongalia County has the highest total RCV ($1,605,027,842) of State facilities in comparison to all the counties in the state.

CRITICAL FACILITIES AND COMMUNITY LIFELINES

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 West Virginia's population. In total, there are 185 critical facilities that may be impacted by utility failure, with Kanawha County having the greatest number of critical facilities (75) and therefore having the greatest vulnerability.

Population

For the purposes of this SHMP, the entire population of West Virginia (1,807,426) is exposed to utility failure (U.S. Census 2023). 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.

Impacts on Socially Vulnerable Populations

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.

Future Changes That May Impact State Vulnerability

Understanding future changes that impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of future conditions

Potential or Projected Development

Although West Virginia has not experienced significant growth, any areas of growth could be impacted by utility failure. Aging infrastructure may also be vulnerable to hazards that cause utility interruption to potential or projected development.

Projected Changes in Population

While statewide population has declined over the past 10 years, population has increased in several areas throughout the state (e.g., Berkely, Jefferson, and Monongalia Counties). From 2010 to 2019, the state’s overall population decreased by 3.3 percent, and it is projected to decrease 7.8 percent by 2040 (West Virginia Department of Transportation 2020). As the population in the state continues to decrease there is the potential that less people will reside or work within the state, which means fewer people will experience utility failure.

Other Factors of Change

As discussed above, projected future conditions for West Virginia indicate more frequent extreme temperature and severe weather events could result in an increase in utility failures. Refer to Probability of Future Hazard Events for details on how future conditions can impact utility failure events.

5.14.3 Consequence Analysis

Impacts to the Public

Utility failure is particularly problematic for homes that are heated with electricity. Widespread power outages during the winter months can directly impact vulnerable populations such as older adults and medically vulnerable. Individuals with medical needs are vulnerable to power failures because medical equipment such as oxygen concentrators requires electricity to operate. Older adults and individuals experiencing economic hardships are also vulnerable to the effects of power failure in terms of exposure to extreme heat or extreme cold. During power failure events, water purification systems may also loss function. Additionally, populations on private wells will not have access to potable water. The outage events that result from storm events can lead to flooding, and without electricity, residents would be unable to pump water from their basements, potentially causing structural and content damage to their homes.

Impacts to Responders

First responders' safety may be at risk during on-scene operations, and they may not be able to respond in a timely manner due to electrical or utility fires. First responders may need to take on additional duties due to a higher-than-normal call volume and demand, traffic control, and responding to transportation incidents.

Interruption of water distribution also has a considerable impact on the firefighting capabilities of many fire departments within West Virginia. Should frequent or widespread water interruption occur, there will be an increased risk for structural fire and wildfire occurrence within the state. In some cases, displaced power lines may also block first responders from locations they may need to get to in order to help the public.

Impacts to Continuity of Operations

Downed powerlines, trees, and communications towers can block roads and inhibit businesses from continuing operations due to loss of communications and transportation of goods and services. Limited power and cell service makes it near impossible for continuity of operations unless a backup generator is present. Disrupted power can also throw off automated machines, which may take weeks to recalibrate and fix resulting in disruptions to the supply chain.

Impacts to Property, Facilities, and Infrastructure

All of the building stock and infrastructure in the state is exposed to the utility failure hazard. Impacts sustained from utility failure 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. Backup power is recommended for facilities and infrastructure to avoid negative impacts from loss of power. Interruption of utility gas or water distribution could also reduce the effectiveness of facilities to operate at full capacity.

Impacts to the Environment

The most significant impact associated with utility interruptions occurs when the interruption involves a release of hazardous materials. This hazardous material may be released in a pipeline accident or when material is in transit. Section 5.6 (Hazardous Materials) includes a complete discussion on the impacts of a hazardous materials release to the environment. Disrupted power lines can also create fires which has the ability to destroy ecosystems and kill plant and animal populations.

Impacts to the Economic Condition of the State

During a utility failure event, the State may experience losses because of an interruption of critical services. Further, increased costs, such as providing shelters and costs related to cooling and heating centers, may be incurred. Extended power outages will require officials to shelter victims who require heat and power for activities of daily living. In addition, many businesses provide services locally, regionally, nationally, and internationally. Disruption in any of these services would mean that many workers and residents may be without a job for an extended period of time which may affect their ability to afford food and shelter. Industrial and commercial use accounts for 65 percent of electric consumption in the state; power failures would have significant impacts (U.S. DOE 2021).

Power interruptions can also cause economic impacts stemming from spoiled food and other goods, costs to the owners/operators of the utility facilities, and costs to government and community service groups. Interruption of utility gas or potable water distribution could also cause significant economic impacts, such as additional costs for bringing in water tenders to maintain fire suppression capabilities and distribution of potable water for public consumption.

Impacts to Public Confidence in State Governance

The public confidence in state governance primarily depends on how effective the State has been in the past at preparing for and responding to utility failure events. Public confidence also depends on the size of the event and the preparation the State takes for each potential event. In general, if the State is transparent in sharing relevant information with the public regarding utility failures, then the public is more apt to trust the State and feel as if it has the capability to support the residents of West Virginia if utility failure occurs.

5.15 Wildfire

2023 SHMP Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, and probability of future occurrence (including how future conditions may impact the hazard). New and updated figures from federal and state agencies are incorporated.
- Information was updated regarding the current population affected by wildfires.
- Wildfire events that occurred in the State of West Virginia (the State) from January 1, 2018, through December 31, 2022, were researched for this 2023 State Hazard Mitigation Plan (SHMP) update.
- State asset exposure to severe storm events was analyzed and local vulnerabilities were assessed.

5.15.1 Hazard Profile

Hazard Description

Wildfire is defined in this plan as any free-burning vegetative fire that initiates from an unplanned ignition, whether natural (e.g., lightning) or human-caused (e.g., powerlines, mechanical equipment, discarded cigarettes, escaped prescribed fires), where the management objective is full suppression (National Wildfire Coordinating Group 2021).

A wildland-urban interface (WUI) fire is 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.

Prescribed burning, also known as controlled burning, is the deliberate use of fire under specified and controlled conditions. Prescribed burning is used by forest management professionals and individual landowners to accomplish one or more of the following tasks:

- **Fuel Reduction** – The reduction of accumulated grass, weeds, pine needles, and hardwood leaves. This type of vegetation can encourage wildfires in young stands and hinder regeneration of older stands.
- **Hardwood Control** – Prevents hardwood trees from competing with pines for nutrients and moisture, impeding visibility and access through the stands, and interfering with natural regeneration in areas better suited for growing pines (National Park Service n.d.).

There are three types of wildfires:

- Ground fires occur when subsurface fuels ignite and burn underground. Ground fires may eventually burn through the surface of the ground and become surface fires.
- Surface fires burn on the surface of the ground and are primarily fueled by low-lying vegetation. Ladder fuels are vegetation that allow surface fires to climb into the tree canopy and become crown fires (National Wildfire Coordinating Group 2021).

- Crown fires burn and spread from treetop to treetop. Unlike ground or surface fires, which spread more slowly, crown fires spread at a rapid pace. Crown fires are often pushed by the wind and can turn into extremely intense fires (De La Torre 2021).

Location

Compared to the forest ecosystems in the Western United States, Appalachian forests are much wetter. As a result, the natural fire cycle is longer, often up to 200 or even 1,000 years. When fires do occur in Appalachia, they typically burn at lower severities through the duff along the forest floor. Crown fires are rare. An intact mature temperate forest offers conditions less likely to burn into severe wildfires. With less undergrowth, the fire cannot jump into the forest crown as easily; with thicker bark, mature trees resist fire damage; and with more shade, the forest floor is often cooler and wetter (West Virginia Rivers 2018).

During the fall, there is a greater risk for wildfires in the state, mainly because of the leaves falling and drying out, which turns into fuel for fires. Also, relative humidity reaches some of its lowest points of the year, meaning the air can get very dry. Stronger winds in the fall also are a major contributor to fueling wildfires (Beddoes 2022). There are two statutory fire seasons in West Virginia, March 1 to May 31 and October 1 to December 31, that prohibit outdoor debris burning from 7 a.m. to 5 p.m. The purpose of the law is to reduce the probability of debris fires to escape and cause wildfires when the risk is high (WVDOF 2020).

The West Virginia State Forest Action Plan reports that humans and human activities cause more than 99 percent of all wildfires in the state, with debris burning being the single biggest ignition source (WVDOF 2020). Arson and power lines are other primary causes of wildfire. Table 5.15-1 displays the main causes of wildfire in West Virginia in the year 2020. The primary cause of wildfire in 2020 was burning debris (36.4 percent), followed by equipment (25.2 percent) and arson (22.6 percent).

Table 5.15-1. Causes of Wildfire in West Virginia 2020

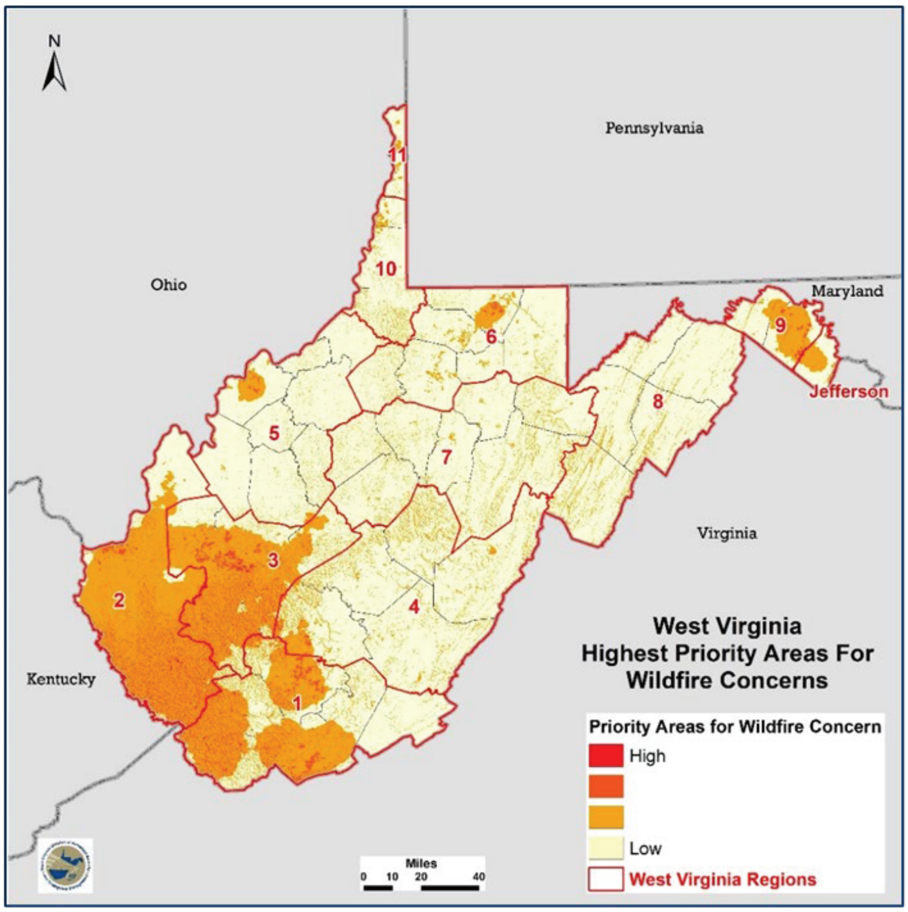
Wildfire Cause	Percentage
Debris Burning	36.4%
Equipment	25.2%
Arson	22.6%
Miscellaneous	7.3%
Children	2.9%
Campfire	2.1%
Railroad	1.4%
Smoker	1.4%
Lightning	0.8%

Source: WVDOF 2021

Wildland fire hazards related to coal mining are burning coal seams and mining refuse disposal areas that generate heat from decomposition. Many of these are on corporate-owned properties in remote areas with difficult access, which contributes to large fire occurrences as the fire may go unnoticed or unreported for several hours or days. The known hazard areas have been mapped so they can be monitored during times they are most likely to cause a wildfire. Wildfire control plans are in place if the hazard should cause a wildfire and some hazards have mitigation measures installed. Some corporations that own large acreages support temporary employees for monitoring, maintenance of hazard mitigation measures, and suppression. The West Virginia Division of Forestry (WVDOF) has and continues to work with landowners where the hazards are located to install mitigation measures. Rights of ingress and egress and liability issues have been a hinderance to installing more mitigation measures, but negotiations are ongoing.

Figure 5.15-1 shows the state's highest priority areas for wildfire concerns. The State indicated in the 2018 SHMP that it would like to increase efforts to provide potential financial and technical assistance for the development of Community Wildfire Protection Plans (CWPP); these plans focus on communities at higher risk of wildfires (West Virginia Emergency Management Division 2018). Currently, there are 25 CWPPs in West Virginia, covering 50,821 acres serving a population of 69,963.

Figure 5.15-1. Highest Priority Areas for Wildfire Concern



Source: West Virginia Emergency Management Division 2018

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. Ohio County has the highest percentage (14.1 percent) of land located in the WUI interface hazard area, while Hancock County has the highest percentage (66.4 percent) of land located in the WUI intermix hazard area land located in the WUI interface and intermix hazard areas is detailed in Table 5.15-2.

