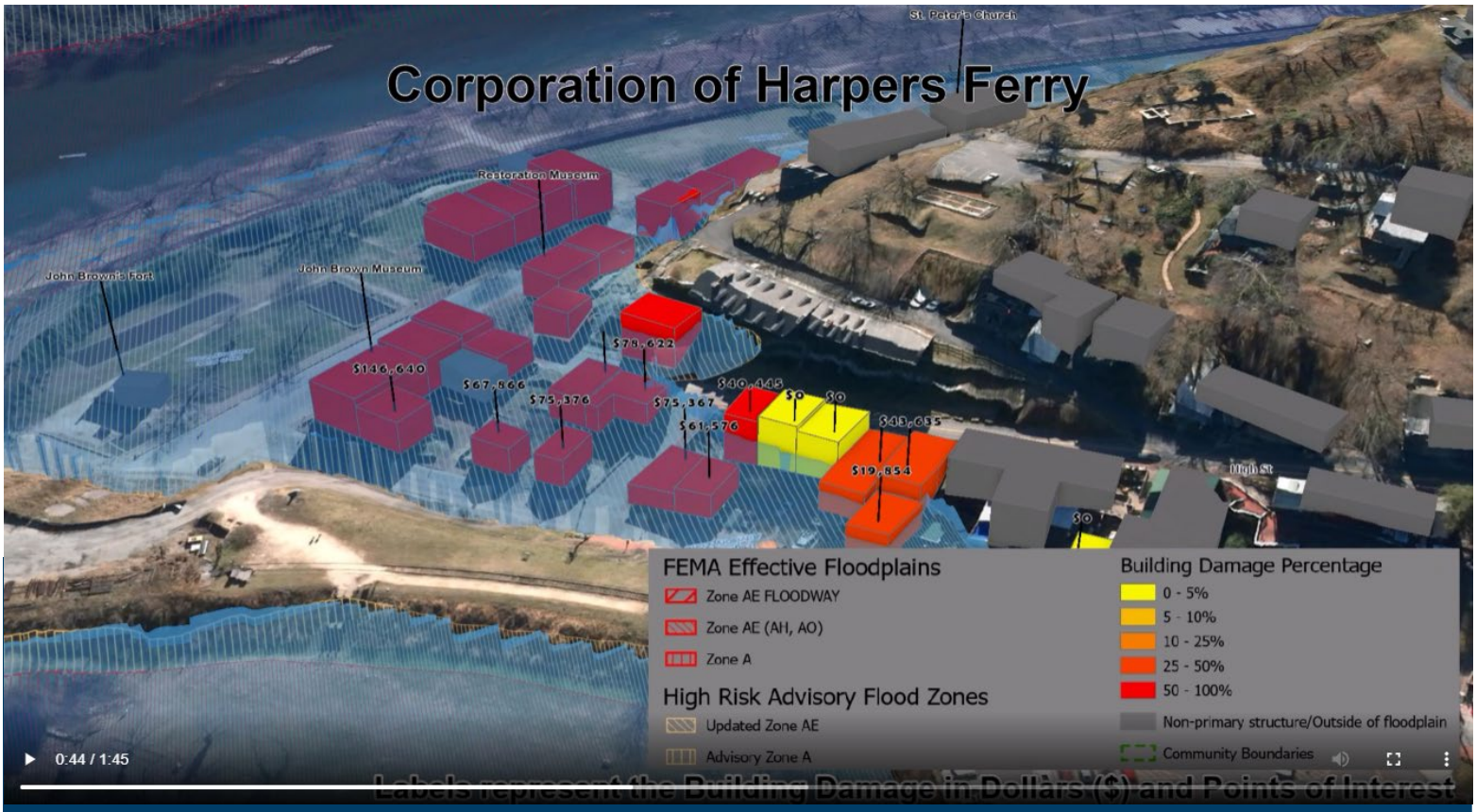

WV Risk Explorer

Localized Risk Assessment Tools for Analysis and Visualization

TECHNICAL DOCUMENTATION

August 2024

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D-R-A-F-T

Technical Documentation for WV Flood Risk Explorer – 8/16//2024

Contents

INTRODUCTION

The **WV Flood Risk Explorer** is a suite of flood risk assessment, visualization, and mitigation tracking tools known as the WV Flood Resiliency Framework for empowering communities and agencies across the state with the knowledge they need to better prepare for future floods. This online application is an interactive tool that shows which communities in West Virginia are most at risk from riverine flooding. These localized risk assessment tools for analysis and visualization reveal flood characteristics, physical / human vulnerabilities, and mitigation measures, all available at eight geographic levels. Benefits of using The WV Flood Risk Explore include support for mitigation planning, hazard mitigation assistance, and risk communication, ultimately ensuring that limited resources are channeled effectively for flood reduction efforts.

8 Aggregate Levels or Geographic Scales. Many of the risk assessment data sets are generated at the building or property level and then aggregated at higher scales. Depending on the purpose and scales of analysis, users can explore property flood risk data at multiple aggregate or geographic scale levels: validating floodplain management practices at the incorporated/unincorporated scales; identifying mitigation actions at the community level, hazard mitigation planning at the county or regional scales, resiliency planning at the statewide scale, initial Risk MAP discovery phase at the watershed scale, or loss of property and life at the river/stream scale. Because certain risk indicators of the Communities scale follow a bimodal distribution, the 284 Communities are subdivided into 55 Unincorporated Areas and 229 Incorporated Places for more detailed analysis of scales. Of the 284 unincorporated/incorporated communities in West Virginia, 266 or 94% of these communities have mapped Special Flood Hazard Areas (SFHA) or high-risk floodplains.

8 Aggregate or Geographic Scale Levels

- Statewide
- 11 Regional Councils
- 55 Counties
- 284 Communities
- 55 Unincorporated Areas
- 229 Incorporated Places
- 33 Watersheds
- 156 Named Streams (Top 2%)

FLOOD RISK ASSESSMENT METHODLOGY

West Virginia is unique in that it maintains a detailed inventory of nearly 98,000 primary structures in the high-risk flood zones of the state. Building-level risk assessments (BLRA) for each structure to include building dollar exposure and damage loss estimates are displayed for each structure on the WV Flood Tool's RiskMAP View.

