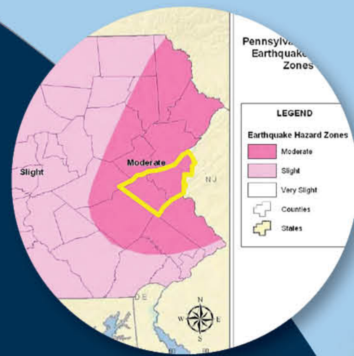

LEHIGH AND
NORTHAMPTON COUNTIES,
PENNSYLVANIA

2024 Lehigh Valley Hazard Mitigation Plan

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Executive Summary

Introduction

The 2024 Lehigh Valley Hazard Mitigation Plan outlines a data-informed strategy for reducing the risk associated with natural and human-caused disasters for residents of Northampton and Lehigh Counties. Hazard mitigation planning is a critical tool for reducing the loss of life and property resulting from natural and human-caused hazards. The concept offers long-term and repeating benefits by disrupting the cyclical nature of disaster-related losses. While mitigation planning cannot fully eliminate the possibility of disasters, the aim of mitigation planning is to reduce the effort necessary to “return to normal” following a disaster. One fundamental principle of hazard mitigation is that investments made before a disaster will significantly diminish the need for post-disaster emergency response, repair, recovery, and reconstruction. By implementing mitigation practices, communities can bolster their resilience which enables residents, businesses, and industries to recover swiftly in a post-disaster environment.

The goals of the 2024 Lehigh Valley Hazard Mitigation Plan are directly aimed at reducing the hardships the area might experience in the wake of a disaster. They include minimizing the risk to life and property, enhancing the resiliency benefits of our natural resources, improving planning and emergency response to protect public health and safety, raising public awareness, and promoting hazard avoidance. It is also intended to support equitable solutions for *all* residents, including individuals with access and functional needs, cultural minority and limited English-speaking populations, children, the elderly, and other vulnerable populations.

Hazard mitigation is not a zero-sum game, and benefits gained through the practice of hazard mitigation do not need to come at the expense of other community interests and objectives. To the contrary, the advantages of mitigation planning can often extend beyond merely reducing a community’s vulnerability to hazards. Actions brought about by hazard mitigation can support broader community objectives, such as preserving open spaces, enhancing water quality, promoting environmental health, and creating recreational opportunities. Consequently, it is crucial to integrate local mitigation planning processes with concurrent local planning initiatives.

A Hazard Mitigation Plan serves as the tangible embodiment of a jurisdiction's commitment to minimizing risks associated with natural hazards. Local officials can rely on this plan in their day-to-day decision-making, from shaping regulations and ordinances to granting permits and funding capital improvements. Additionally, Local Hazard Mitigation Plans establish the foundation upon which communities prioritize future grant funding, aligning resources with areas most in need of support and protection.

This document reflects a comprehensive update of the 2018 Lehigh Valley Hazard Mitigation Plan, and was adopted on MONTH DAY, 2024.

Planning Process

Developing a hazard mitigation plan which best serves the interests and wishes of those in the Lehigh Valley is achieved in part by incorporating a wide range of community voices, resources, and stakeholders in a robust planning process. The process of creating the 2024 Lehigh Valley Hazard Mitigation Plan featured opportunities for public participation through meetings and multiple surveys.

Local hazard mitigation planning is the process of organizing community resources, identifying and assessing hazard risks and determining how to best minimize or manage those risks. This process results in a Hazard Mitigation Plan that identifies specific mitigation actions, each designed to achieve both short term planning objectives and a long-term community vision. To ensure the functionality of each mitigation action, responsibility is assigned to a specific individual, department, or agency along with a schedule for its implementation. Plan maintenance procedures are established to implement, as well as to evaluate and enhance the Plan as necessary. Developing clear plan maintenance procedures ensures that the Lehigh Valley Hazard Mitigation Plan remains a current, dynamic, and effective planning document over time.

As an incentive for State and local governments to develop Hazard Mitigation Plans, the Federal Government requires mitigation planning as a component of eligibility for hazard mitigation project funding. The new FEMA Local Mitigation Planning Policy Guide, which took effect on April 19, 2023, outlines a strategy for developing a mitigation plan that can serve as the foundation of effective hazard mitigation. Local jurisdictions must have a FEMA-approved local Hazard Mitigation Plan at the time of obligation of grant funds to be eligible for grant funding under the unified Hazard Mitigation Assistance (HMA) programs. This requirement reinforces the importance of mitigation planning and emphasizes planning for disasters before they occur.