Table 5.15-2. Total Acres of Land Area Located in the Wildfire Hazard Areas by County

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
Barbour	218,598	9,408	4.3%	63,183	28.9%
Berkeley	205,141	22,063	10.8%	75,529	36.8%
Boone	321,687	2,881	0.9%	87,903	27.3%
Braxton	328,023	4,327	1.3%	54,198	16.5%
Brooke	59,321	5,220	8.8%	33,667	56.8%
Cabell	184,109	18,833	10.2%	111,232	60.4%
Calhoun	179,487	2,088	1.2%	27,354	15.2%
Clay	219,951	1,078	0.5%	36,656	16.7%
Doddridge	205,051	3,182	1.6%	29,635	14.5%
Fayette	427,276	11,741	2.7%	100,293	23.5%
Gilmer	217,274	3,319	1.5%	13,329	6.1%
Grant	305,479	9,696	3.2%	33,294	10.9%
Greenbrier	654,360	30,028	4.6%	86,046	13.1%
Hampshire	412,248	18,574	4.5%	125,649	30.5%
Hancock	56,222	5,216	9.3%	37,329	66.4%
Hardy	373,689	11,827	3.2%	56,782	15.2%
Harrison	266,023	19,370	7.3%	109,337	41.1%
Jackson	300,968	16,474	5.5%	84,844	28.2%
Jefferson	134,920	13,178	9.8%	14,008	10.4%
Kanawha	582,312	27,213	4.7%	220,982	37.9%
Lewis	246,359	6,249	2.5%	35,851	14.6%
Lincoln	280,594	4,200	1.5%	111,641	39.8%
Logan	291,325	3,921	1.3%	101,191	34.7%
Marion	199,006	10,270	5.2%	98,925	49.7%
Marshall	199,304	5,756	2.9%	71,835	36.0%
Mason	284,059	16,966	6.0%	78,102	27.5%
McDowell	342,174	4,205	1.2%	68,719	20.1%
Mercer	268,828	17,285	6.4%	117,485	43.7%
Mineral	210,134	12,771	6.1%	62,671	29.8%
Mingo	270,756	4,224	1.6%	121,900	45.0%
Monongalia	232,200	14,593	6.3%	109,356	47.1%
Monroe	302,704	17,162	5.7%	37,486	12.4%
Morgan	146,880	4,255	2.9%	91,028	62.0%

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
Nicholas	415,482	7,827	1.9%	102,146	24.6%
Ohio	69,666	9,803	14.1%	42,390	60.8%
Pendleton	446,485	7,714	1.7%	25,033	5.6%
Pleasants	85,837	2,887	3.4%	17,167	20.0%
Pocahontas	601,520	6,783	1.1%	48,646	8.1%
Preston	415,612	23,819	5.7%	104,823	25.2%
Putnam	223,706	14,935	6.7%	109,174	48.8%
Raleigh	388,484	29,587	7.6%	104,949	27.0%
Randolph	664,970	15,900	2.4%	56,432	8.5%
Ritchie	290,396	6,192	2.1%	22,024	7.6%
Roane	309,410	5,242	1.7%	46,880	15.2%
Summers	233,898	7,342	3.1%	49,653	21.2%
Taylor	110,892	8,373	7.6%	44,812	40.4%
Tucker	265,897	4,638	1.7%	25,668	9.7%
Tyler	166,857	5,937	3.6%	18,790	11.3%
Upshur	226,613	9,795	4.3%	73,692	32.5%
Wayne	325,702	9,645	3.0%	126,226	38.8%
Webster	355,637	3,053	0.9%	25,705	7.2%
Wetzel	231,289	4,128	1.8%	21,426	9.3%
Wirt	150,356	6,561	4.4%	12,141	8.1%
Wood	241,020	25,738	10.7%	93,388	38.7%
Wyoming	320,602	2,994	0.9%	79,883	24.9%
Total	**15,466,796**	**576,466**	**3.7%**	**3,758,488**	**24.3%**

Source: Radeloff et al 2017; USGS 2022; West Virginia University Geographic Information Systems (GIS) Technical Center (WVU GISTC) 2022

EXTENT

The WVDOF has five categories of wildfire danger. Table 5.15-3 describes each category and the expected intensity for each.

Table 5.15-3. Wildfire Risk Categories

Wildfire Category	Category Color	Description
Low	Dark Green	Fuels do not ignite readily from small firebrands, although a more intense heat source, such as lightning, may start fires in duff or punky wood. Fires in open cured grasslands may burn freely a few hours after rain, but timber fires spread slowly by creeping or smoldering and burn in irregular fingers. There is a little danger of spotting.
Moderate	Light Green or Blue	Fires can start from accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low. Fires in open cured grasslands will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur but is not persistent. Fires are not likely to become serious and control is relatively easy.
High	Yellow	All fine dead fuels ignite readily, and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and their control difficult unless they are attacked successfully while small. Outdoor burning should be restricted to early morning and late evening hours.
Very High	Orange	Fires start easily from all causes. Immediately after ignition, they spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high intensity characteristics such as long-distance spotting and fire whirlwinds when they burn in heavier fuels. Outdoor burning is not recommended.
Extreme	Red	Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high intensity burning will usually be faster and occur from smaller fires than in the very high fire danger class. Direct attack is rarely possible and may be dangerous except immediately after ignition. Fires that develop headway in heavy slash or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions, the only effective and safe control action is on the flanks until the weather changes, or the fuel supply lessons. No outdoor burning should take place in areas with extreme fire behavior.

Source: WVDOF 2022

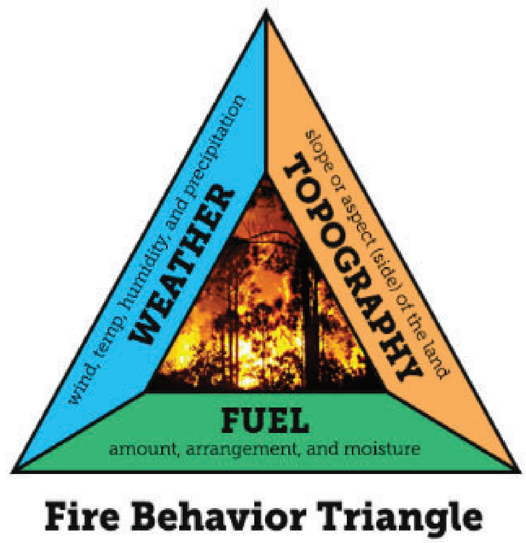
Heat, fuel, and oxygen are all required for the creation and maintenance of any fire, as depicted in the wildfire triangle as shown in Figure 5.15-3. When not enough heat is generated or when water is used to reduce the heat level; when the fuel is exhausted, removed, or isolated; or when the oxygen supply is limited, then a side of the triangle is broken, and the fire is extinguished.

- **Heat**—A heat source is needed for the initial ignition of wildfires. Heat is also generated by the fire. For a fire to grow, heat must be transferred to the initial and surrounding fuel. It allows fire to spread by removing the moisture from the nearby fuel, enabling it to ignite or travel more easily.
- **Fuel**—The fuel side of the triangle (as shown in the image above) refers to both the external and internal properties of the fuel. External properties refer to the type and the characteristics of the fuel material. Internal properties of fuel address aspects of fuel chemistry. Fuel is characterized by its moisture content, size and shape, quantity, and the location of the fuel type (ground, surface, ladder, or aerial).
- **Oxygen**—Air contains about 21 percent oxygen. Most fires require air with at least 16 percent oxygen content to burn under most conditions. Oxygen supports the chemical processes that occur during a

wildland fire. When fuel burns, it reacts with oxygen from the surrounding air, releasing heat and generating combustion products (NIFC n.d.).

All wildfires begin with an ignition source. Fire behavior describes the manner in which fuels ignite, flames develop, and fire spreads. The “fire behavior triangle” illustrates how the four primary factors influence wildfire behavior: fuel, topography, weather, and the chemical reaction. Each point of the triangle represents one of the three factors, while the center represents the chemical reaction that must take place for the fire to ignite; the sides represent the interplay between the factors. For example, drier and warmer weather combined with dense fuel loads and steeper slopes will cause more hazardous fires than light fuels on flat ground (NIFC n.d.).

Figure 5.15-2. The Fire Behavior Triangle



Source: WeatherSTEM 2017

Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when one might break out. However, there are tools used to identify the possibility of fire weather in an area. Fire weather watches and red flag warnings are used to convey the possibility of severe fire weather to wildland fire agencies.

The National Weather Service (NWS) issues Fire Weather Watches and Red Flag Warnings to alert fire departments and residents of the onset, or possible onset, of critical weather and dry conditions that could lead to rapid or dramatic increases in wildfire activity. The watches, warnings, and evacuation notices are science-based predictions that are intended to provide adequate time for evacuation. Fire weather forecasts are available on the NWS website accessed at https://www.weather.gov/fire/ and provides a hazard/overview map, the NWS Fire Wx Forecast Map, Today’s SPC Outlook, the Latest Wildland Fire Outlook, and Current Large Incidents.

A Fire Weather Watch is issued by the NWS when the potential for severe fire weather exists in the near future. A watch is used when there is a relatively low probability of occurrence and less chance of verifying. The fire danger rating is usually in the high to extreme category. It is normally issued 12 to 24 hours in advance of the expected onset of severe fire weather conditions and typically in conjunction with the routine forecasts. The area affected, onset time, and a statement describing the conditions are included in the forecast. A Red Flag Warning is issued by the NWS to indicate the imminent danger of severe fire weather combined with a relatively high probability of occurrence. At issuance, the fire danger is usually in the high to extreme category. A Red Flag Warning may or may not be preceded by a Fire Weather Watch (NWS n.d.).

Previous Occurrences and Losses

The National Oceanic and Atmospheric Administration (NOAA) Storm Events Database reports that 31 wildfire events occurred between 1950 and 2022. However, the WVDOF reported over 1,700 wildfires between 2018 and 2021, burning approximately 15,096 acres (WVDOF 2022).

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1954 and 2022, the State had two FEMA-designated wildfire-related disasters (DR), emergencies (EM), or fire suppression authorization (FSA). An FSA declaration is issued to ease the financial burden on local fire department by reimbursing for suppression costs associated with fighting fire on federal property. Upon passage of the Disaster Mitigation Action of 2000 (DMA 2000), the FSA Program was replaced by the Fire Management Assistance Grant Program (FMAG) in late 2021 (FEMA 2021), though the State has not received any FMAG declarations since the change was made. Wildfires for which FEMA issued disaster declarations are summarized in Table 5.15-4.

Table 5.15-4. FEMA Disaster Declarations for Wildfire (1954 to 2022)

Date(s) of Event	Incident	Federal Designation	Counties Affected
November 16-30, 2001	West Virginia Southwest Complex Fire	FSA-2391-WV	Boone, Cabell, Clay, Kanawha, Lincoln, Logan, McDowell, Mercer, Mingo, Raleigh, Wayne, Wyoming
November 16-30, 2001	Trough and Smoke Hole Fire Complexes	FSA-2392-WV	Grant, Hardy

Source: FEMA 2023

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was not included in any wildfire-related agricultural disaster declarations (USDA 2023).

Previous Events

For this 2023 SHMP, known wildfire events reported by WVDOF that impacted West Virginia between 2018 and 2021 are listed in Table 5.15-5; there is currently no available data for 2022 (WVDOF 2022). For this SHMP update, there was limited information regarding wildfire events in the state.

Table 5.15-5. Wildfire Events in West Virginia (2018 to 2021)

Year	Number of Wildfires	Acres Burned
2018	457	5,803
2019	408	3,307
2020	371	1,776
2021	550	4,210

Source: WVDOF 2022

Probability of Future Hazard Events

Overall Probability

For this SHMP update, the most up-to-date data was collected to calculate the probability of future occurrence of wildfire events for the project area. Information from FEMA, USDA, the NOAA-NCEI storm events database, the

WVDOF, and local news sources were used to identify the number of wildfire events that occurred between 2018 and 2022. Table 5.15-6 presents the probability of future wildfires in West Virginia.

Table 5.15-6. Probability of Future Wildfire Events in West Virginia

Hazard Type	Number of Occurrences between 2018 and 2022	Percent Chance of Occurrence in Any Given Year
Fire/Wildfire	1,786	100%

Source: USDA 2022; FEMA 2022; WVDOF 2022; West Virginia Emergency Management Division 2018

Projected Future Conditions

A major factor contributing to wildfire risk is drought, a phenomenon which is expected to worsen in the future. Heatwaves may also become more common and severe. A 2022 report from FEMA's U.S. Fire Administration cites future conditions as a key driver of wildfire in the WUI. The report also states that, "The southeastern U.S. has the potential for larger fires (greater than 12,000 acres) to increase by 300 percent to 400 percent" by the middle of the 21st century (U.S. Fire Administration 2022).

Changing weather patterns may also result in an increased occurrence of invasive species. Invasive shrubs and herbs may increase the density of the understory, thereby increasing fuel. on the other hand, many invasive shrubs and herbs begin growing earlier in spring than native plants. This early green-up may reduce the flammability of fire-adapted communities during the spring fire season. Invasive pests can also interact with climate and wildfire by altering forest fuels and forest structure.

5.15.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For wildfire, the entirety of West Virginia has been identified as a potential hazard area. Therefore, all assets in the state (population, structures, critical facilities, and lifelines), as described in the State Profile, are vulnerable. The impacts on population, existing structures, critical facilities, and the economy are presented below.

State Assets

For the purposes of this risk assessment, an asset is considered potentially vulnerable if it is in an identified hazard area. To assess the vulnerability of the state buildings, GIS software was used to overlay the statewide wildfire hazard areas with buildings. Interface WUI includes developed areas that have sparse or no wildland vegetation but are close in proximity to a large patch of wildland, whereas intermix WUI is defined as the area where houses and wildland vegetation directly intermingle (USDA 2019). The spatial analysis for the wildfire hazard determined there are 405 state buildings located in the WUI interface wildfire risk hazard area with the greatest number of state buildings located in Kanawha County (50 buildings), while Marion County had the greatest replacement cost value of $239.9 million. The Department of Health and Human Resources has the greatest number of buildings (58) in the WUI interface wildfire risk hazard area, while Fairmont State University has the highest replacement cost value ($225.3 million).

The spatial analysis also determined there are 171 state buildings located in the WUI intermix wildfire risk hazard area with the greatest number of state buildings located in Kanawha County (30 buildings), while Mercer County has the highest replacement cost value ($189.4 million). The Division of Highways has the greatest number of buildings (23) in the WUI intermix wildfire risk hazard area, while Concord University has the highest replacement cost value ($172.9 million).

Table 5.15-7 to Table 5.15-10 summarize the state buildings located in the interface and intermix high wildfire risk hazard areas by counties and agencies, respectively.