While the **WV Flood Tool** shows flood characteristics, exposure, vulnerability, loss estimates, and mitigation measures at the property level, the **WV Flood Risk Explorer** aggregates hazard data to indicate the communities most at risk of riverine flooding. The WV Flood Risk Explorer quantifies flood risk by various indicators that are grouped into the following categories: floodplain characteristics, building exposure, building characteristics, critical infrastructure, community assets, damage estimates, people / social factors, and other hazards. The cumulative risk assessment includes damage loss and population displacement models computed from FEMA's Hazus methodology. Also incorporated in the risk assessment is a social vulnerability index, developed for West Virginia based on eight socioeconomic and demographic indicators. Most of the flood risk indicators are measured for a major storm like the 1% annual chance (100-yr) flood event.

Indicator Rankings and Flags. There are 27 primary flood risk flood risk indicators from the incorporated place to regional geographic scale, and eight indicators for the watershed and stream scales. Using the inclusive percent ranking function, flood indicator rankings are computed for each flood risk variable and for every geographic level. Percentile ranking values range from 0 to 1, with the higher values indicating greater vulnerability. During the percent ranking calculations, the incorporated place and watershed scales with less than 10 and 100 buildings, respectively, are excluded from any ratio calculations. For each geographic scale, the percentiles of each risk variable are then summed and an overall percentile ranking computed for each of the eight geographic scales. Flags of each indicator variable are calculated for the top 10% (90^{th} percentile) and top 20% (80^{th} percentile) of each geographic level to support different scales of analysis.

Data Dictionaries and Export Function. Data dictionaries describe the contents, format, and structure of the databases for the Risk Indicators and Supplemental Assessment Information. All general and flood risk data sets can be downloaded to a spreadsheet file using the Export Data function. Access and view the Data Dictionaries in Excel format at the WV Risk Explorer website.

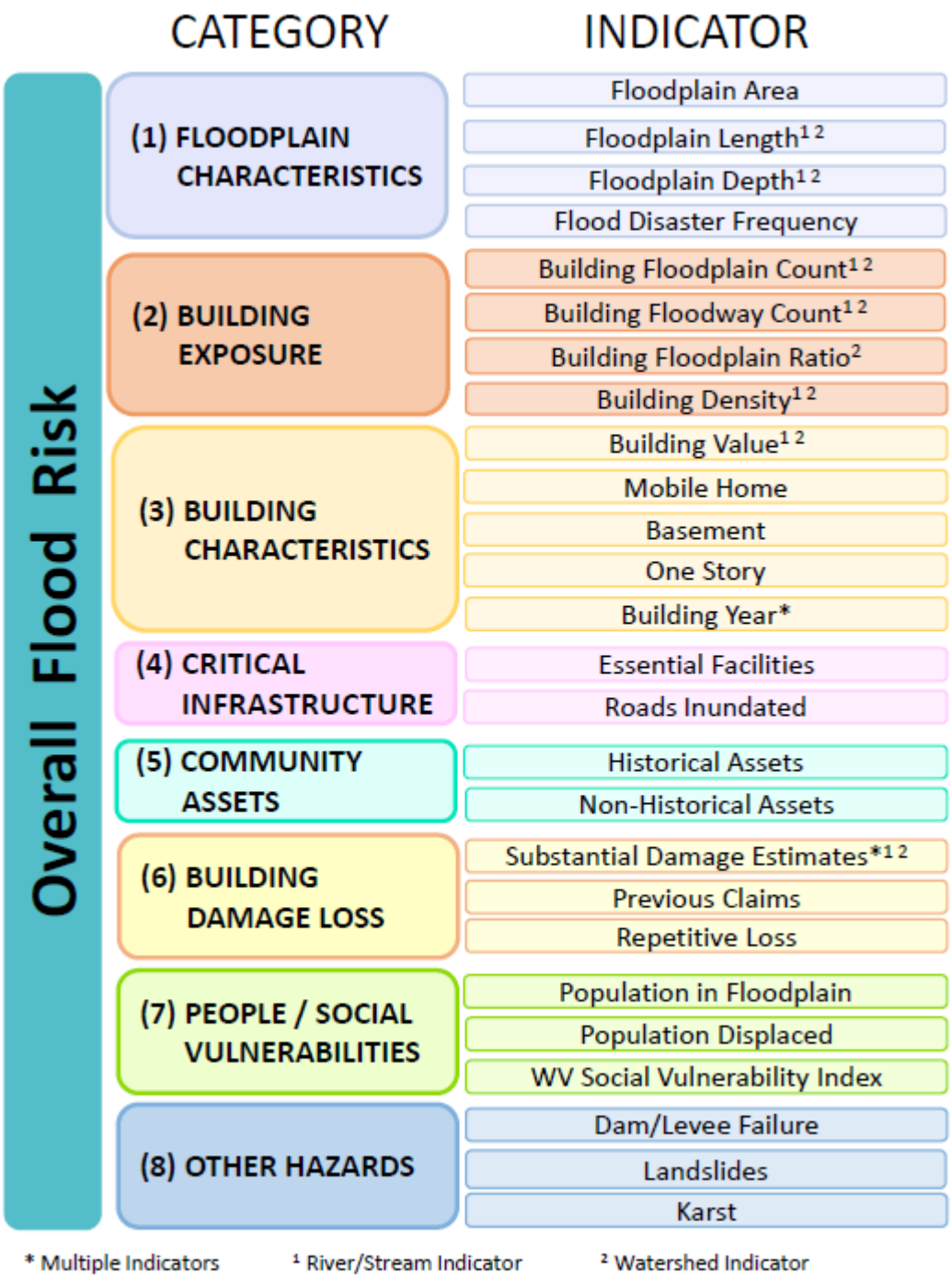
Risk Assessment Reports. Various web reports are generated for each geographic scale. Pre-defined report types are as follows.

- Single Geographic Entity (all scales)
  - High Risk Indicator Report – Only the Top 20% Risk Indicators shown.
  - All Risk Indicators Report – All Risk Indicators
  - Full Risk Assessment Report – All Risk Indicators and Supplemental Information
  - Building-Level Report (Top Building Rankings – Value, Depth, Damage, Minus-Rated)

- Comparison Risk Indicator Report (all scales). Compares selected geographic unit with highest to lowest risk communities.

Shared URL Links. Shared links allow users to share web reports by geographic scale and report type. Web reports include hyperlinks to additional floor risk information. The syntax of the shared URL link must contain the (1) report type, (2) geographic feature identifier (CID, FIPS, HUC8, or Stream Name), and (3) scale level (M-Munipalities/Incorporated Place, U-Unincorporated Area, CID-Community, C-County, R-Regional Council, ST-WV-State, W-Watershed, S-Stream/River.

Figure 1. Flood Risk Assessment Categories and Risk Indicators.