Table 5.15-7. State Facilities Within the WUI Interface Wildfire Hazard Area by County

State Facilities Within the WUI Interface Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Interface Wildfire Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Barbour	8	$40,000	$1,171,289	$1,211,289
Berkeley	4	$4,171,000	$470,000	$4,641,000
Boone	3	$0	$85,000	$85,000
Braxton	5	$0	$168,600	$168,600
Brooke	3	$2,900,000	$85,000	$2,985,000
Cabell	17	$62,322,526	$2,774,075	$65,096,601
Calhoun	1	$0	$300,000	$300,000
Clay	2	$0	$243,100	$243,100
Doddridge	4	$725,000	$79,000	$804,000
Fayette	12	$32,046,767	$5,204,000	$37,250,767
Gilmer	5	$88,806,230	$12,435,500	$101,241,730
Grant	5	$525,006	$587,800	$1,112,806
Greenbrier	20	$90,831,577	$15,855,100	$106,686,677
Hampshire	8	$6,205,924	$930,400	$7,136,324
Hancock	4	$71,500	$165,100	$236,600
Hardy	7	$1,500,000	$515,000	$2,015,000
Harrison	10	$4,058,614	$3,729,682	$7,788,296
Jackson	4	$1,200,000	$1,669,500	$2,869,500
Jefferson	0	$0	$0	$0
Kanawha	50	$202,921,581	$31,365,320	$234,286,901
Lewis	6	$13,755,596	$3,659,273	$17,414,869
Lincoln	4	$800,000	$781,000	$1,581,000
Logan	5	$0	$287,600	$287,600
Marion	15	$224,449,522	$15,431,800	$239,881,322
Marshall	6	$4,329,891	$925,600	$5,255,491
Mason	8	$3,173,083	$1,180,350	$4,353,433
McDowell	5	$1,125,000	$395,000	$1,520,000
Mercer	12	$7,950,000	$1,512,400	$9,462,400
Mineral	9	$2,747,022	$1,333,000	$4,080,022
Mingo	10	$15,995,822	$4,415,300	$20,411,122
Monongalia	6	$19,129,502	$1,169,000	$20,298,502
Monroe	5	$652,903	$439,427	$1,092,330

State Facilities Within the WUI Interface Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Interface Wildfire Hazard Area by County		
Morgan	8	$4,467,671	$909,800	$5,377,471
Nicholas	2	$510,000	$115,000	$625,000
Ohio	10	$4,276,000	$3,446,000	$7,722,000
Pendleton	3	$900,000	$96,900	$996,900
Pleasants	4	$130,000	$180,000	$310,000
Pocahontas	3	$0	$75,000	$75,000
Preston	5	$22,756,331	$3,780,169	$26,536,500
Putnam	15	$19,558,800	$5,684,300	$25,243,100
Raleigh	15	$106,926,530	$17,040,600	$123,967,130
Randolph	19	$16,308,784	$5,249,080	$21,557,864
Ritchie	4	$0	$220,000	$220,000
Roane	6	$1,505,400	$950,840	$2,456,240
Summers	4	$151,200	$251,300	$402,500
Taylor	2	$1,083,940	$228,700	$1,312,640
Tucker	3	$129,600	$89,300	$218,900
Tyler	4	$1,000,000	$630,210	$1,630,210
Upshur	3	$4,370,709	$3,729,000	$8,099,709
Wayne	3	$300,000	$100,000	$400,000
Webster	4	$0	$330,000	$330,000
Wetzel	4	$0	$450,900	$450,900
Wirt	1	$0	$30,000	$30,000
Wood	15	$15,410,202	$2,075,400	$17,485,602
Wyoming	5	$191,500	$210,400	$401,900
Total	**405**	**$992,410,733**	**$155,236,115**	**$1,147,646,848**

Source: WVEMD; Radeloff et al 2017

Table 5.15-8. State Facilities Within the WUI Interface Wildfire Hazard Area by Agency

State Facilities Within the WUI Interface Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Interface Wildfire Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Adjutant General's Office State of West Virginia	0	$0	$0	$0
Administration, Secretary of Department of Administration	1	$0	$112,000	$112,000
Agriculture, Department of State of West Virginia	4	$1,200,000	$1,220,000	$2,420,000
Air and Environmental Quality Boards State of West Virginia	0	$0	$0	$0
Alcohol Beverage Control Administration State of West Virginia	0	$0	$0	$0
Architects, Board of State of West Virginia	0	$0	$0	$0
Armory Board State of West Virginia	21	$51,195,669	$16,449,000	$67,644,669
Arts, Culture & History, Department of State of West Virginia	0	$0	$0	$0
Attorney General, Office of The State of West Virginia	0	$0	$0	$0

State Facilities Within the WUI Interface Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Interface Wildfire Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Aviation, Division of	1	$2,000,000	$250,000	$2,250,000
Bar, State State of West Virginia	0	$0	$0	$0
Barbers & Cosmetologists, Board of State of West Virginia	1	$0	$100,000	$100,000
Blue Ridge Community & Technical College	0	$0	$0	$0
Bluefield State College	0	$0	$0	$0
Board of Treasury Investments	0	$0	$0	$0
Bridgevalley Community & Tech College	1	$29,146,767	$2,690,000	$31,836,767
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	1	$0	$100,000	$100,000
Commission For National and Community Service, WV	1	$0	$80,000	$80,000
Concord University	0	$0	$0	$0
Conservation Agency, West Virginia State of West Virginia	6	$0	$167,710	$167,710
Consolidated Public Retirement Board Department of Administration	0	$0	$0	$0
Consumer Advocate, Division of WV Public Service Commission	1	$0	$150,000	$150,000
Corrections, Division of State of West Virginia	5	$17,693,619	$2,225,402	$19,919,021
Courthouse Facilities Improvement Authority	1	$300,000	$200,000	$500,000
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	2	$0	$0	$0
Dietitians, Board of Licensed	0	$0	$0	$0
Eastern Panhandle Instructional Coop	3	$300,000	$595,000	$895,000
Eastern WV Community & Tech. College	2	$1,500,000	$70,000	$1,570,000
Economic Development Authority State of West Virginia	0	$0	$0	$0
Economic Development, WV Dept of	0	$0	$0	$0
Education, Department of State of West Virginia	8	$0	$640,080	$640,080
Educational Broadcasting Authority State of West Virginia	1	$30,000	$0	$30,000
Enterprise Resource Planning Board, WV	0	$0	$0	$0
Environmental Protection, Division of State of West Virginia	10	$34,500	$1,570,912	$1,605,412
Ethics Commission, West Virginia Department of Administration	1	$65,000	$65,000	$130,000
Examiners In Counseling, Board of State of West Virginia	0	$0	$0	$0
Fairmont State University	1	$211,509,751	$13,786,800	$225,296,551
Fire Commission State of West Virginia	0	$0	$0	$0
Fleet Management Office, Dept of Admin State of West Virginia	1	$0	$50,000	$50,000
Forestry, Division of State of West Virginia	7	$292,488	$932,300	$1,224,788
General Services Division Department of Administration	1	$4,550,000	$100,000	$4,650,000
Geological and Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	1	$88,806,230	$12,031,000	$100,837,230
Governor, Office of The State of West Virginia	0	$0	$0	$0

State Facilities Within the WUI Interface Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Interface Wildfire Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Health & Human Resources, Department of State of West Virginia	58	$187,701,974	$21,358,675	$209,060,649
Higher Education Policy Commission, WV	0	$0	$0	$0
Highways, Division of State of West Virginia	43	$48,291,619	$9,125,940	$57,417,559
Homeland Security & Emergency Management Division	1	$0	$205,000	$205,000
Insurance Commissioner, Office of The State of West Virginia	1	$0	$25,000	$25,000
Investment Management Board, WV State of West Virginia	0	$0	$0	$0
Joint Committee on Government & Finance State of West Virginia	1	$0	$73,871	$73,871
Justice & Community Services, Div. of	1	$0	$750,000	$750,000
Juvenile Services, Division of	9	$12,566,000	$2,508,300	$15,074,300
Labor, Division of State of West Virginia	0	$0	$0	$0
Land Division/Dept of Agriculture State of West Virginia	1	$129,407	$0	$129,407
Landscape Architects, Board of State of West Virginia	0	$0	$0	$0
Library Commission State of West Virginia	1	$0	$166,959	$166,959
Lottery Commission State of West Virginia	0	$0	$0	$0
Marshall University	0	$0	$0	$0
Military Affairs, Secretary of and Public Safety	0	$0	$0	$0
Miner's Health Safety, Division of and Training, State of West Virginia	3	$1,900,000	$1,550,000	$3,450,000
Motor Vehicles, Division of State of West Virginia	9	$0	$1,085,000	$1,085,000
Mountain State Esc	1	$1,000,000	$250,000	$1,250,000
Mountwest Community & Technical College	1	$2,813,114	$200,000	$3,013,114
National Coal Heritage Area Authority	3	$2,000,000	$450,000	$2,450,000
Natural Resources, Division of State of West Virginia	7	$655,006	$835,900	$1,490,906
New River Community & Technical College	1	$8,990,000	$2,500,000	$11,490,000
Northern Community & Tech College, WV College Square	0	$0	$0	$0
Occupational Therapy Board State of West Virginia	1	$0	$10,000	$10,000
Office of Technology/IS&C Department of Administration	0	$0	$0	$0
Osteopathic Medicine, WV Board of State of West Virginia	0	$0	$0	$0
Osteopathic Medicine, WV School of	6	$66,788,139	$8,217,098	$75,005,237
Parks, West Virginia State C\O Division of Natural Resources	10	$4,952,847	$734,300	$5,687,147
Pharmacy, Board of State of West Virginia	1	$850,000	$80,000	$930,000
Physical Therapy, Board of State of West Virginia	0	$0	$0	$0
Pierpont Community and Technical College	0	$0	$0	$0
Practical Nurses, Board of State of West Virginia	0	$0	$0	$0
Prosecuting Attorneys Institute, WV	0	$0	$0	$0
Psychologists Examiners, Board of State of West Virginia	0	$0	$0	$0
Public Service Commission State of West Virginia	0	$0	$0	$0

State Facilities Within the WUI Interface Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Interface Wildfire Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Purchasing, Division of Department of Administration	0	$0	$0	$0
Rail Authority State of West Virginia	0	$0	$0	$0
Real Estate Commission State of West Virginia	0	$0	$0	$0
Regional Jail & Corr. Fac. Authority State of West Virginia	0	$0	$0	$0
Registered Nurses, Board of State of West Virginia	0	$0	$0	$0
Rehabilitation Services Division of Commerce	16	$0	$3,206,999	$3,206,999
Respiratory Care, WV Board of	0	$0	$0	$0
School Building Authority, West Virginia	1	$500,000	$300,000	$800,000
Schools For The Deaf and The Blind State of West Virginia	0	$0	$0	$0
Senior Services, Bureau of State of West Virginia	0	$0	$0	$0
Shepherd University	0	$0	$0	$0
Southern Educational Services Coop	0	$0	$0	$0
Southern WV Community & Tech College	1	$15,882,800	$3,515,000	$19,397,800
Speech Pathology & Audiology Examiners West Virginia Board of	0	$0	$0	$0
State Police, West Virginia Dept of Military Affairs & Public Safety	39	$18,428,788	$5,680,000	$24,108,788
Supreme Court of Appeals State of West Virginia	53	$0	$5,134,100	$5,134,100
Tax Appeals, WV Office of	0	$0	$0	$0
Tax Department State of West Virginia	2	$0	$5,120,000	$5,120,000
Treasurer of State State of West Virginia	0	$0	$0	$0
University Physicians and Surgeons	6	$13,530,000	$2,775,000	$16,305,000
Unknown	21	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	6	$0	$52,000	$52,000
Veterinary Medicine, Board of State of West Virginia	1	$0	$25,000	$25,000
Water Development Authority State of West Virginia	0	$0	$0	$0
West Liberty University	0	$0	$0	$0
West Virginia Parkways Authority	7	$29,715,500	$8,540,000	$38,255,500
West Virginia State University - Institute	1	$130,503,950	$9,519,200	$140,023,150
West Virginia State University - Malden	1	$1,114,000	$115,000	$1,229,000
West Virginia University	0	$0	$0	$0
West Virginia University Arthurdale	1	$31,259	$43,669	$74,928
West Virginia University At Parkersburg	0	$0	$0	$0
West Virginia University Beckley	0	$0	$0	$0
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	0	$0	$0	$0
West Virginia University Fort Ashby	1	$2,747,022	$705,000	$3,452,022
West Virginia University Granville	1	$18,789,502	$986,000	$19,775,502
West Virginia University Jacksons Mill	1	$11,287,734	$3,312,473	$14,600,207

State Facilities Within the WUI Interface Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Interface Wildfire Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	0	$0	$0	$0
West Virginia University Montgomery	0	$0	$0	$0
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	1	$452,903	$53,427	$506,330
West Virginia University Wardensville	0	$0	$0	$0
West Virginia University Weston	1	$2,165,145	$75,000	$2,240,145
Workforce West Virginia	2	$0	$117,000	$117,000
WV Public Employees Grievance Board	0	$0	$0	$0
WVsom Clinic Inc Dba Robert C Byrd Clinic	1	$0	$2,250,000	$2,250,000
Total (WV State)	**405**	**$992,410,733**	**$155,236,115**	**$1,147,646,848**

Source: WVEMD; Radeloff et al 2017

Table 5.15-9. State Facilities Within the WUI Intermix Wildfire Hazard Area by County

State Facilities Within the WUI Intermix Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Intermix Wildfire Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Barbour	2	$0	$15,000	$15,000
Berkeley	5	$17,495,660	$1,719,072	$19,214,732
Boone	5	$20,050,000	$4,416,000	$24,466,000
Braxton	7	$2,669,153	$2,890,000	$5,559,153
Brooke	0	$0	$0	$0
Cabell	6	$7,883,550	$2,229,000	$10,112,550
Calhoun	0	$0	$0	$0
Clay	1	$0	$0	$0
Doddridge	8	$65,699,435	$8,498,500	$74,197,935
Fayette	4	$5,245,296	$1,576,667	$6,821,963
Gilmer	0	$0	$0	$0
Grant	0	$0	$0	$0
Greenbrier	1	$4,416,000	$766,000	$5,182,000
Hampshire	4	$13,650	$217,450	$231,100
Hancock	3	$661,500	$50,600	$712,100
Hardy	3	$33,031,471	$3,384,035	$36,415,506
Harrison	4	$1,821,232	$2,658,500	$4,479,732
Jackson	0	$0	$0	$0
Jefferson	0	$0	$0	$0
Kanawha	30	$79,675,000	$10,588,301	$90,263,301

State Facilities Within the WUI Intermix Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Intermix Wildfire Hazard Area by County		
County	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure & Contents)
Lewis	2	$211,000	$132,000	$343,000
Lincoln	1	$25,000	$0	$25,000
Logan	10	$42,895,150	$12,254,036	$55,149,186
Marion	4	$24,400,000	$2,435,000	$26,835,000
Marshall	0	$0	$0	$0
Mason	0	$0	$0	$0
McDowell	1	$0	$0	$0
Mercer	6	$172,098,124	$17,271,850	$189,369,974
Mineral	2	$443,000	$349,500	$792,500
Mingo	1	$3,120,000	$25,000	$3,145,000
Monongalia	9	$10,102,000	$2,422,000	$12,524,000
Monroe	0	$0	$0	$0
Morgan	12	$1,951,442	$570,000	$2,521,442
Nicholas	1	$200,000	$50,000	$250,000
Ohio	5	$2,680,000	$520,000	$3,200,000
Pendleton	0	$0	$0	$0
Pleasants	0	$0	$0	$0
Pocahontas	2	$6,333,200	$1,311,000	$7,644,200
Preston	4	$440,000	$395,000	$835,000
Putnam	0	$0	$0	$0
Raleigh	3	$7,532,900	$811,700	$8,344,600
Randolph	3	$38,075,000	$2,824,000	$40,899,000
Ritchie	0	$0	$0	$0
Roane	2	$120,000	$15,000	$135,000
Summers	0	$0	$0	$0
Taylor	1	$0	$132,000	$132,000
Tucker	1	$221,580	$250,000	$471,580
Tyler	0	$0	$0	$0
Upshur	3	$200,000	$35,000	$235,000
Wayne	4	$1,866,769	$97,564	$1,964,333
Webster	0	$0	$0	$0
Wetzel	1	$0	$0	$0
Wirt	1	$0	$28,500	$28,500
Wood	9	$74,653,680	$15,096,323	$89,750,003
Wyoming	0	$0	$0	$0
Total	**171**	**$626,230,792**	**$96,034,598**	**$722,265,390**

Source: WVEMD 2022; Radeloff et al 2017

Table 5.15-10. State Facilities Within the WUI Intermix Wildfire Hazard Area by Agency

State Facilities Within the WUI Intermix Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Intermix Wildfire Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Adjutant General's Office State of West Virginia	1	$100,000	$50,000	$150,000
Administration, Secretary of Department of Administration	0	$0	$0	$0
Agriculture, Department of State of West Virginia	1	$75,000	$0	$75,000
Air and Environmental Quality Boards State of West Virginia	0	$0	$0	$0
Alcohol Beverage Control Administration State of West Virginia	0	$0	$0	$0
Architects, Board of State of West Virginia	0	$0	$0	$0
Armory Board State of West Virginia	15	$78,339,828	$11,807,564	$90,147,392
Arts, Culture & History, Department of State of West Virginia	0	$0	$0	$0
Attorney General, Office of The State of West Virginia	0	$0	$0	$0
Aviation, Division of	0	$0	$0	$0
Bar, State State of West Virginia	1	$1,230,000	$250,000	$1,480,000
Barbers & Cosmetologists, Board of State of West Virginia	0	$0	$0	$0
Blue Ridge Community & Technical College	1	$17,395,660	$1,334,072	$18,729,732
Bluefield State College	0	$0	$0	$0
Board of Treasury Investments	0	$0	$0	$0
Bridgevalley Community & Tech College	0	$0	$0	$0
Cedar Lakes Conference Center State of West Virginia	0	$0	$0	$0
Chiropractic Examiners Board State of West Virginia	0	$0	$0	$0
Commission For National and Community Service, WV	0	$0	$0	$0
Concord University	1	$158,888,424	$14,040,500	$172,928,924
Conservation Agency, West Virginia State of West Virginia	6	$0	$889,900	$889,900
Consolidated Public Retirement Board Department of Administration	0	$0	$0	$0
Consumer Advocate, Division of WV Public Service Commission	0	$0	$0	$0
Corrections, Division of State of West Virginia	3	$41,864,101	$8,789,300	$50,653,401
Courthouse Facilities Improvement Authority	0	$0	$0	$0
Dentistry, Board of State of West Virginia	0	$0	$0	$0
Department of Transportation	0	$0	$0	$0
Dietitians, Board of Licensed	1	$0	$20,000	$20,000
Eastern Panhandle Instructional Coop	1	$0	$85,000	$85,000
Eastern WV Community & Tech. College	1	$8,173,410	$600,000	$8,773,410
Economic Development Authority State of West Virginia	0	$0	$0	$0
Economic Development, WV Dept of	0	$0	$0	$0
Education, Department of State of West Virginia	12	$0	$1,872,000	$1,872,000
Educational Broadcasting Authority State of West Virginia	2	$6,612,000	$3,100,000	$9,712,000
Enterprise Resource Planning Board, WV	0	$0	$0	$0

State Facilities Within the WUI Intermix Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Intermix Wildfire Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Environmental Protection, Division of State of West Virginia	6	$233,080	$3,778,985	$4,012,065
Ethics Commission, West Virginia Department of Administration	0	$0	$0	$0
Examiners In Counseling, Board of State of West Virginia	0	$0	$0	$0
Fairmont State University	0	$0	$0	$0
Fire Commission State of West Virginia	0	$0	$0	$0
Fleet Management Office, Dept of Admin State of West Virginia	0	$0	$0	$0
Forestry, Division of State of West Virginia	3	$0	$426,000	$426,000
General Services Division Department of Administration	1	$33,288,000	$500,000	$33,788,000
Geological and Economic Survey State of West Virginia	0	$0	$0	$0
Glenville State College	0	$0	$0	$0
Governor, Office of The State of West Virginia	0	$0	$0	$0
Health & Human Resources, Department of State of West Virginia	13	$13,980,000	$3,865,000	$17,845,000
Higher Education Policy Commission, WV	2	$4,330,000	$3,300,000	$7,630,000
Highways, Division of State of West Virginia	23	$20,373,194	$4,856,500	$25,229,694
Homeland Security & Emergency Management Division	0	$0	$0	$0
Insurance Commissioner, Office of The State of West Virginia	0	$0	$0	$0
Investment Management Board, WV State of West Virginia	0	$0	$0	$0
Joint Committee on Government & Finance State of West Virginia	0	$0	$0	$0
Justice & Community Services, Div. of	0	$0	$0	$0
Juvenile Services, Division of	5	$13,301,200	$1,702,000	$15,003,200
Labor, Division of State of West Virginia	0	$0	$0	$0
Land Division/Dept of Agriculture State of West Virginia	0	$0	$0	$0
Landscape Architects, Board of State of West Virginia	0	$0	$0	$0
Library Commission State of West Virginia	0	$0	$0	$0
Lottery Commission State of West Virginia	0	$0	$0	$0
Marshall University	0	$0	$0	$0
Military Affairs, Secretary of and Public Safety	0	$0	$0	$0
Miner's Health Safety, Division of and Training, State of West Virginia	2	$17,050,000	$3,500,000	$20,550,000
Motor Vehicles, Division of State of West Virginia	0	$0	$0	$0
Mountain State Esc	0	$0	$0	$0
Mountwest Community & Technical College	0	$0	$0	$0
National Coal Heritage Area Authority	0	$0	$0	$0
Natural Resources, Division of State of West Virginia	1	$200,000	$50,000	$250,000
New River Community & Technical College	0	$0	$0	$0
Northern Community & Tech College, WV College Square	0	$0	$0	$0
Occupational Therapy Board State of West Virginia	0	$0	$0	$0

State Facilities Within the WUI Intermix Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Intermix Wildfire Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
Office of Technology/IS&C Department of Administration	1	$0	$2,450,000	$2,450,000
Osteopathic Medicine, WV Board of State of West Virginia	0	$0	$0	$0
Osteopathic Medicine, WV School of	1	$0	$18,500	$18,500
Parks, West Virginia State C\O Division of Natural Resources	17	$9,888,769	$2,009,700	$11,898,469
Pharmacy, Board of State of West Virginia	0	$0	$0	$0
Physical Therapy, Board of State of West Virginia	1	$0	$80,000	$80,000
Pierpont Community and Technical College	0	$0	$0	$0
Practical Nurses, Board of State of West Virginia	1	$0	$60,000	$60,000
Prosecuting Attorneys Institute, WV	0	$0	$0	$0
Psychologists Examiners, Board of State of West Virginia	0	$0	$0	$0
Public Service Commission State of West Virginia	0	$0	$0	$0
Purchasing, Division of Department of Administration	0	$0	$0	$0
Rail Authority State of West Virginia	0	$0	$0	$0
Real Estate Commission State of West Virginia	0	$0	$0	$0
Regional Jail & Corr. Fac. Authority State of West Virginia	3	$82,648,048	$3,380,000	$86,028,048
Registered Nurses, Board of State of West Virginia	0	$0	$0	$0
Rehabilitation Services Division of Commerce	1	$0	$554,000	$554,000
Respiratory Care, WV Board of	1	$0	$100,000	$100,000
School Building Authority, West Virginia	0	$0	$0	$0
Schools For The Deaf and The Blind State of West Virginia	0	$0	$0	$0
Senior Services, Bureau of State of West Virginia	1	$0	$150,000	$150,000
Shepherd University	0	$0	$0	$0
Southern Educational Services Coop	0	$0	$0	$0
Southern WV Community & Tech College	3	$36,729,150	$8,015,219	$44,744,369
Speech Pathology & Audiology Examiners West Virginia Board of	1	$0	$20,000	$20,000
State Police, West Virginia Dept of Military Affairs & Public Safety	17	$15,880,111	$2,450,000	$18,330,111
Supreme Court of Appeals State of West Virginia	3	$0	$74,500	$74,500
Tax Appeals, WV Office of	0	$0	$0	$0
Tax Department State of West Virginia	0	$0	$0	$0
Treasurer of State State of West Virginia	1	$0	$675,000	$675,000
University Physicians and Surgeons	0	$0	$0	$0
Unknown	10	$0	$0	$0
Veterans Assistance, Department of State of West Virginia	2	$0	$20,000	$20,000
Veterinary Medicine, Board of State of West Virginia	0	$0	$0	$0
Water Development Authority State of West Virginia	0	$0	$0	$0
West Liberty University	1	$2,000,000	$500,000	$2,500,000

State Facilities Within the WUI Intermix Wildfire Hazard Area		Replacement Cost Value for State Facilities Within the WUI Intermix Wildfire Hazard Area by Agency		
Agency	Number of Structures	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)
West Virginia Parkways Authority	0	$0	$0	$0
West Virginia State University - Institute	0	$0	$0	$0
West Virginia State University - Malden	0	$0	$0	$0
West Virginia University	0	$0	$0	$0
West Virginia University Arthurdale	0	$0	$0	$0
West Virginia University At Parkersburg	1	$51,935,381	$9,834,823	$61,770,204
West Virginia University Beckley	0	$0	$0	$0
West Virginia University Bruceton Mills	0	$0	$0	$0
West Virginia University Charleston	0	$0	$0	$0
West Virginia University Fort Ashby	0	$0	$0	$0
West Virginia University Granville	0	$0	$0	$0
West Virginia University Jacksons Mill	0	$0	$0	$0
West Virginia University Kearneysville	0	$0	$0	$0
West Virginia University Keyser	0	$0	$0	$0
West Virginia University Montgomery	1	$4,857,375	$0	$4,857,375
West Virginia University Reedsville	0	$0	$0	$0
West Virginia University Union	0	$0	$0	$0
West Virginia University Wardensville	1	$6,858,061	$784,035	$7,642,096
West Virginia University Weston	0	$0	$0	$0
Workforce West Virginia	1	$0	$42,000	$42,000
WV Public Employees Grievance Board	0	$0	$0	$0
WVsom Clinic Inc Dba Robert C Byrd Clinic	0	$0	$0	$0
Total (WV State)	**171**	**$626,230,792**	**$96,034,598**	**$722,265,390**

Source: WVEMD; Radeloff et al 2017

Critical Facilities and Community Lifelines

It is recognized that a number of critical facilities are located in the wildfire hazard area. 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). Transportation routes are vulnerable to wildfire and have the potential to be blocked off, creating limited access from first responders. Facilities that are most vulnerable are those that are already in poor condition and may not be able to withstand high heat associated with fires. Utility infrastructure is also vulnerable; interruption of services may impact critical facilities that need to be in operation during a hazard. 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.

Due to the state's geography, each county needs to be as self-sufficient as possible in terms of wildfire response and recovery personnel and equipment. Statewide, there are 51 facilities in the WUI Interface Wildfire Hazard area and 28 facilities in the WUI intermix wildfire hazard area. Kanawha County has the greatest number of critical facilities (15) located in the WUI interface area as well as the most located in the WUI intermix wildfire risk hazard area (11) compared to the other counties. Table 5.15-11 summarizes the total number of critical facilities by lifeline category located in the WUI interface area by county. Table 5.15-12 summarizes the total number of critical facilities by lifeline category located in the WUI intermix area by county.