FLOOD RISK CATEGORIES AND INDICATORS

FLOODPLAIN CHARACTERISTICS. Flood risk indicators of the **floodplain characteristics** category measure the area, length, and depth of high-risk flood zones. This category also includes the frequency of declared flood disasters since 1953 to measure flood risk.

- **Floodplain Area:** Total acreage of Special Flood Hazard Area (used for unincorporated place and larger scales); or ratio of Special Flood Hazard Area to total geographic scale area (used for incorporated place scale).
- **Floodplain Length:** Total length in miles of Special Flood Hazard Area (used for unincorporated place and larger scales); or ratio of Special Flood Hazard Area to total community area (used for incorporated place scale).
- **Median Flood Depth:** Median value of flood depths of all primary structures inventoried in the high-risk flood zones.
- **Flood Disaster Frequency:** Number of-declared flood disasters in a county since 1953.

BUILDING EXPOSURE. The category **building exposure** counts primary structures in the high-risk Special Flood Hazard Area and Regulatory Floodway. It also identifies building densities by the ratios of buildings in high-risk flood areas to total buildings or to specific geographic areas. All buildings inventoried in the high-risk flood zones, or 1% annual chance (100-yr) floodplain, are verified as primary structures using various reference data sets: tax parcel assessments, E-911 addresses, aerial imagery, building pictures, elevation certificates, etc. Building counts of less than 10 structures are excluded from risk assessments at the incorporated place scale.

- **Building Floodplain Count:** Building count in Special Flood Hazard Area.
- **Building Floodway Count:** Building count in Regulatory Floodway.
- **Building Floodplain Ratio:** Percentage of floodplain buildings to total buildings.
- **Building Density:** Density of buildings in high-risk flood areas to total floodplain acres (or building per mile for rivers/streams).

BUILDING CHARACTERISTICS. This group of risk indicators is associated with **building characteristics**, such as the median appraisal dollar value of all primary structures in high-risk floodplains susceptible to flooding. Additionally, this category includes building property factors more vulnerable to flood risk, like the percentages of floodplain buildings that are manufactured homes, one-story structures, PRE-FIRM structures, or have subgrade basements. Although building stock type and value properties are primarily determined from tax assessment data (building value, occupancy class, foundation type, story, building year, and area), the Building-Level Risk Assessment (BLRA) database allows for the default tax assessment data values to be replaced with more accurate user-defined values from other data sources. The building year and date of the initial Flood Insurance Rate Map (FIRM) identifies the Pre- or Post-FIRM status of structures. The last risk factor of this category is minus-rated POST-FIRM structures, a percentage of structures that may not have been mitigated properly according to local floodplain management ordinances. Note that all the detailed building attributes of this category are collected for all primary structures in the Special Flood Hazard Area, or 1% annual chance (100-yr) floodplain.

- **Building Value:** Median of appraised values from the most recent tax assessment data or other building value data sources for tax-exempt structures.
- **Mobile Home Ratio:** Percentage of manufactured buildings (occupancy code RES2) among all single-family structures (RES1 and RES2).
- **Subgrade Basement Ratio:** Percentage of primary structures with subgrade basements. A basement is any portion of a structure that has a subgrade floor (below ground level) on all sides.
- **One-Story Building Ratio:** Percentage of one-story structures.
- **Pre-FIRM Building Ratio:** Percentage of Pre-FIRM buildings.
- **Post-FIRM Building Ratio:** Percentage of minus rated Post-FIRM buildings.

CRITICAL INFRASTRUCTURE. The **critical infrastructure** category includes risk indicators for essential facilities and roadways, both community lifelines that enable the continuous operations of critical business and government functions during and after a disaster.

- **Essential Facilities:** Number of essential facilities in the in the high, moderate, and reduced risk flood zones. Providing critical services to the community, essential facilities include police and fire stations, E-911 emergency operations centers, schools, hospitals, and nursing homes.
- **Roads Inundated Ratio:** Percentage of roads inundated by flood waters of 1 foot or more by a major 1% annual chance (100-yr) flood event.

COMMUNITY ASSETS. Community assets are historical structures listed on the National Register of Historic Places, government facilities (federal, state, local), emergency medical services (EMS), religious organizations, utilities, postsecondary educational facilities, or other buildings of significance that contribute to the built environment of a community. The **community assets** category is comprised of historical and non-historical assets in the Special Flood Hazard Area, or 100-yr floodplain.

- **Historical Assets:** Number of historical community assets listed on the National Register of Historic Places, the official list of the Nation's historic places worthy of preservation, and includes buildings identified within National Register Areas constructed before 1930.
- **Non-Historical Assets:** Number of non-historical community assets including utilities (water, sewage, gas, electric, or phone), post-secondary educational facilities, emergency medical services (EMS), government buildings providing public services, and facilities hosting religious services.

DAMAGE ESTIMATES. This category of risk indicators measures building damage by estimation models and recorded flood insurance claims. Substantially damaged building risk indicators estimate the number and ratio of primary structures where the damage exceeds 50% of the building value. Damage loss estimates are calculated using FEMA's Hazus methodology and the best available depth grids for a 1% annual chance event. Other risk indicators of the **damage estimates** category are FEMA data sets that include previous NFIP flood claims and repetitive loss structures.

- **Substantial Damage Count:** Estimated number of primary structures substantially damaged from a 1% annual chance (100-yr) flood.

- **Substantial Damage Ratio:** Percentage of substantially damaged structures (damaged equal to or greater than 50% of the building value) to total floodplain structures.
- **Previous Damage Claims:** Number of previous flood-related insurance claims for a geographic unit since 1978.
- **Repetitive Loss Structures:** Number of NFIP-insured structures that have had at least 2 paid flood losses of more than $1,000 each in any 10-year period since 1978.

PEOPLE / SOCIAL. This group of risk indicators measures various **people and social** vulnerabilities. Population in the floodplain is computed at the building level by identifying the type of residential building (single family, apartment, et.) and corresponding number of units, then multiplied by the average household size from community-level Census statistics. Population displacement is calculated for those residential structures where the flood depth exceeds 1 foot. Additionally, short-term shelter needs for up to three weeks are computed using FEMA's Hazus methodology, in which the above-mentioned displaced population is combined with Census income and age data to generate the shelter model estimates.

Population risk indicators calculate the population percentage residing in the high-risk flood zones and population percentage displaced by a 1% annual chance flood event. A WV Social Vulnerability Index (SVI) of eight socioeconomic and demographic indicators measures a population's vulnerability to flood hazard. The select SVI indicators are economic factors (Poverty Rate, Unemployment Rate), population characteristics (Vulnerable Ages Rate, Disability Rate, Population without a High School Education, Population Change), and housing (Median Housing Unit Value, Mobile Homes as Percentage of Housing).