Table 5.15-11. Critical Facilities Located Within the WUI Interface Wildfire Hazard Area

Critical Facilities Located Within the WUI Interface Wildfire Hazard Area								
County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Barbour	0	0	0	0	0	1	0	1
Berkeley	0	0	0	0	0	1	0	1
Boone	0	0	0	0	0	0	0	0
Braxton	0	0	0	0	0	1	0	1
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	1	1	2
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	0	0	0
Fayette	0	0	0	0	0	1	0	1
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	1	0	0	2	0	3
Hampshire	0	0	0	0	0	0	0	0
Hancock	0	0	0	0	0	0	0	0
Hardy	0	0	0	0	0	2	0	2
Harrison	0	0	0	0	1	1	0	2
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	0	0	0	0	0	0
Kanawha	1	0	1	0	2	10	1	15
Lewis	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	1	0	1
Marion	0	0	0	0	1	2	0	3
Marshall	0	0	0	0	0	1	0	1
Mason	0	0	0	0	0	0	0	0
McDowell	0	0	0	0	0	1	0	1
Mercer	0	0	0	0	0	1	0	1
Mineral	0	0	0	0	0	1	0	1
Mingo	0	0	0	0	0	2	0	2
Monongalia	0	0	0	0	0	0	0	0

Critical Facilities Located Within the WUI Interface Wildfire Hazard Area								
County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	0	0	0
Ohio	0	0	1	0	0	1	0	2
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	0	0	0
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0
Putnam	0	0	0	0	0	1	0	1
Raleigh	0	0	0	0	1	0	0	1
Randolph	0	0	0	0	0	2	0	2
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	2	0	2
Summers	0	0	0	0	0	1	0	1
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0
Tyler	0	0	0	0	0	0	0	0
Upshur	0	0	0	0	0	0	0	0
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	1	0	0	1
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	2	1	3
Wyoming	0	0	0	0	0	0	0	0
Total	**1**	**0**	**3**	**0**	**6**	**38**	**3**	**51**

Source: WVEMD; Radeloff et al 2017

Table 5.15-12. Critical Facilities Located Within the WUI Intermix Wildfire Hazard Area

Critical Facilities Located Within the WUI Intermix Wildfire Hazard Area								
County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Barbour	0	0	0	0	0	0	0	0
Berkeley	0	0	0	0	0	0	0	0
Boone	0	0	0	0	0	1	0	1
Braxton	0	0	0	0	0	1	0	1
Brooke	0	0	0	0	0	0	0	0
Cabell	0	0	0	0	0	0	0	0
Calhoun	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0
Doddridge	0	0	0	0	0	3	0	3

Critical Facilities Located Within the WUI Intermix Wildfire Hazard Area								
County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Fayette	0	0	0	0	0	1	0	1
Gilmer	0	0	0	0	0	0	0	0
Grant	0	0	0	0	0	0	0	0
Greenbrier	0	0	0	0	0	0	0	0
Hampshire	0	0	0	0	0	2	0	2
Hancock	0	0	0	0	0	0	0	0
Hardy	0	0	0	0	0	0	0	0
Harrison	0	0	0	0	0	0	0	0
Jackson	0	0	0	0	0	0	0	0
Jefferson	0	0	0	0	0	0	0	0
Kanawha	0	0	1	0	1	9	0	11
Lewis	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0
Logan	0	0	0	0	0	2	0	2
Marion	0	0	0	0	0	0	0	0
Marshall	0	0	0	0	0	0	0	0
Mason	0	0	0	0	0	0	0	0
McDowell	0	0	0	0	0	1	0	1
Mercer	0	0	0	0	0	1	0	1
Mineral	0	0	0	0	0	0	0	0
Mingo	0	0	0	0	0	0	0	0
Monongalia	1	0	0	0	0	0	0	1
Monroe	0	0	0	0	0	0	0	0
Morgan	0	0	0	0	0	0	0	0
Nicholas	0	0	0	0	0	0	0	0
Ohio	0	0	0	0	0	1	0	1
Pendleton	0	0	0	0	0	0	0	0
Pleasants	0	0	0	0	0	0	0	0
Pocahontas	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0
Putnam	0	0	0	0	0	0	0	0
Raleigh	0	0	0	0	0	1	0	1
Randolph	0	0	0	0	0	1	0	1
Ritchie	0	0	0	0	0	0	0	0
Roane	0	0	0	0	0	0	0	0
Summers	0	0	0	0	0	0	0	0
Taylor	0	0	0	0	0	0	0	0
Tucker	0	0	0	0	0	0	0	0

Critical Facilities Located Within the WUI Intermix Wildfire Hazard Area								
County	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Transportation	Total
Tyler	0	0	0	0	0	0	0	0
Upshur	0	0	0	0	0	0	0	0
Wayne	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
Wetzel	0	0	0	0	0	0	0	0
Wirt	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	1	0	1
Wyoming	0	0	0	0	0	0	0	0
Total	**1**	**0**	**1**	**0**	**1**	**25**	**0**	**28**

Source: WVEMD; Radeloff et al 2017

Population

Wildfires have the potential to impact human health and life of residents and responders, structures, infrastructure, and natural resources. Based on the analysis, 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. Overall, Mingo County has the highest percentage of the population who are highly vulnerable (86.03 percent of the population exposed is highly vulnerable).

Table 5.15-13 and Table 5.15-14 list the estimated population living in the high wildfire risk hazard areas (both Interface and Intermix) that could be impacted should a wildfire occur. The analysis indicates that the population in Mercer County has the highest number of highly vulnerable people for interface, and Kanawha County has the highest number of highly vulnerable people for intermix. This analysis does not include the number of tourists and visitors in the state whose lodgings are also located in these high-risk areas. Therefore, these results may be underestimating exposure and vulnerability.

Table 5.15-13. Population Located within the WUI Interface Wildfire Hazard Area

Population Located Within the WUI Interface Wildfire Hazard Area			% Population Highly Vulnerable
County	Highly Vulnerable Population	Total Population	
Barbour	390	1,276	30.56%
Berkeley	0	8,284	0.00%
Boone	34	1,159	2.96%
Braxton	74	263	27.90%
Brooke	2,532	6,821	37.12%
Cabell	10,995	42,686	25.76%
Calhoun	0	265	0.00%
Clay	20	56	35.54%
Doddridge	0	739	0.00%
Fayette	4,267	9,419	45.30%

Population Located Within the WUI Interface Wildfire Hazard Area			% Population Highly Vulnerable
County	Highly Vulnerable Population	Total Population	
Gilmer	284	603	47.16%
Grant	514	1,015	50.64%
Greenbrier	4,452	7,398	60.17%
Hampshire	496	1,072	46.26%
Hancock	2,323	8,448	27.50%
Hardy	0	1,471	0.00%
Harrison	6,296	24,751	25.44%
Jackson	0	4,959	0.00%
Jefferson	0	6,681	0.00%
Kanawha	12,782	65,134	19.62%
Lewis	401	2,025	19.81%
Lincoln	146	484	30.14%
Logan	1,457	2,147	67.86%
Marion	4,533	15,408	29.42%
Marshall	1,748	8,703	20.08%
Mason	0	4,631	0.00%
McDowell	255	324	78.54%
Mercer	13,097	18,947	69.12%
Mineral	119	4,403	2.71%
Mingo	1,474	1,713	86.03%
Monongalia	492	26,127	1.88%
Monroe	0	1,168	0.00%
Morgan	0	1,001	0.00%
Nicholas	0	2,061	0.00%
Ohio	2,574	16,769	15.35%
Pendleton	0	262	0.00%
Pleasants	0	659	0.00%
Pocahontas	0	278	0.00%
Preston	551	4,006	13.75%
Putnam	0	21,395	0.00%
Raleigh	10,341	28,197	36.67%
Randolph	4,051	7,219	56.11%
Ritchie	0	571	0.00%
Roane	709	892	79.57%
Summers	257	1,569	16.37%
Taylor	1,101	3,525	31.24%
Tucker	0	492	0.00%
Tyler	0	1,352	0.00%
Upshur	0	5,435	0.00%
Wayne	0	8,081	0.00%

Population Located Within the WUI Interface Wildfire Hazard Area			% Population Highly Vulnerable
County	Highly Vulnerable Population	Total Population	
Webster	0	379	0.00%
Wetzel	0	3,557	0.00%
Wirt	0	614	0.00%
Wood	9,703	34,951	27.76%
Wyoming	57	328	17.50%
Total	**98,523**	**422,173**	**23.34%**

Source: Centers for Disease Control and Prevention (CDC) 2020; Radeloff et al 2017

Table 5.15-14. Population Located within the WUI Intermix Wildfire Hazard Area

Population Located Within the WUI Intermix Wildfire Hazard Area			% Population Highly Vulnerable
County	Highly Vulnerable Population	Total Population	
Barbour	1,803	8,384	21.51%
Berkeley	1,002	35,181	2.85%
Boone	2,626	14,897	17.63%
Braxton	1,062	3,196	33.23%
Brooke	0	13,266	0.00%
Cabell	1,763	32,232	5.47%
Calhoun	0	2,373	0.00%
Clay	393	1,915	20.54%
Doddridge	0	2,815	0.00%
Fayette	6,692	20,016	33.43%
Gilmer	956	1,500	63.76%
Grant	859	2,106	40.81%
Greenbrier	3,412	11,575	29.48%
Hampshire	4,104	10,321	39.76%
Hancock	3,168	19,374	16.35%
Hardy	0	4,101	0.00%
Harrison	1,747	28,212	6.19%
Jackson	0	11,623	0.00%
Jefferson	206	8,405	2.45%
Kanawha	17,411	84,983	20.49%
Lewis	1,327	5,164	25.70%
Lincoln	1,340	11,292	11.87%
Logan	14,949	22,099	67.65%
Marion	694	27,950	2.48%
Marshall	463	17,439	2.66%
Mason	0	10,755	0.00%
McDowell	1,015	4,587	22.12%
Mercer	13,627	30,505	44.67%

Population Located Within the WUI Intermix Wildfire Hazard Area			% Population Highly Vulnerable
County	Highly Vulnerable Population	Total Population	
Mineral	213	11,296	1.89%
Mingo	8,456	13,702	61.72%
Monongalia	1,092	40,394	2.70%
Monroe	0	3,523	0.00%
Morgan	0	14,165	0.00%
Nicholas	0	12,479	0.00%
Ohio	294	21,781	1.35%
Pendleton	0	971	0.00%
Pleasants	0	2,379	0.00%
Pocahontas	0	2,347	0.00%
Preston	452	15,570	2.91%
Putnam	0	22,100	0.00%
Raleigh	12,288	27,366	44.90%
Randolph	595	9,389	6.34%
Ritchie	0	1,226	0.00%
Roane	2,588	4,821	53.68%
Summers	870	3,523	24.68%
Taylor	3,144	10,092	31.15%
Tucker	0	2,406	0.00%
Tyler	0	2,381	0.00%
Upshur	0	10,680	0.00%
Wayne	0	22,261	0.00%
Webster	0	2,217	0.00%
Wetzel	0	3,462	0.00%
Wirt	0	822	0.00%
Wood	521	24,529	2.13%
Wyoming	595	6,884	8.64%
Total	**111,730**	**1,807,426**	**6.18%**

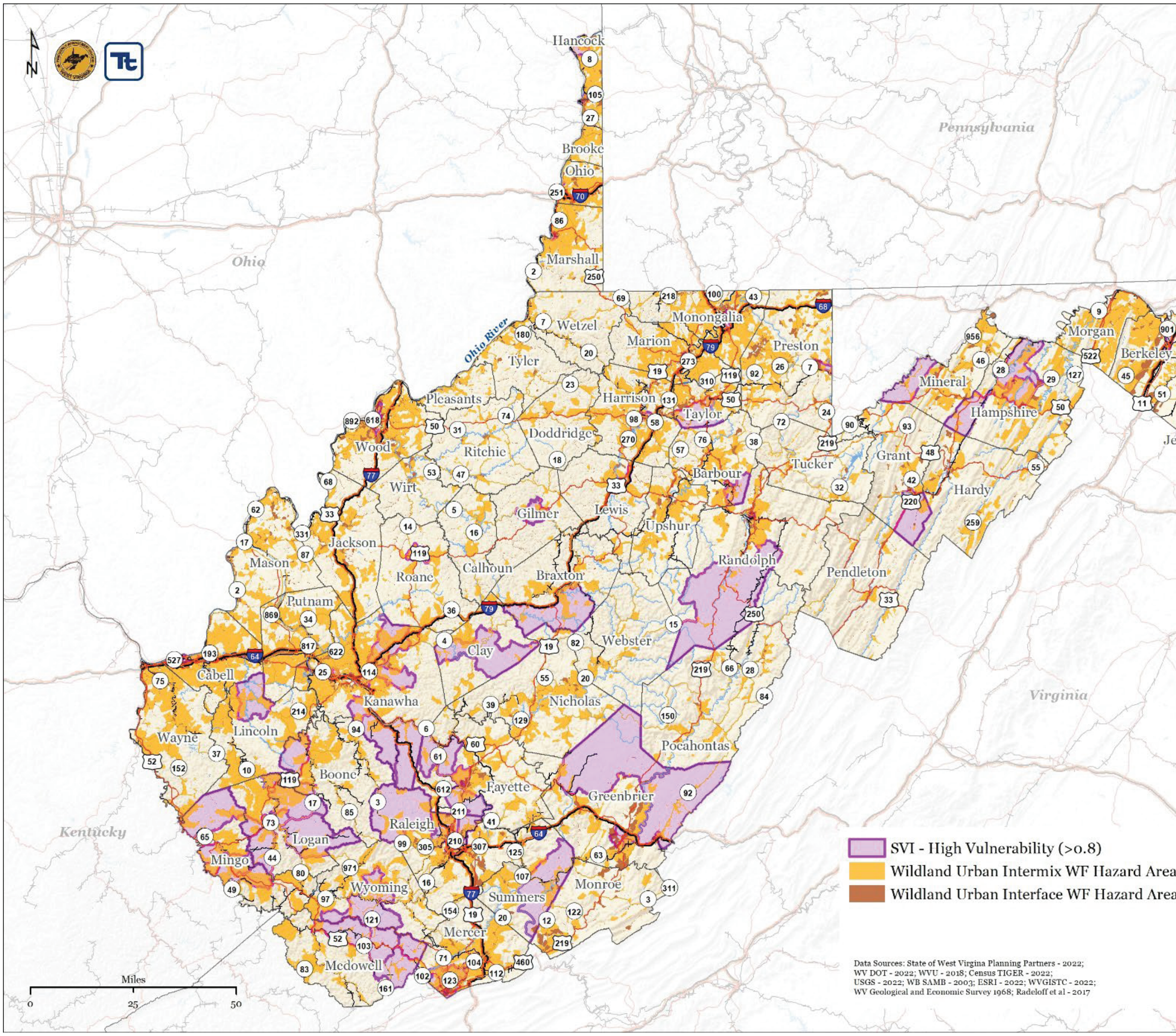
Source: CDC 2020; Radeloff et al 2017

Impacts on Socially Vulnerable Populations

Many communities and populations are especially vulnerable to wildfires, including low-income communities, migrant populations, populations whose primarily language is not English, indigenous populations, communities of older adults, and those with respiratory and other health concerns. The elderly (persons over the age of 65, 19.9 percent of the population), the young (persons under the age of 5, 5.2 percent of the population), and individuals living below the U.S. Census poverty threshold (16.9 percent of the population) are considered highly vulnerable based on a variety of factors including their physical and financial ability to react or respond during a hazard, the location and construction quality of their housing, and the ability to be self-sustaining for prolonged periods of time after an incident because of limited ability to stockpile supplies. In addition, members of immigrant communities may not speak English and may also be concerned about impacts to their immigration status and elect not to seek help during wildfire events. Indigenous populations are also affected, as they may lose sacred sites; fisheries and hunting and gathering grounds may be degraded (National Academies Press 2020).

Similarly, when a wildfire impacts an area with leased properties where multiple families live in one structure, it may be difficult for those not listed on the lease to prove that they were affected by the fire for insurance purposes. This could result in a lack of access to services. Additionally, fires can quickly increase the price of housing and rent due to limited space available, which further displaces people already affected by the fire and increases homelessness. Figure 5.15-3 provides more information on where the hazard area is located in relation to the social vulnerability index.

Figure 5.15-3. WUI Hazard Area and Social Vulnerability Index



Future Changes That May Impact State Vulnerability

Understanding future changes that may impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors in examining potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including impacts of future conditions.

Potential or Projected Development

It is anticipated that any new development and new residents in the wildland urban intermix/interface will be exposed to the wildfire hazard. Companies and potential homeowners should be mindful of the wildfire hazard areas when considering building in certain areas.

Projected Changes in Population

According to population projections in 2022 from the WVU Bureau of Business and Economic Research, West Virginia's population was projected to fall from 1,793,716 in 2020 to 1,705,509 in 2040 (West Virginia University 2022). As of July 1, 2019, according to estimates by the U.S. Census Bureau, West Virginia's total population is 1,792,147, representing a 3.3 percent decline since 2010 (approximately 60,487 fewer residents). West Virginia lost population both naturally, with 19,000 more deaths than births, and through migration, with 27,000 more people leaving the state than moving in (WVDOT 2020). Refer to Section 2 (State Profile), which includes a discussion on population trends for the State.

As stated previously, over 90 percent of wildfires in the State are caused by humans. As the overall resident population changes, there may be an increase in the number of human-caused wildfires as more people move into currently less developed parts of the state and as more people engage in activities that may accidentally spark wildfires. In addition to the resident population, the visitor population to the state is also increasing. Visitors may be less familiar with wildfire risk as well as precautions that should be taken to prevent or limit wildfire ignition. The increase in both resident and visitor populations may stress existing resources available for wildfire suppression activities as more water will be needed for human use and consumption.

Other Factors of Change

Future conditions, which may include warmer temperatures, could increase vulnerability to wildfire. 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 can create the conditions for a wildfire outbreak.

Droughts have the ability to stress native plant and animal species, especially in higher-elevation ecosystems, with increased exposure to non-native biological invasions due to shifting populations and fires (USGS 2018). Invasive species can increase wildfire risk.

5.15.3 Consequence Analysis

Impacts to the Public

The most at-risk populations include those within a short distance of the interface between the built environment and the wildland environment, including home and landowners along and within the wildland urban interface/intermix. Impacts to the public include potential for injury or loss of life, and destruction and/or loss of land and property due to wildfire. Loss of property can leave people homeless and with a hefty list of assets that need to be replaced, and some of these may be out-of-pocket costs. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations, including children, the elderly, and those with respiratory and cardiovascular diseases.

In addition, Wildfires may also make land more vulnerable to landslides if heavy precipitation follows a wildfire event. This has the potential to put more of the public at risk from a secondary hazard incident resulting from wildfire.

Impacts to Responders

Wildfires are often fast-moving, causing mass destruction in a shortened time frame. Emergency response to wildfires must involve several first response organizations, ranging from local police to specific federal agencies. Assessments must be done to determine the current needs of the situation, including evacuation, search and rescue, distribution of resources, firefighting, and relocation of displaced individuals. All these emergency responders can be exposed to the dangers from the initial incident as well as after-effects from smoke inhalation and heat stroke.

Wildfires may immobilize a region and shut down transportation which, in turn, stops the flow of supplies and disrupts the distribution of medical and emergency services and goods. Wildfires can quickly burn up buildings, trees, and additional infrastructure, making it difficult for responders to access the incident area. Rural areas may experience isolation for days at a time until first responders can safely access the area.

Impacts to Continuity of Operations

Intense fires can bring down trees, electrical wires, telephone poles, lines, and communication towers. Communication and power can be disrupted for days while utility companies work to repair the extensive damage. Wildfires can obstruct and slow transportation by knocking down trees and utility lines and causing structural collapses in buildings not designed to withstand the heat. Uncontrolled fires can also impact airports and roadways, sometimes even closing them completely, stopping the flow of supplies and disrupting continuity of operations in the state and counties.

Wildfires may also disrupt the distribution of gasoline, kerosene, diesel fuel, fuel oils, propane, and other petroleum products as these goods can also fuel fires to grow even more unmanageable. This disruption could cause major problems for organizations and businesses that rely on such supplies as well as impact the average citizen relying on gas to attend work. Additionally, such a disruption could affect or disable backup power generation.

Impacts to Property, Facilities, and Infrastructure

Wildfires make properties, facilities, and critical infrastructure highly vulnerable to damage. The most vulnerable structures to wildfire events are those within the wildland urban interface/intermix hazard area. Buildings and infrastructure constructed of wood or vinyl siding are generally more likely to be impacted by the fire hazard than buildings constructed of brick or concrete due to various melting points.

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. The vulnerability of infrastructure to this flooding varies according to physical factors of the associated drainage area, including size, slope, and its variation throughout the drainage area, and the severity of the fire (Valentin and Stormont 2019). In addition to protecting human life and communities, wildfire mitigation efforts need to consider areas that are at high risk to post-fire impacts due to flooding of critical infrastructure (Fraser, Chester and Underwood 2019). Roads provide a vital transportation link between populated areas. Road closures, as a result of a wildfire event, will have significant impacts on those communities and each county.

The state has more than 906.44 miles located in the interface wildfire hazard area and 42.31 miles of state-owned roads located in the intermix high wildfire risk areas. Raleigh County has the greatest number of road miles (39.15 miles) exposed in the interface wildfire hazard area, and Ohio County has the greatest number of road miles (47.91 miles) exposed in the intermix wildfire hazard area. A complete list of state roads located in the Interface and Intermix wildfire risk areas is included in Table 5.15-15 below.

Table 5.15-15. State Roads Located Within the WUI Interface and Intermix Hazards Areas

County	State Roads Located Within the WUI Interface Wildfire Hazard Area	State Roads Located Within the WUI Intermix Wildfire Hazard Area
	Mileage of Roadway	Mileage of Roadway
Barbour	10.88	0.25
Berkeley	12.50	13.38
Boone	29.28	14.77
Braxton	15.22	25.50
Brooke	12.84	17.46
Cabell	15.64	18.02
Calhoun	7.82	19.97
Clay	12.67	20.25
Doddridge	8.81	31.79
Fayette	27.62	8.33
Gilmer	13.27	32.43
Grant	10.40	6.11
Greenbrier	14.71	12.46
Hampshire	16.93	22.89
Hancock	12.07	26.03
Hardy	10.61	11.41

County	State Roads Located Within the WUI Interface Wildfire Hazard Area	State Roads Located Within the WUI Intermix Wildfire Hazard Area
	Mileage of Roadway	Mileage of Roadway
Harrison	21.92	8.17
Jackson	16.30	21.16
Jefferson	1.84	19.18
Kanawha	37.05	7.35
Lewis	0.01	27.11
Lincoln	22.64	1.82
Logan	24.91	39.87
Marion	6.52	15.53
Marshall	4.45	14.16
Mason	31.14	14.82
McDowell	27.71	24.79
Mercer	24.79	51.90
Mineral	16.80	39.46
Mingo	15.68	19.36
Monongalia	17.89	16.20
Monroe	13.41	22.66
Morgan	5.18	7.85
Nicholas	27.43	20.35
Ohio	6.74	47.91
Pendleton	3.84	9.86
Pleasants	6.63	1.77
Pocahontas	16.27	8.03
Preston	28.25	16.97
Putnam	30.15	37.85
Raleigh	39.15	30.97
Randolph	4.47	37.58
Ritchie	20.24	5.05
Roane	5.69	16.34
Summers	19.25	7.39
Taylor	4.92	23.27
Tucker	10.54	3.62
Tyler	18.58	10.24
Upshur	4.49	9.38
Wayne	23.31	15.67
Webster	12.93	33.32
Wetzel	20.42	24.97
Wirt	13.61	15.89
Wood	38.48	10.43

County	State Roads Located Within the WUI Interface Wildfire Hazard Area	State Roads Located Within the WUI Intermix Wildfire Hazard Area
	Mileage of Roadway	Mileage of Roadway
Wyoming	31.52	33.97
Total	**906.42**	**1,053.27**

Source: Radeloff et al 2017; WVDOT 2021

Impacts to the Environment

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, affecting the types, structure, and spatial extent of native vegetation. Low-intensity fires can clear and thin the forest by removing flammable vegetation from the forest floor, improving soil and habitat for wildlife, and promoting the new growth of native plants (Snow 2022). However, in some circumstances, it can also cause severe negative environmental impacts, such as the following:

- Soil Erosion—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats (California Ecosystems Climate Solutions 2020).
- Reduced Agricultural Resources—Wildfire can have disastrous consequences on agricultural resources, removing them from production and necessitating lengthy restoration programs (Philip 2019).
- Spread of Invasive Plant Species—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes and become difficult and costly to control (U.S. Department of the Interior, Office of Wildland Fire 2022).
- Destroyed Endangered Species Habitat—Wildfire can have negative consequences for endangered species by degrading their habitat (Butcher, Kristin 2019).
- Soil Sterilization—Some wildfires burn so hot that they can sterilize the soil. Topsoil exposed to extreme heat can become water-repellant and soil nutrients may be lost (FireSafe Sonoma 2020).
- Damaged Fisheries—Fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality (NASA Jet Propulsion Laboratory, California Institute of Technology 2022) (Beakes, et al. 2014).
- Damaged Cultural and Historical Resources—The destruction of cultural and historic resources may occur, scenic vistas can be damaged, and access to recreational areas can be reduced (National Park Service 2021).

Overall, wildfires have physical, chemical, and biological impacts on ecosystem resources and the environment (DeBano et al. 1998). Wildfires threaten air quality, water quality, soil properties, nutrient cycling, vegetation, and wildlife habitat. During periods of heavy rainfall, the burned areas can erode, becoming mud flows and debris flows, thereby increasing sedimentation loads in streams and rivers and potentially impacting water quality, fisheries, and long-term coral health. Further impacts include stream bank destabilization, which could worsen impacts of heavy rainfall and lead to riparian flooding.

Fires that reach urban areas are also dangerous to the environment. The increasing age and density of infrastructure within West Virginia can exacerbate consequences of fires on the environment because of the increased amount of chemicals and contaminants that would be released from burning infrastructure. These chemicals, such as iron, lead, and zinc, may leach into the storm water, contaminate nearby streams, and impair aquatic life.

Impacts to the Economic Condition of the State

Wildfire events can have major economic impacts on a community from the initial loss of structures as well as the subsequent loss of revenue from destroyed businesses. These hazard events may cost thousands of taxpayer dollars to suppress and control and may involve hundreds of operating hours on fire apparatus as well as thousands of volunteer man hours from the volunteer firefighters. There are also many direct and indirect costs to local businesses that need to excuse volunteers from working to fight these fires.

Property loss is an immediate economic impact of wildfires, in addition to secondary impacts that carry on for years. With the loss of property comes the displacement of individuals and families from their homes, the decimation of businesses, and significant effects on insurers. Local employment and wages may actually increase during large wildfires as fire suppression efforts generate employment opportunities. However, wildfires tend to make local labor markets less stable over time because they cause dramatic disparities in seasonal employment (Reiff, Anderson and Velasquez 2022).

Wildfires not only have the potential to wipe out outdoor areas that draw in tourists but also to drive people away for years to come. Tourists and outdoors enthusiasts tend to avoid state and national parks when smoke is present, and this can have a widespread impact on other industries as well. In this way, wildfires can also negatively affect hospitality, restaurant, and other industries present in these key locations (Reiff, Anderson and Velasquez 2022).

A fire occurs in a structure every 64 seconds across the U.S., although outdoor fires remain more common. In total, fires in the U.S. in 2020 caused $21.9 billion in property damage. The largest wildfires may cause well over $1 billion in property loss and damage individually—the costliest wildfire in U.S. history, 2018's Camp Fire, resulted in a loss of about $10 billion at the time. In addition, eight of the ten costliest wildfires ever in the U.S. have taken place in the past four years (Reiff, Anderson and Velasquez 2022).