- **Population in Floodplain:** Percentage of population residing in the high-risk Special Flood Hazard Area to total population.
- **Population Displaced:** Estimated percentage of population displaced by a major flood of a 1% annual chance (100-yr) probability, causing inundation of equal to or greater than 1 foot.
- **WV Social Vulnerability Index:** Social vulnerability index developed for West Virginia based on eight socioeconomic and demographic indicators.

RISK FACTORS: DESCRIPTION, RATIONALE, RECOMMENDATIONS, DATA SOURCES

Floodplain Area (Acres)

Acreage of Special Flood Hazard Area (SFHA), or 1%-annual-chance (100-yr) floodplain. Note that the following areas are excluded in the total acreage: Open water lakes > 10 acres; Large riverbank-to-bank > 500 ft.; Federal lands > 10 acres.

Rationale	Recommendations
For unincorporated areas and at the county level, it may be more challenging for communities larger in geographic size to enforce their floodplain management ordinance. Often larger jurisdictions have more acres and miles of floodplain extent than compared to smaller communities. In smaller communities, the floodplain area is compacted and thus new development in the floodplain should be easier to monitor than larger rural areas or countywide.	Larger jurisdictions must be vigilant in monitoring and permitting new development for an expansive geographic area that includes a large amount floodplain area and miles. Additionally, in rural areas, thick foliage and private drives may result in floodplain structures being harder to view or access.

Data Sources: FEMA FIRMs; Streams and Waterbodies (USGS NHD 24K), Public Lands (USGS PAD-US)

Floodplain Area Ratio (%)

Percentage of total community area that lies within the Special Flood Hazard Area (SFHA).

Rationale	Recommendations
At the community level, incorporated places with a higher ratio of floodplain area to community area face more significant challenges for development. Small towns in which a high percentage of their total incorporated land is in the Special Flood Hazard Area (SFHA) often have a higher flood exposure than other communities. Essential facilities and other significant structures that provide critical services to the community are often located in high-risk floodplains of smaller communities.	A high floodplain ratio indicates less available land for development outside the floodplain. Communities facing this situation should adopt higher standards for development within the floodplain. Additionally, they should consider implementing green infrastructure solutions, such as wetlands and permeable surfaces in vicinity of their communities, to manage flood risks effectively. Smaller jurisdictions must be vigilant in relocating critical facilities away from the floodplain along with enforcing its floodplain management ordinance for any development. Although expensive to build and maintain, engineering flood mitigation structures like levees, floodwalls, and dams protect vulnerable flood-prone communities.

Data Sources: FEMA FIRMs; Streams and Waterbodies (USGS NHD 24K), Public Lands (USGS PAD-US)
Note: Modified floodplain acreage. Floodplain acreage excluded if Open water lakes > 10 acres; Large riverbank-to-bank > 500 ft.; Federal lands > 10 acres.

Floodplain Length (Miles)

The total river/stream length in miles of high-risk 1%-annual-chance (100-year) floodplains. Same rationale and recommendations as *Floodplain Area* indicator.

Rationale	Recommendations
For unincorporated areas and at the county level, it may be more challenging for communities larger in geographic size to enforce their floodplain management ordinance. Often larger jurisdictions have more acres and miles of floodplain extent than compared to smaller communities. In smaller communities, the floodplain area is compacted and thus new development in the floodplain should be easier to monitor than larger rural areas or countywide.	Larger jurisdictions must be vigilant in monitoring and permitting new development for an expansive geographic area that includes a large amount floodplain area and miles.

Data Sources: FEMA FIRMs; Streams and Waterbodies (USGS NHD 24K), Public Lands (USGS PAD-US)
Notes: includes floodplain miles for both effective and advisory floodplains.

Floodplain Length Ratio (Miles/Acre)

Length of floodplain length in miles to total community area. Units are miles per acres. Same rationale and recommendations as *Floodplain Area Ratio* indicator.

Rationale	Recommendations
For unincorporated areas and at the county level, it may be more challenging for communities larger in geographic size to enforce their floodplain management ordinance. Often larger jurisdictions have more acres and miles of floodplain extent than compared to smaller communities. In smaller communities, the floodplain area is compacted and thus new development in the floodplain should be easier to monitor than larger rural areas or countywide.	Larger jurisdictions must be vigilant in monitoring and permitting new development for an expansive geographic area that includes a large amount floodplain area and miles.

Data Sources: FEMA FIRMs; Streams and Waterbodies (USGS NHD 24K), Public Lands (USGS PAD-US)
Notes: includes floodplain miles for both effective and advisory floodplains.

Flood Declared Disasters (#)

Number of-declared flood disasters in a county since 1953.

Rationale	Recommendations
Previous disasters and frequency indicate potential for future risk. In addition, the recentness of flood disasters has proven to increase communities' willingness to seek mitigation activities. The frequency of flooding and claim history are factors in determining a building's unique flood risk and associated premium. To reduce flood risk, many flood control structures (e.g., dams, levees, flood walls) built in the 20th Century have decreased the number of major flood disasters. Stream gauges and other warning systems have also been implemented to reduce flood risk. Non-structural mitigation measures of individual structures (buyout properties, mitigation reconstruction, elevated structures, relocated structures, dry and wet floodproofing, etc.) have occurred in high-risk flood zones as well.	A major disaster declaration provides a wide range of federal assistance programs for individuals and public infrastructure, including funds for both emergency and permanent work. Historical flooding including high water marks should be incorporated into communities' flood reduction efforts. In addition to high water marks, flood depths, repetitive loss structures, mitigated properties, substantial damage estimates, similar topography, etc. are variables to consider when creating Areas of Mitigation Interest (AoMI) for local communities. Natural hazard mitigation saves $6 on average for every $1 spent on federal mitigation grants, according to an analysis by the National Institute of Building Sciences. Flash flooding typically during the summer months is the leading cause of flood fatalities in West Virginia. It is recommended that risk emergency response planners, floodplain managers, and local officials study flood fatality locations and risk behaviors of past major flood events. Additionally, the structural and non-structural measures implemented since the major flood disaster should be evaluated.

Data Sources: FEMA's Disaster Declarations for States and Counties online database. Incident subcategories include "flood" or "severe storms" or "hurricanes".

Flood Depth Median (Feet)

Median value of base flood (100-yr) depths of all primary structures inventoried in the high-risk flood zones.

Rationale	Recommendations
The depth of floodwater around a structure is by far the most critical element to be considered in planning and designing flood proofing measures. The floodwater depth largely determines the strength and stability requirements for the structure as a whole and for individual structural elements below the design flood level. Source: USACE. A building's flood depth and distance from the flooding source determine a structure's unique flood risk and associated premium.	Mitigation measures such as elevation and wet floodproofing are not economically effective for very deep flood depths greater than 12 feet. Source USACE. Dry floodproofing is not recommended where the depth of water under base flood conditions is greater than 3 feet and base flood velocities exceed 5 feet per second. Source FEMA.

Data Sources: WV BLRA; FEMA model-backed depth grids; Hazus-generated depth grids.
Notes: In some cases, depth grid anomalies or map errors may result in high flood depths of select structures and thus should be validated.

Building Floodplain Count (#)

All primary insurable structures in the effective 100-year floodplain or Special Flood Hazard Area (SFHA).

Rationale	Recommendations
Higher Building Exposure and Damage Losses. The higher number of buildings in the floodplain indicates higher physical and human exposure to riverine flooding. More structures also correlate to higher debris totals and displaced people from a major storm. Mandatory Flood Insurance Requirement. If a building owner has a mortgage from a federally regulated lender and the property is in the Special Flood Hazard Area, then the building owner is required by Federal law to carry flood insurance. WV Floodprone Communities. Of the 284 unincorporated/incorporated communities in West Virginia, 266 or 94% of these communities have mapped Special Flood Hazard Areas (SFHA). CRS Programming Variable. The building count in the SFHA is a programming variable required for those communities participating in FEMA's Community Rating System (CRS) program.	Communities with a high floodplain building count should actively engage property owners about flood insurance and minimizing flood losses of property owners. See Floodsmart.gov for more information. Communities can become more resilient to flooding by exceeding the minimum NFIP requirements. Higher building standards adopted by local communities may include increasing the freeboard of the base flood elevation; or encourage property owners to build to the higher 500-year flood elevation or historical high-water mark. Floodplain managers and emergency planners should pre-load at-risk structures into substantial damage estimator software. Local officials should review early warning systems as well as short-term shelters located outside the floodplain and away from inundated roads. State and county leaders should prioritize pre-disaster planning for communities with many flood-prone buildings. Refer to FEMA and ASFPM mitigation strategies for steps to prepare for flooding and reducing risk. Use FEMA's Cost of Flooding tool to estimate the cost of flood damage from just a few inches of water. With flood insurance, property owners can recover faster and more fully. Natural hazard mitigation saves $6 on average for every $1 spent on federal mitigation grants, according to an analysis by the National Institute of Building Sciences.
Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA	

Building Floodway Count (#)

Primary structures located in the Regulatory Floodway of 100-year floodplain

Rationale	Recommendations
High flood velocities and deep flood depths increase the likelihood of physical damage and loss of life. Structures in the floodway require the purchase of mandatory flood insurance for federally-backed loans. Restricted development. Before a local permit can be issued for proposed development in the floodway, a "No-Rise/No Impact" certification must be submitted by a professional engineer licensed in West Virginia to ensure a proposed project won't increase flood levels.	Community floodplain management ordinances often recommend not constructing closed foundations or solid perimeter walls where flood velocities exceed 5 feet per second. Source: Kershaw County, SC. Nonstructural mitigation measures are not recommended either where high flood velocities exceed 6 feet per second or where debris impacts may occur. Source USACE. FEMA recommends open foundations (e.g., piers, posts, columns, pilings) for riverine SFHAs where flow velocities are expected to exceed 10 feet per second. Source FEMA.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA

Building Floodplain Ratio (%)

Percentage of floodplain buildings to total buildings.

Rationale	Recommendations
A higher ratio of buildings in the floodplain to total buildings signifies a greater physical and human exposure to flooding	See building count in SFHA.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA
Note: Building counts of less than 10 structures are excluded from risk assessments at the incorporated place scale.

Building Density (Buildings/Acre)

Density of buildings in high-risk flood areas to total floodplain acres (or building per mile for rivers/streams).

Rationale	Recommendations
A higher ratio of buildings in the floodplain to total floodplain are signifies a greater physical and human exposure to flooding	See building count in SFHA.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA
Note: Building counts of less than 10 structures are excluded from risk assessments at the incorporated place scale.

Building Median Value ($)

The median of appraised building values from the most recent tax assessment data or other building value data sources for tax-exempt structures in the high-risk floodplain.

Rationale	Recommendations
Median Building Value quantifies the financial risk of potential flood damage to residential and commercial properties. A higher total building value in floodplains can lead to increased insurance costs. So, it may encourage property owners to take proactive measures to protect their investments and reduce vulnerability. Building Replacement Cost Value. Buildings with higher costs to repair generally result in higher losses, resulting in higher premiums. In addition to building value, other building characteristic such as occupancy class, foundation type, first floor height, number of floors, construction type, flood openings, and elevated machinery and equipment affect flood insurance premiums and discounts.	Communities should plan to keep new development outside high-risk floodplains. Implementing stricter zoning laws and land use regulations can help prevent future construction in flood-prone areas, thereby mitigating flood risk. They should also consider acquisition and relocation projects, such as buying out properties, to reduce the building value in floodplains and decrease insurance and recovery costs. Flood insurance should be purchased to protect from damage loss and recover quickly. National Flood Insurance Program Risk Rating 2.0: Frequently Asked Questions Rate Explanation Guide Discount Explanation Guide Flood Insurance Mitigation Discount Tool

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA

Bldg. Mobile Homes Ratio (%)

Percentage of manufactured buildings (occupancy code RES2) among all single-family structures (RES1 and RES2) in the high-risk floodplain.

Rationale	Recommendations
Lightweight manufactured homes are not designed to withstand floods and are more vulnerable to flood damage. Communities with a higher prevalence of manufactured homes often encounter more obstacles in achieving resilience, as these structures typically do not offer the same level of security as traditionally constructed homes. Moreover, these homes are often situated in regions beyond the urban core, where access to major roadways and public transit systems may be limited. Building construction type (e.g., masonry building versus prefabricated trailer) is a factor in determining the building's unique flood risk and associated premium. For example, masonry walls perform better in different flooding events than wood frame walls.	Manufactured (mobile) homes should be prioritized for evacuation during flooding. Mobile homes must be elevated so that the lowest floor is above the Base Flood Elevation (BFE) of a 1% Annual-Chance event and anchored to a permanent foundation to resist flotation, collapse, or lateral movement. When a manufactured home is elevated, it is important that all parts exposed to floodwaters are made of flood damage-resistant materials. Additionally, utility systems and mechanical equipment of a mobile home must be elevated to or above the BFE. Flood vents must be appropriately provided to protect enclosing elements below the lowest floor. Source: FEMA and WV Emergency Management Division.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA
Note: Building counts of less than 10 structures are excluded from risk assessments at the incorporated place scale.