Impacts to Public Confidence in State Governance

The public confidence in state governance primarily depends on how effective the State has been in the past at preparing for and responding to wildfire events. Public confidence also depends on the size of the event and the preparation the State takes for these events. In general, if the State is transparent in sharing relevant information with the public; proves it has the capability to support the residents of West Virginia if a wildfire occurs; and demonstrates its reliability to the public through the availability of programs and services relevant to wildfire events, then the public will remain confident in the state's governance (Chew, et al. 2021).

5.16 Winter Weather

2023 SHMP Update Changes

- The hazard profile was significantly enhanced to include detailed descriptions of the following: hazard definition, location, extent, previous occurrences, and probability of future occurrences (including how future conditions may impact the hazard).
- Information was updated regarding the current population affected by severe winter weather.
- Winter weather events that occurred in the State of West Virginia (the State) from January 1, 2018, through December 31, 2022, were researched for this 2023 SHMP.
- New and updated figures from federal, state, and local agencies were incorporated.
- Local vulnerabilities were assessed, and a consequence analysis was conducted to address hazard impacts on the public, responders, continuity of operations, property and infrastructure, environment, economic conditions of the state, and public confidence in state governance.

5.16.1 Hazard Profile

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of future conditions) and vulnerability assessment for the winter weather hazard in West Virginia.

Hazard Description

Winter weather is classified as snow, ice, and extremely cold conditions; the dominant forms of precipitation for these events occur only at cold temperatures. For this 2023 hazard mitigation plan update, winter weather hazards include heavy snow, blizzards, sleet, ice storms, and nor'easters. Types of winter weather events or conditions are further defined as follows:

- **Heavy snow** is the accumulation of 4 inches or more of snow within 12 hours or less or the accumulation of 6 inches or more of snow within 24 hours (NWS n.d.).
- **Blizzards** are dangerous winter storms that are a combination of blowing snow and wind, resulting in very low visibility. While heavy snowfalls and severe cold often accompany blizzards, they are not required. Sometimes strong winds pick up snow that has already fallen, creating a ground blizzard (NSSL 2023).
- **Sleet** occurs when snowflakes only partially melt when they fall through a shallow layer of warm air. These slushy drops refreeze as they next fall through a deep layer of freezing air above the surface and eventually reach the ground as frozen raindrops that bounce on impact (NSSL 2023).
- **Ice storms** result in the accumulation of at least.25" of ice on exposed surfaces. They create hazardous driving and walking conditions. Tree branches and powerlines can easily snap under the weight of the ice (NSSL 2023).

- **Nor'easters** are low-pressure systems that form and travel along the eastern coast of the United States. While the storms often affect the Northeast, the term nor'easter is derived from the fact that the winds around the low-pressure system blow from the northeast. These storms are more common from September to April and may bring snow and high winds to the regions they affect (National Geographic 2022).

Location

All regions of West Virginia are subject to winter weather. The mountains of West Virginia see some of the highest snowfall totals east of the Mississippi River, with an annual average of 100 inches. A record snowfall of more than 200 inches occurred during the winter of 2009–10, with more than 100 inches falling in the month of February, when the region was impacted by three major storms (NOAA 2022).

Extent

The magnitude or severity of a winter storm depends on several factors, including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) produces the Regional Snowfall Index (RSI) for significant snowstorms that affect the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5 and is based on the spatial extent of the storm, amount of snowfall, and the interaction of the extent and snowfall totals with the population based on the 2010 Census (see Table 5.16-1). The NCEI has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA 2022).

Table 5.16-1. RSI Snowstorm Impacts

Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	10+

Source: NOAA 2022
Note: RSI Regional Snowfall Index

The National Weather Service (NWS) operates a widespread network of observing systems, such as geostationary satellites, Doppler radars, and automated surface observing systems that feed into the current state-of-the-art numerical computer models to provide a look into what will happen next, ranging from hours to days. The models are then analyzed by NWS meteorologists, who then write and disseminate forecasts. According to NWS (NWS 2021), the magnitude of a severe winter storm can be qualified into five main categories by event type.

Table 5.16-2. Winter Storm Category Thresholds

Storm Type	Description
Heavy Snowstorm	Accumulations of 4 inches or more of snow in a 6-hour period or 6 inches of snow in a 12-hour period.
Sleet Storm	Significant accumulations of solid pellets that form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces, posing a hazard to pedestrians and motorists.
Ice Storm	Significant accumulation of rain or drizzle freezing on objects (trees, power lines, roadways) as it strikes them, causing slippery surfaces and damage from sheer weight of ice accumulations.
Blizzard	Wind velocity of 35 mph or more, temperatures below freezing, considerable blowing snow with visibility frequently below one-quarter mile prevailing over an extended period.
Severe Blizzard	Wind velocity of 45 mph, temperatures of 10 °F or lower, a high density of blowing snow with visibility frequently measured in feet prevailing over an extended period.

Source: NWS 2021

Additionally, the NWS uses winter weather watches, warnings, and advisories to help people anticipate what to expect in the days and hours prior to an approaching storm (NWS 2021). Refer to Figure 5.16-1 for the warning thresholds.

Figure 5.16-1. Winter Storm Warning Thresholds

Source: NOAA n.d.

Warning Time

It is unusual for a winter storm to occur without warning. Forecasts of incoming winter weather are generally available several days ahead of winter storms. Winter weather warnings and watches are issued by the local NWS office. The NWS will update the watches and warnings and will notify the public when they are no longer in effect.

The NWS issues the following winter weather advisories, watches, and warnings (National Weather Service n.d.):

- **Winter Weather Advisory**—A Winter Weather Advisory means that there is a high probability of enough snow, sleet, or ice to inconvenience people, but not enough to warrant a Winter Storm Warning.
- **Winter Storm Watch**—A Winter Storm Watch is issued when a significant winter storm is possible. People can expect two or more inches of snow, 1/2 inch or more of sleet, or 1/4 inch or more of freezing rain. Winter Storm Watches may be issued 12-48 hour before the winter storm is expected.
- **Winter Storm Warning**—A Winter Storm Warning means that there is a high probability of a winter weather event that includes two or more inches of snow, 1/2 inch or more of sleet, or 1/4 inch or more of freezing rain. The Winter Storm Warning may be issued at the discretion of the forecaster or an emergency manager when significant impacts are expected but the precipitation criteria are not necessarily met.
- **Ice Storm Warning**—An Ice Storm Warning is issued when there is a high probability of 1/4 inch or more of freezing rain, or when a forecaster or emergency manager expects significant impacts but the freezing rain criteria is not necessarily met.
- **Blizzard Warning**—A Blizzard Warning is issued when there is a high probability that blizzard conditions (sustained wind speeds or gust of at least 35 mph and visibility reduced to less than 1/4 mile for at least 3 hours) will exist within the next 36 hours.

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, the State was included in five disaster (DR) or emergency (EM) declarations for winter weather-related events. Generally, these disasters cover a wide region of the state; therefore, they can impact many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2023).

Table 5.16-3. Winter Storm Events in the State (1993 to 2022)

Date(s) of Event	Incident	Federal Designation	Counties Affected
March 13-17, 1993	Severe Snowfall and Winter Storm	EM-3109-WV	Statewide
January 6-12, 1996	Blizzard	DR-1084-WV	Statewide
December 18-20, 2009	Severe Winter Storm and Snowstorm	DR-1881-WV	Boone, Calhoun, Clay, Fayette, Greenbrier, Jefferson, Kanawha, McDowell, Mercer, Mingo, Nicholas, Pendleton, Pocahontas, Raleigh, Randolph, Ritchie, Roane, Wyoming
February 5-11, 2010	Severe Winter Storms and Snowstorms	DR-1903-WV	Berkeley, Brooke, Doddridge, Grant, Hampshire, Hancock, Hardy, Jefferson, Merion, Marshall, Mineral, Monongalia, Morgan, Ohio, Pocahontas, Preston, Ritchie, Tucker, Tyler, Wetzel
March 3-14, 2015	Severe Winter Storm, Flooding, Landslides, and Mudslides	DR-4210-WV	Barbour, Boone, Braxton, Cabell, Doddridge, Fayette, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Marshall, McDowell, Mercer, Mingo, Monongalia, Putnam, Raleigh, Ritchie, Roane, Summers, Tucker, Tyler, Upshur, Wayne, Webster, Wetzel, Wirt, Wood, Wyoming

Date(s) of Event	Incident	Federal Designation	Counties Affected
February 10-16, 2021	Severe Winter Storms	DR-4603-WV	Cabell, Lincoln, Mason, Putnam, Wayne

Source: FEMA 2023

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, the State was not included in any agricultural disaster declarations pertaining to winter weather (USDA 2023).

Previous Events

For this 2023 SHMP, winter weather events were summarized between January 1, 2018, and December 31, 2022. Table 5.16-4 includes details of winter weather events that occurred in the state between 2018 and 2022. Major events include those that resulted in losses or fatalities, as reported by the NOAA NCEI, events that led to a FEMA disaster declaration, and/or event that led to a USDA declaration. Due to over 900 events having been recorded between 2018 and 2022, the following criteria was used to narrow the events shown in Table 5.16-4:

- Events searched for in the NOAA NCEI Storm Events Database included blizzard, heavy snow, ice storm, sleet, winter storm, and winter weather
- Episode narratives are used for the event description
- Event narratives are not included in the event description
- Events with no property and/or crop damages are not included in Table 5.16-4
- Events with a fatality are included in Table 5.16-4

Table 5.16-4. Winter Weather Events in West Virginia, 2018 to 2022

Date(s) of Event	Event Type	FEMA/USDA Declaration	Counties Affected	Description
January 16-17, 2018	Winter Weather, Heavy Snow	N/A	Barbour, Berkeley, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Grant, Hampshire, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Mason, McDowell, Mineral, Mingo, Morgan, Nicholas, Pendleton, Pleasants, Pocahontas, Putnam, Raleigh, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Webster, Wirt, Wood, Wyoming	A weather system crossed the middle Ohio River Valley Appalachians on the morning of the 16th. Light snow b midnight, and picked up toward sunrise as colder air su moderate to heavy snowfall along and just south of I-6 Charleston; this area received 4 to 6 inches of snow. Ca Kanawha Counties received 4.5 to 5.5 inches of snow. J snow started, roads quickly deteriorated, leading to mu vehicle accident on I-64 in Cabell County near Milton re 19-year-old woman. Outside of the heavier snow, a per moderate snow fell from the pre-dawn through late aft with generally two to four inches across the lowlands a across the mountains. No monetary damages were incu
March 8-9, 2018	Winter Weather, Heavy Snow	N/A	Grant, Mineral, Pendleton, Preston, Randolph, Tucker	Snowfall began during the afternoon of the 8th. In gene moving systems that produced brief visibility less than coating of snow. One heavier system played a role in 1 northbound lanes of I-77 near Beckley. The interstate w hours. Travelers on the interstate stated that visibility the road had a light coating of snow. Seven injuries wer of the accident. $500,000 in property damages were in
March 20-22, 2018	Winter Weather, Winter Storm, Heavy Snow	N/A	Barbour, Berkeley, Braxton, Clay, Fayette, Grant, Greenbrier, Hampshire, Hardy, Harrison, Mercer, Mineral, Monroe, Morgan, Nicholas, Pocahontas, Raleigh, Randolph, Summers, Upshur, Webster	Rain changed to a wintry mix on the 20th. There was e period of heavier snow around midday. A light wintry m of the 20th. On the 21st, a round of heavier precipitatio form of snow. The snow tapered off later in the day as the north and east. $58,000 in property damages were event.
November 14-16, 2018	Winter Weather, Winter	N/A	Berkeley, Brooke, Fayette, Grant, Greenbrier, Hampshire, Hancock, Hardy, Jefferson, Marshall, Mercer,	Warm and moist air entered the region the night of No morning of November 15th. This warm and moist air re across the area but falling through a shallow layer of be above and at ground level, and onto surfaces also belov

Date(s) of Event	Event Type	FEMA/USDA Declaration	Counties Affected	Description
	Storm, Ice Storm		Mineral, Monongalia, Monroe, Pendleton, Pocahontas, Preston, Raleigh, Randolph, Summers, Tucker	was a freezing rain event that deposited up to one-qua trees, power lines, and roads. At least 12,000 customer because of the ice. Widespread precipitation was broug including heavy snow and mixed precipitation. Four to was measured north of I-80 and in the higher elevation inches of snow happened elsewhere. $105,000 in prop incurred from this event.
December 11, 2019	Winter Weather	N/A	Mercer	A weather system passing over West Virginia produced turned to snow as temperatures dropped, with accumu one inch in spots around Mercer County. With the cold water on the roads froze and created hazardous road c conditions caused a school bus to slide down a road an building. $6,000 in property damages were incurred fro
December 13, 2019	Winter Weather	N/A	Berkeley, Braxton, Grant, Hampshire, Hardy, Jefferson, Lewis, Marion, Mineral, Morgan, Pendleton, Preston, Tucker, Upshur	A period of freezing rain occurred on the morning of th amounts ranged from a trace to about a tenth of an inc central West Virginia. Light icing caused multiple accide Braxton and Lewis Counties. The interstate was closed crews worked to clean up the crashes and treat the roa to the hospital following one of the accidents in Braxto County, there were 13 separate weather-related accide property damages were incurred from this event.
December 16-17, 2019	Winter Weather, Ice Storm	N/A	Berkeley, Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan	A period of snow occurred on the morning of the 16th. the area and caused the snow to change to rain with po on the 16th into the morning of the 17th. Ice amounts around a quarter to a half inch across western Mineral were reported down across roads over western Minera accretion. $15,000 in property damages were incurred
February 10-12, 2021	Severe Winter Storms	DR-4603-WV	Berkeley, Boone, Braxton, Cabell, Clay, Grant, Hampshire, Hardy, Harrison, Jackson, Jefferson, Kanawha, Lewis, Lincoln, Logan, Marion, Mason, McDowell, Mineral, Mingo, Monongalia, Morgan, Ohio,	Winter precipitation crossed the area on February 10th snowfall accumulations. Snowfall totals of 3 to 6 inches north and east of Charleston, with six inches being repo northeast of Rock Cave. Ice accumulations greater than were observed throughout the southern portions of th inches of ice from freezing rain reported 2 miles south Virginia. This resulted in significant tree damage across with more than 45,000 customers in West Virginia losin

Date(s) of Event	Event Type	FEMA/USDA Declaration	Counties Affected	Description
			Pendleton, Pocahontas, Preston, Putnam, Raleigh, Ritchie, Roane, Taylor, Tucker, Upshur, Wayne, Wetzel, Wirt, Wood, Wyoming	Huntington airport was shut down for a time on the 11 runways and a power outage. The westbound lanes of during the morning commute on the 11th due to a trac roadway near Nitro. $66,000 in property damages were event.
February 15-16, 2021	Severe Winter Storms	DR-4603-WV	Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Marion, Marshall, Mason, Mineral, Mingo, Monongalia, Nicholas, Ohio, Pleasants, Putnam, Raleigh, Ritchie, Roane, Tyler, Wayne, Wetzel, Wirt, Wood	On the afternoon of the 15th, freezing rain was observ Charleston metro area and the western borders of the outages around the Huntington area and other portion Virginia were reported in response to ice laying along a down power lines, which would continue to take a toll winter storm arrived only three days later. With trees a along the roadways, many ambulances were unable to injured patients. $189,000 in property damages were i
February 17-18, 2021	Winter Weather, Winter Storm, Heavy Snow	N/A	Barbour, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Harrison, Jackson, Kanawha, Lewis Wirt, Lincoln, Logan, Mason, McDowell , Mingo, Nicholas, Pocahontas, Putnam, Raleigh, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Wyoming	A winter storm impacted West Virginia with snow and February 17th through the 18th. Between 3 and 6 inch Central and Northern West Virginia, with the highest a the Sutton Lake area of Braxton County. Freezing rain f southeastern West Virginia and down into Virginia and weather pattern hindered efforts to restore power acr previous winter storms and caused hazardous travel co region. The snow accumulating on top of ice from prev additional tree damage and power outages. According the weight of the snow and ice from these storms caus onto wires and transmission towers to buckle. An estim poles needed to be replaced, and roughly 2,400 spans put back up. $61,000 in property damages were incurr
January 2-4, 2022	Winter Weather	N/A	Barbour	A quick-moving system brought a dusting of snow duri of January 2nd-3rd. Colder air filtered into the area, wh overnight on the 3rd and into the morning of January 4 hazardous conditions due to black ice and caused seve $15,000 in property damages were incurred from this e

Date(s) of Event	Event Type	FEMA/USDA Declaration	Counties Affected	Description
January 6-7, 2022	Winter Weather, Heavy Snow	N/A	Barbour, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Mason, McDowell, Mingo, Nicholas, Pleasants, Pocahontas, Putnam, Raleigh, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Webster, Wirt, Wood, Wyoming	A system crossed into the area on January 6th, resultin throughout the afternoon and evening hours. Snowfall 12 inches around the Charleston metro area and up to the mountains and adjacent foothills. Snow began to fa afternoon with 1 to 2 inches per hour snowfall rates. A West Virginia observed longer than normal travel times due to slick spots and vehicle accidents. Overnight free light lake-effect snow showers also resulted in a slow n the 7th. Between 6 and 12 inches of snow covered mos I-64 in northeast Kentucky northeastward across a larg Virginia. $10,000 in property damages were incurred fr
December 15, 2022	Winter Weather, Ice Storm	N/A	Greenbrier, Preston, Tucker	The combination of sleet and freezing rain resulted in s I-64 near the border with Virginia, the White Sulphur Sp bound minivan collided with a WVDOH work truck betw and 181. The accident led to the closure of both westbo $75,000 in property damages were incurred from this e
December 22, 2022	Winter Weather	N/A	Braxton, Fayette, Gilmer, Nicholas, Pocahontas, Raleigh, Randolph, Webster	A system entered the area during the morning hours of temperatures that were in place at the time of precipit precipitation across northern West Virginia and along t Freezing rain was observed just after midnight on the 2 black ice leading to slippery spots in time for the morni vehicle crashes in Raleigh, Fayette, and Gilmer Countie icy roadways. $10,000 in property damages were incur

Source: FEMA 2023; NOAA NCEI 2023
Notes:
DR Federal Disaster Declaration
EM Emergency Management
EMA Emergency Management Agency
FEMA Federal Emergency Management Agency
NCEI National Centers for Environmental Information
NOAA National Oceanic Atmospheric Administration
N/A Not applicable/not available

PROBABILITY OF FUTURE HAZARD EVENTS

Overall Probability

According to FEMA's list of disaster declarations, the USDA's list of disaster declarations, the NOAA NCEI Storm Events Database, and the 2018 SHMP, the State experienced over 900 winter weather events between 1950 and 2022, as summarized in Table 5.16-5.

Table 5.16-5. Probability of Future Winter Weather Events in West Virginia

Hazard Type	Number of Occurrences Between 1950 and 2022	Percent Chance of Occurrence in Any Given Year
Blizzard	9	12.5%
Heavy Snow	247	100%
Ice Storm	50	100%
Sleet	0	0%
Winter Storm	216	100%
Winter Weather	417	100%
Total	**939**	**100%**

Source: NOAA NCEI 2023

Projected Future Conditions

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 (NOAA 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 (U.S. Global Change Research Program 2018). If current projections remain, the State can expect more frequent and intense winter weather events.

5.16.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For severe winter weather, the entirety of West Virginia has been identified as the hazard area. Therefore, all assets in the state (population, structures, critical facilities, and lifelines), as described in the State Profile, are vulnerable. The impacts on population, existing structures, critical facilities, and the economy are presented below.

STATE ASSETS

For the purposes of this risk assessment, an asset is considered potentially vulnerable if it is in an identified hazard area. As stated previously, for the winter weather hazard the entire area of the State is the hazard area. Therefore, a total of 1,117 state facilities are vulnerable to winter weather. The total replacement cost value for all 1,117 facilities is $6,103,990,956. Kanawha County has the most facilities (200) while Monongalia County has the highest total RCV ($1,605,027,842) of state facilities in comparison to all the counties in the state. See Section 2 (State Profile) for tables identifying the numbers and replacement cost value of state facilities in each county.

All State roads are also vulnerable to the winter weather hazards. Snow and ice can fully cover roads for extended periods of time, resulting in closures and cutting off critical access to communities. In addition, freezing, melting, and refreezing of the roads can create potholes and degrade the quality of the roads. See Section 2 (State Profile) for tables identifying the miles of roadway in each county.

Critical Facilities and Community Lifelines

Transportation routes are vulnerable to winter weather and have the potential to be inaccessible, creating isolation issues. This includes all roads and bridges affected by winter weather. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand refreezing. Utility infrastructure is also vulnerable; interruption of services may not only impact vulnerable populations but may also impact 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 winter storm event. These critical facility structures are largely constructed of concrete and masonry; therefore, these should undergo only minimal structural damage from severe winter weather events.

In total, there are 185 critical facilities that may be impacted by winter weather, with Kanawha County having the greatest number of critical facilities (75). The total replacement cost value of all the critical facilities that have the potential to be impacted by winter weather is $658,480,508. See Section 2 (State Profile) for tables identifying the numbers of critical facilities and their replacement cost value in each county.

Population

For the purpose of this SHMP, the entire population of the State (1,807,426) 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. Kanawha County has a population of 181,014, which makes it the most populous county in the state and extremely vulnerable to severe winter weather. This analysis does not include the number of tourists and visitors in the state; therefore, this estimate may be underestimating exposure and vulnerability. Section 2 (State Profile) identifies the population of each county vulnerable to the winter weather hazard.

Impacts on Socially Vulnerable Populations

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, 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 (e.g., homes with poor insulation and heating supply). 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. Current loss estimation models such as Hazus are not equipped to measure public health impacts. The best preparation for these effects includes awareness that they can occur, education of the public on prevention, and planning to deal with them during responses to winter weather events.

Future Changes That May Impact State Vulnerability

Understanding factors of change that impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The state considered the following factors to examine conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of future conditions

Potential or Projected Development

Although West Virginia has not experienced significant growth, any areas of growth could be impacted by the severe winter weather hazard because the entire state is exposed and vulnerable. However, due to increased standards and codes, new development may be less vulnerable to the hazard, while aging infrastructure will become increasingly vulnerable.

Projected Changes in Population

West Virginia is losing population faster than recent forecasts, which do not account for county-by-county increases. According to population projections in 2022 from the West Virginia University (WVU) Bureau of Business and Economic Research, West Virginia's population was projected to fall from 1,793,716 in 2020 to 1,705,509 in 2040 (West Virginia University 2022). As of July 1, 2019, according to estimates by the U.S. Census Bureau, West Virginia's total population is 1,792,147, representing a 3.3 percent decline since 2010 (approximately 60,487 fewer residents). West Virginia lost population both naturally, with 19,000 more deaths than births, and through migration, with 27,000 more people leaving the state than moving in (WVDOT 2020). Refer to Section 2 (County Profile), which includes a discussion on population trends for the county.

The overall anticipated decrease in population for West Virginia will potentially lower the threat of the winter weather hazard and its impact on life, but it will not eliminate the hazard. As the population leaves the state, the buildings and structures once resided in will remain standing, leaving the structural risk to the winter weather hazard the same as before. The groups most vulnerable to the hazard will remain the same, as will the geographic and topographic areas most vulnerable.

Other Factors of Change

The impacts of future conditions to the state have the potential to increase the probability of winter weather events as discussed in the Probability of Future Hazard Events section above. Overall projected temperature increases will lead 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 (U.S. Global Change Research Program 2018).

5.16.3 Consequence Analysis

Impacts to the Public

According to the NOAA National Severe Storms Laboratory (NSSL), winter weather indirectly kills hundreds of people in the United States every year, primarily from automobile accidents, overexertion, and exposure. Winter storms are often accompanied by strong winds that may create blizzard-like conditions, drifting snow, extreme cold temperatures, and dangerous wind chills. Winter weather is considered to be deceptive because most deaths and other impacts or losses are indirectly related to the storms, as it is the temperature that can lead to hypothermia and frostbite, which require immediate medical attention. People can die in traffic accidents on icy roads, heart attacks while shoveling snow, or hypothermia from prolonged exposure to cold; however, vehicular accidents account for most of the injuries and deaths related to heavy snow (NSSL 2023). The mountainous terrain of West Virginia results in some areas of steep roadways, which can make it more difficult for the population to safely shovel or travel on snow-covered roads; bridges and overpasses are particularly dangerous because they freeze before other surfaces.

In addition, heavy accumulations of ice and snow can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. This endangers those that may need assistance evacuating, as well as those that need to call for help when injured. Even small accumulations of ice and snow may call for shutting down air and rail transportation which could disrupt medical and emergency services as well as the transportation of emergency supplies, endangering those that are in need of help even more (NWS 2019).

Impacts to Responders

In the aftermath of a winter weather event, workers may be involved in a variety of response and recovery operations. Emergency response to floods may several first response organizations, ranging from local police, fire and EMS departments, and public service workers. Assessments must be done to determine the current needs of the situation, including evacuation, plowing snow, salting or brining roads, search and rescue operations, distribution of resources, relocation of displaced individuals, firefighting, and utility repairs. In addition to the risks of responding to a winter weather event, emergency responders can be exposed to cold-related illnesses and injuries from winter weather, including chilblains, frostbite, trench foot, and hypothermia.

Heavy snow can immobilize a region and paralyze a city, shutting down air and rail transportation, stopping flow of supplies, and disrupting medical and emergency services. Accumulations of snow and ice can collapse buildings and knock down trees, communication, and power lines, making it difficult for responders to be able to pinpoint those who need assistance and where they may be. In rural areas, homes and farms may be isolated for days due to snow and ice accumulations making roads impassable. In the mountains, heavy snow and snow drifts may hinder the delivery of emergency services and endanger the responders.

Impacts to Continuity of Operations

Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice have the ability to be life-threatening and can inhibit transportation of goods and services. Heavy snow and ice may collapse, old, yet relied upon infrastructure which can inhibit continuity of operations for businesses. Excessive amounts of snow impact airports and roadways, sometimes even closing them completely, stopping the flow of international and national supplies.

Impacts to Property, Facilities, and Infrastructure

All facilities in West Virginia are exposed and vulnerable to the winter storm hazard. High snow accumulation may make infrastructure vulnerable to structure 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).

Winter weather can also impact and damage utilities and above-ground wires and towers by freezing infrastructure, falling tree limbs, and weighing down above-ground infrastructure. Loss of power can also impact potable water and wastewater treatment facilities.

Impacts to the Environment

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 (Columbia Climate School 2018).

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).

Impacts to the Economic Condition of the State

Potential economic impacts include loss of agriculture, business, and tourism (though tourism could also be *increased* due to winter weather events, particularly at the State's ski resorts and other snow-dependent activities). 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 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. Potential secondary impacts from winter storms also impact the local economy, including the interruption of transportation corridors and loss of business function for the duration of the event. Finally, extensive damage to forests can affect timber values and create flammable woody debris, exacerbating wildfire vulnerability.

Impacts to Public Confidence in State Governance

The public confidence in state governance would primarily depend on how effective the State has been preparing for and responding to winter events. Public confidence also depends on the size of the event and the preparation the State takes for each event. In general, if the State is transparent in sharing relevant information with the public, then the public is more apt to trust the State and feel as if it has the capability to support the residents of West Virginia if a winter weather event occurs. The State also demonstrates its reliability to the public through availability of programs and services relevant to winter weather assistance (Chew, et al. 2021).