Bldg. Subgrade Basements Ratio (%)

Percentage of primary structures with subgrade basements in the high-risk floodplain. A basement is any portion of a structure that has a subgrade floor (below ground level) on all sides.

Rationale	Recommendations
Subgrade basements can flood quickly, especially in the event of flash floods, leading to structural damage, property loss, and increased recovery costs. Due to their below-ground location, basements are at a higher risk of flooding during heavy rainfall or rising water levels, especially in areas with poor drainage or high-water tables. Additionally, electrical equipment in basements can increase the risk of electrocution while flooding. The foundation type provides important insight as to where the flood risk is likely to begin. For instance, risk varies based on whether a building's foundation is underground, at ground, or above ground. Consequently, the foundation type is a factor in determining a building's unique flood risk and associated premium.	Basements below BFE are not allowed in new development and flood insurance coverage is very limited in existing basements for very good reason. It only takes an inch of water over the sill and the entire basement fills up! Excavating a basement into fill doesn't always make it safe because saturated groundwater can damage the walls. Source: WV Emergency Management Division. For existing basements, filling them in, if possible, can be a mitigation effort. Constructing berms and barriers, only with required permits, can help water slope away from basements. Electrical components, mechanicals, and appliances in floodplain basements should be elevate to at least one foot above the base flood elevation. When elevating is not an option, barrier walls and waterproofing can be considered to protect such equipment from serious damage. Installing sump pumps and backflow valves can help mitigate basement flooding with a relatively lower cost. Overhead sewer systems can be used to prevent sewer backup while flooding in basements. Source: FEMA. Never enter a flooded basement unless you know the power has been turned off. The water level may be above the electrical outlets or there may be a submerged electrical cord. Be alert for gas leaks: Use a flashlight to inspect for damage. Don't smoke or use candles, lanterns or open flames unless you know the gas has been turned off and the area has been ventilated. Source.
Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA	

Building 1-Story Ratio (%)

Percentage of one-story structures in the high-risk floodplain.

Rationale	Recommendations
Flood Fatality Risk. Occupants of one-story buildings cannot go to the higher elevations in their places while flooding. Also, they may face challenges during flood evacuation and emergency sheltering, especially for flash floods. Therefore, such structures may potentially cause higher human loss. Flood Damage. Buildings with more floors spread their risk over a higher area. Consequently, the number of stories is a factor in determining a building's unique flood risk and associated premium.	Occupants of one-story buildings should be informed about the increased flood risk associated with their structures to be more vigilant. These buildings should be prioritized in evacuation action plans, with occupants evacuated before inundation begins at their structures and access roads to their places. Providing early warning systems and clear evacuation routes can help ensure the safety of these residents.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA

Bldg. Year Pre-FIRM Ratio (%)

Percentage of Pre-FIRM buildings in the high-risk floodplain. A pre-FIRM building (for floodplain management purposes) is a (1) building constructed before December 31, 1974, or a (2) building constructed before the effective date of an initial Flood Insurance Rate Map (FIRM), or a (3) newly mapped Post-FIRM structure mapped into an expanded Special Flood Hazard Area from a restudy.

Rationale	Recommendations
Pre-FIRM structures are more vulnerable to flooding because they were constructed before the initial Flood Insurance Rate Map (FIRM) date and thus were not built according to the regulations and building codes for floodplain development. Additionally, many pre-FIRM buildings are unwisely located, repeatedly flooded, and account for a significant portion of flood insurance claims. Source: WV Conservation Agency.	The inventory of pre-FIRM floodplain structures will continue to be at risk of flooding unless deliberate actions are taken to reduce their losses. Source: WV Conservation Agency. Flood insurance can serve as a mitigation effort for pre-FIRM structures. Such buildings can be insured using "subsidized" rates. These rates are designed to help people afford flood insurance even though their buildings were not built with flood protection in mind. Source: FEMA.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA ; FEMA FIRM dates

Bldg. Year Minus Rated Post-FIRM Ratio (%)

Percentage of buildings in floodplain constructed or substantially improved after December 31, 1974, or after the effective date of an initial Flood Insurance Rate Map (FIRM), in which the first floor is more than one foot below the base flood elevation (BFE).

Rationale	Recommendations
Buildings rated as more than one foot below the Base Flood Elevation (BFE) are at a higher risk for flooding. Post-FIRM structures are expected to be constructed in accordance with regulations and building codes for floodplain development. Knowing the ratio of Minus Rated Post-FIRM buildings can inform risk assessments and emergency planning about the unexpected higher risk at such post-FIRM structures. Floodplain management is a community-based effort to prevent or reduce the risk of flooding, resulting in a more resilient community. According to FEMA, structures built to meet or exceed NFIP minimum floodplain management standards incur a minimum 65% less flood damage on average. Through the local adoption and enforcement of the NFP's minimum land use and development standards, NFIP Compliance saves individuals, their homes, and livelihoods; and saves communities, their tax base, local economy, and livability.	While investigating minus rated post-FIRM structures, historical FIRM maps should be considered to check if these structures were in the Special Flood Hazard Area (SFHA) when they were constructed. Mitigating the risk at minus-rated structures will save money from floodplain management. Owners of such buildings should be educated about the risks and encourage participation in flood insurance programs and mitigation initiatives. Grants or low-interest loans should be offered to owners of such post-FIRM structures for retrofitting their buildings with flood mitigation measures.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA ; FEMA FIRM dates

Infrastructure: Essential Facilities (#)

Number of essential facilities in the in the high, moderate, and reduced risk flood zones. Providing critical services to the community, essential facilities include police and fire stations, E-911 emergency operations centers, schools, hospitals, and nursing homes.

Rationale	Recommendations
Fire and police departments, as well as E-911 centers, must continue operating during natural disasters. Hospitals and nursing homes with immobile patients are particularly susceptible to flooding. Children are especially vulnerable, and schools often serve as refuges during floods. Communities need to establish emergency protocols to maintain critical services amidst a flood.	Essential facilities within a floodplain must receive enhanced protection to ensure their operational continuity and service provision following a flood. Additionally, plans should be developed for the long-term relocation of essential facilities, such as police and fire stations, schools, and nursing homes, out of the floodplain.

Data Sources: Effective and Advisory Floodplains for 1% and 0.2% Annual-Chance events; WV BLRA; Emergency Management Division; Department of Education; USA Reference; Department of Transportation.

Infrastructure: Roads Inundated Ratio (%)

Percentage of roads inundated by flood waters of 1 foot or more by a major 1% annual chance (100-yr) flood event.

Rationale	Recommendations
A foot of water can float many vehicles and make roads impassable. Analyzing inundation at this level is essential, as it can block regular access to properties and services. Approximately three feet of water is near the limit for using high-profile vehicles for high-water rescues. At depths of about six feet or higher, boats and helicopters are required for rescues.	Communities should compare historical flooding events with flood estimation models for active major roads and plan for alternative evacuation or rescue routes. In the long run, they should consider increasing roadway elevation to mitigate the risk.

Data Sources: TIGER/Line, Census data; Depth grids from FEMA models; FEMA Hazus software generated, FSF Models.

Community Assets Historical (#)

Number of historical community assets listed on the National Register of Historic Places, the official list of the Nation's historic places worthy of preservation, and includes buildings identified within National Register Areas constructed before 1930.

Rationale	Recommendations
Historical assets often have significant cultural value, so it is crucial to know how many historical assets are in flood-prone areas to aid in allocating resources for flood resilience and emergency response. Besides, It may affect insurance premiums for these assets and eligibility for government funding for flood mitigation.	Communities need to identify the flood risk, vulnerabilities, and existing capacity for resilience of historical properties in floodplain. For historical community assets, it is crucial to document the property and its character-defining features as a record and guide for future repair work. This documentation should be stored in a safe location, with at least one duplicate kept at a secure site. The building, its site, and setting should be maintained in good repair, and character-defining features should be monitored regularly. Adaptive flood mitigation options should always be selected to minimize impacts on the historical character and appearance of a historical building or district. These options can range from temporary protective measures, such as temporary barriers, systems, or equipment, to structural and landscape adaptations. Examples include constructing berms or levees, elevating roads, sidewalks, and infrastructure along with buildings, all while maintaining the historical spatial relationships and settings. Historical assets should be protected by proper drainage to avoid erosion of foundation walls by floods, water draining toward the building, or landscape damage. Additionally, improving or restoring on-site or adjacent natural systems, such as wetlands and green spaces, can be very helpful in mitigating flood risk. Since historical community assets often have basements, similar recommendations for protecting basements from floods should be applied. These include elevating electrical components, mechanicals, and appliances or protecting them with barrier walls and waterproofing and installing sump pumps along with backflow valves. Source: National Park Service.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA; National Register site and area designations

Community Assets Non-Historical (#)

Number of non-historical community assets including utilities (water, sewage, gas, electric, or phone), post-secondary educational facilities, emergency medical services (EMS), government buildings providing public services, and facilities hosting religious services.

Rationale	Recommendations
Buildings such as churches often serve as emergency shelters during floods. Flooding can disrupt critical community lifelines, including safety, water, shelter, health, and energy. The inundation of government buildings can cause service disruptions and damage important documents and records.	It is crucial for floodplain managers and risk planners to perform hazard vulnerability analyses of community assets to devise appropriate mitigation strategies. They should also create plans for the long-term relocation of key community assets (e.g., utilities, town halls, churches, etc.) out of the floodplain. Examples of mitigation measures for utilities are emergency response plans, barriers around key assets, elevated electrical equipment, emergency generators, and bolted down chemical tanks. Source: FEMA.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA; Reference USA; Homeland Infrastructure Foundation-Level Data; WV Water Development Authority; WV Infrastructure Jobs Development Council; WV Division of Natural Resources; Community feedback.

Bldg. Substantial Damage Count (%)

Estimated number of primary structures substantially damaged from a 1% annual chance (100-yr) flood.

Rationale	Recommendations
Flood loss models generated using FEMA's flood loss methodology quantify the degree of flood risk, including estimates of substantially damaged structures. Quantifying flood risk is crucial for effective risk communication and flood reduction efforts. Substantial damage estimate is a key indicator of the severity and impact of flood events, aiding in the efficient allocation of resources for recovery and reconstruction, adjusting insurance premiums, and understanding risk exposure. For many communities with pre-FIRM structures, the substantial damage determination is one of the strongest tools to get owners to comply with NFIP minimum and any higher standards required by the community. Source: FEMA Region 3.	Substantially damaged buildings can qualify for the Increased Cost of Compliance (ICC) under the National Flood Insurance Program. This assistance can help cover the expenses related to meeting mitigation requirements including elevation, relocation, demolition, floodproofing for non-residential structures, or combinations of these. Policyholders with flood insurance in high-risk areas (Special Flood Hazard Area) can receive up to $30,000 to help them bring their home or business into compliance with their local community's floodplain management regulations. Source: FEMA. Communities with high numbers of substantial damages should consider such assistance programs to mitigate the risk. Just 1 inch of water can cause $25,000 of damage to your home. Use FEMA's Cost of Flooding tool to show the public how much flood damage—even from just a few inches of water—could cost them.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA; Depth grids based on HEC-RAS and Hazus depth models.

Bldg. Substantial Damage Ratio (%)

Percentage of substantially damaged structures (damaged equal to or greater than 50% of the building value) to total floodplain structures.

Rationale	Recommendations
See Substantial Damage Count.	See Substantial Damage Count.

Data Sources: See Substantial Damage Count.

Bldg. Previous Damage Claims (%)

Number of previous flood-related insurance claims for a geographic unit since 1978.

Rationale	Recommendations
A high number of claims in a community indicates that flooding is occurring, and community members are making claims against their policies. The frequency of flooding and claim history are factors in determining a building's unique flood risk and associated premium.	Communities with a high number of previous flood claims should be prioritized for mitigation planning and funding. Establishing or enhancing floodplain management policies, including stricter building codes and land use regulations, can help mitigate future flood damage and reduce the number of claims.

Data Sources: FEMA NFIP Policy and Claims Report, West Virginia, 2024.

Bldg. Repetitive Loss Structures (%)

Number of NFIP-insured structures that have had at least 2 paid flood losses of more than $1,000 each in any 10-year period since 1978.

Rationale	Recommendations
A preponderance of repetitive loss structures indicates that the community is at a higher risk for future losses. Repetitive loss structures can cause direct cost of the continued need for emergency services as well as the indirect cost related to lost economic activity and sales tax revenue from businesses that are off-line during recovery efforts in addition to lost property taxes for abandoned properties. Source: FEMA Region 3.	Repetitive loss structures may be eligible for the Flood Mitigation Assistance (FMA) grant program by FEMA up to a 90% cost share for mitigation efforts such as property acquisition, structure demolition or relocation, building elevation, and dry flood proofing of non-residential structures. Source: FEMA. Communities with high numbers of repetitive loss structures should consider such grants to mitigate the risk. They should also consider comprehensive plans and economic development plans to identify sites for relocation from flood-prone areas in order to avoid future risk. Source: FEMA Region 3.

Data Sources: FEMA NFIP Policy and Claims Report, West Virginia, 2024. WV geocoded all statewide repetitive lost structures in 2020.

Population in Floodplain Ratio (%)

Percentage of population residing in the high-risk Special Flood Hazard Area to total population.

Rationale	Recommendations
More people residing in floodplains means higher human exposure to floods causing higher human loss. Most people die from flash flooding from extreme precipitation events. Flood disaster research reveals that certain populations are more vulnerable: younger and older populations, and people with disabilities or pre-existing health conditions. Additionally, flood fatalities may correspond to risky behavior: people underestimating the degree of risk by failing to evacuate to higher ground in a timely manner; entering flood waters in person or vehicle; or attempting to rescue other people, pets, or their belongings. Many households also have companion pets such as dogs and cats. According to U.S. pet ownership statistics, the percentage of households owning dogs is 45% and cats 26%.	Community officials should consider land Use planning and zoning to keep residential development away from the floodplains. The risk should be communicated with people residing in floodplains to educate them about the hazard and mitigation efforts such as flood insurance, elevating structures, wet flood proofing, etc. Emergency evacuation plans for flood disasters should include flood warning systems, flood impact evacuations to specific flood stages, etc. for evacuating people and pets. Review the disaster planning website Ready.gov for flooding and other disasters, which also has recommendations for people with disabilities, older adults, and pets and animals. Review the National Safety Council and the National Weather Service's Flood Safety Tips and Resources.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA; Total population and average household size from Census Bureau's 2021 American Community Survey (ACS) 5-year estimates.

Population Displaced Ratio (%)

Estimated percentage of population displaced by a major flood of a 1% annual chance (100-yr) probability, causing inundation of equal to or greater than 1 foot.

Rationale	Recommendations
Short-term displacement may occur when inundation damages residential units or blocks access to them. Evacuees plan to return to their communities after the inundation ends and the damaged residential units are restored. Until then, they may stay with relatives or friends in safer areas, go to hotels, or use short-term shelters. Population displacement estimates can aid in pre-disaster emergency management and evacuation planning.	Communities should use population displacement estimates to enhance emergency response, particularly for evacuation during high-risk floods. They should use these estimates to identify evacuation routes and improve planning for transportation, shelters, and supplies. Emergency plans should include mobile pet shelter resources (e.g., trailers, plastic crates, pens, etc.) for companion dogs and cats as well as other animals.

Data Sources: Effective and Advisory Floodplains for 1% Annual-Chance event; WV BLRA; Total population and average household size from Census Bureau's 2021 American Community Survey (ACS) 5-year estimates; Depth grids based on HEC-RAS and Hazus depth models.

WV Social Vulnerability Index (%)

Social vulnerability index developed for West Virginia based on eight socioeconomic and demographic indicators.

Rationale	Recommendations
A community with a higher social vulnerability is less likely to be able to recover from a flood disaster quickly and fully. The WV Socioeconomic Index is a combination of eight social and economic indicators to measure a population's vulnerability to flood hazards based on a localized approach. The select indicators are economic factors (Poverty Rate, Unemployment Rate), population characteristics (Vulnerable Ages Rate, Disability Rate, Population without a High School Education, Population Change), and housing (Median Housing Unit Value, Mobile Homes as Percentage of Housing).	Decision makers should pay attention to the social vulnerability index to identify the most vulnerable communities. By using available grants more efficiently, they can better serve these populations before, during, and after a flood event. This proactive approach ensures resources are allocated where they are needed most, enhancing overall community resilience and recovery efforts. Additionally, investing in community outreach and education programs can help vulnerable populations better understand flood risks and how to prepare for them, further improving their resilience.

Data Sources: Census Bureau's American Community Survey (ACS) 5-year estimate of 2021; Census Bureau's Decennial Census (DEC) of 2010 & 2020 (For population change).

CUMULATIVE RISK INDEX (%)

Cumulative risk score of geographic scale unit.

Rationale

West Virginia has some of the highest flood vulnerability in the United States and all 55 counties in the state are at significant flood risk. Repeated flooding can push communities past their ability to recover, especially in areas with significant socio-economic challenges. Resiliency, or the ability to withstand and mitigate the stress of a disaster, is key to successful recovery.

West Virginia is unique in that it is the only state in the nation that has conducted a detailed building-level riverine flood risk assessment of more than 84,000 structures located in FEMA's Special Flood Hazard Areas, and then created an online WV Flood Resiliency Framework (WVFRF) toolkit of risk assessment and visualization tools for analysis at nine geographic scales: state, region, county, community, incorporated place, unincorporated area, watershed, river/stream, and building level. These localized analytical and visualization tools combined with quantifiable flood risk factors and cumulative risk scores are beneficial in the risk planning and mitigation prioritization of flood-prone communities.

Recommendations

Intended users of the West Virginia Risk Index include floodplain managers, planners, and emergency managers at the local, regional, state, and federal levels, as well as other decision makers and interested members of the general public. Both civic actors and academic researchers helped to launch the West Virginia Flood Resiliency Framework (WVFRF), a freely available online resource to support residents, local leaders, non-profits, and government officials in efforts to increase community flood resiliency through improved knowledge about flood risk, floodplain management, and disaster response and recovery.

With improved understanding of natural hazard risk, communities can take action to reduce the risk specific to that community. Specifically, the West Virginia Risk Index can help with:

PLANNING

- Enhancing state resiliency and hazard mitigation plans
- Updating emergency operation plans
- Prioritizing and allocating resources
- Identifying the need for more refined risk assessments

RISK COMMUNICATIONS

- Encouraging community-level risk communication and engagement
- Educating new homeowners and renters
- Informing the insurance and mortgage industries

MITIGATION

- Identifying areas of mitigation interest
- Supporting the development or enhancement of codes and standards
- Informing long-term community recovery

Although the WV Risk Index provides a more localized analysis of the riverine flood hazard, the number one hazard for West Virginia, FEMA's National Risk Index provides a baseline risk measurement for 18 natural hazards at the county and census tract scales.

Data Sources: Refer to risk indicator variable data sources.