The 2024 Lehigh Valley Hazard Mitigation Plan was developed by a multi-jurisdictional planning team consisting of representatives of 66 jurisdictions. The Planning Team consists of leaders from the Lehigh Valley who possess skills and expertise benefiting the hazard mitigation planning process. Development of the Plan was also supported by numerous stakeholders and community members. The community feedback received by the Planning Team helped to shape the goals, objectives, and actions set forth in the Plan. The final product represents a multi-jurisdictional strategy that identifies the most effective risk reduction efforts for the Lehigh Valley as a whole. The following communities participated in the development of this plan:

Table 1: Participating Jurisdictions

Northampton County	Lehigh County
Allen Township	Alburtis Borough
Bangor Borough	Allentown City
Bath Borough	Catasauqua Borough
Bethlehem Township	Coopersburg Borough
Bushkill Township	Coplay Borough
Chapman Borough	Emmaus Borough
East Allen Township	Fountain Hill Borough

East Bangor Borough	Hanover Township
Easton City	Heidelberg Township
Forks Township	Lower Macungie Township
Freemansburg Borough	Lower Milford Township
Glendon Borough	Lowhill Township
Hanover Township	Lynn Township
Hellertown Borough	Macungie Borough
Lehigh Township	North Whitehall Township
Lower Mount Bethel Township	Salisbury Township
Lower Nazareth	Slatington Borough
Lower Saucon Township	South Whitehall Township
Moore Township	Upper Macungie Township
Nazareth Borough	Upper Milford Township
Northampton Borough	Upper Saucon Township
North Catasauqua Borough	Washington Township
Palmer Township	Weisenberg Township
Pen Argyl Township	Whitehall Township
Plainfield Township	*Lehigh Valley Authority*
Portland Borough	*Lehigh-Northampton Airport Authority*
Roseto Borough	
Stockertown Borough	
Tatamy Borough	
Upper Mount Bethel Township	
Upper Nazareth Township	
Walnutport Borough	
Washington Township	
West Easton Borough	
Williams Township	
Wilson Borough	
Wind Gap Borough	
Bethlehem City	

This plan was completed in compliance with the Disaster Mitigation Act of 2000, 44 CFR § 201.3(d), the Pennsylvania Emergency Management Agency Standard Operating Guide (PEMA SOG), and the Local Hazard Mitigation Planning Policy Guide effective April 19, 2023.

Risk Assessment

A core component of any hazard mitigation plan is a risk assessment. The 2024 Lehigh Valley Hazard Mitigation Plan analyzed the risk of 27 natural and human-caused hazards. The specific hazards profiled in this plan are listed in Table 2.

Table 2: Hazards Profiled in 2024 Lehigh Valley Plan

Natural Hazards	Human-Caused Hazards
Drought	Civil Disturbance/Mass Gatherings
Earthquakes	Dam Failure

Extreme Temperatures	Drug Overdose
Floods, Flash Floods, Ice jams	Environmental Hazards/Explosion
Hailstorms	Gas/Liquified Pipelines
Invasive Species	Levee Failure
Landslides	Nuclear Incident
Lightning Strikes	Structural/Urban Fires
Pandemic & Infectious Diseases	Structural Collapse
Radon	Terrorism
Subsidence/Sinkholes	Transportation Crashes
Wildfires	Utility Interruption
Windstorm/Tornadoes	Cyberterrorism
Winter Storms	

The 27 natural and human-caused hazards analyzed in this Plan include 25 hazards from the 2018 plan as well as two new hazards: gas/liquified pipelines and cyber-terrorism. To analyze these hazards, the Planning Team reviewed local, state, and national datasets and relevant scientific literature to develop a detailed understanding of their frequency, magnitude, and other characteristics. Additionally, the Planning Team reviewed geospatial data for critical facilities in the planning area to assess the risk posed to these facilities by the different hazards. Where possible, the financial toll of hazards impacting critical facilities in the planning area was also assessed.

The hazard analysis included in this Plan supported the development of a hazard risk priority ranking based on conclusions about the frequency of occurrence, potential impact, spatial extent, warning time, and duration of each hazard. FEMA's Hazus-MH loss estimation methodology was also used in evaluating known flood risks according to their relative long-term cost, measured in expected damages. This risk assessment was designed to assist communities in seeking the most appropriate mitigation actions to pursue and implement by focusing their efforts on those hazards of greatest concern and those structures or planning areas facing the greatest risk(s).

The Community Profile and HIRA collectively served as the basis for updating the goals outlined in the 2018 plan to reflect the Lehigh Valley's priorities in 2024. For more detailed information, see Section 4. Risk Assessment.

Capability Assessment

To inform the development of a comprehensive mitigation strategy, the planning team conducted a Capability Assessment to identify the tools, expertise, planning mechanisms, staff, and other resources and capabilities of the Counties and participating municipalities. This assessment contains three key components: an inventory of an existing planning and regulatory tools, an analysis of the participating jurisdictions' capacity to use them effectively, and a review and summary of how the mitigation plan will be integrated into other planning mechanisms. The assessment process is a key step in the mitigation planning process that identifies existing gaps, conflicts and/or weaknesses that may need to be addressed through future mitigation planning goals, objectives, and actions. It also highlights the measures in place that merit continued support and enhancement through future mitigation efforts. The capability assessment helps to ensure that proposed mitigation actions are practical considering the local ability to implement them. For more detailed information, see Section **Error! Reference source not found.**.

Mitigation Strategy

The Mitigation Strategy outlined in Section 6 of this plan functions as a comprehensive guide for future hazard mitigation policies and projects for the Lehigh Valley and its participating municipalities. This Plan continues the practice – implemented in the 2018 update – of utilizing goals, objectives, and actions to describe what the region aims to achieve. In the context of this plan, these are defined as follows:

1. **Mitigation Goals**: These represent the overarching aspirations of the Lehigh Valley. Defined as broad policy statements, they depict the long-term outcomes which the community seeks to achieve.

2. **Mitigation Objectives**: These delve deeper, detailing strategies or steps aimed at realizing the aforementioned goals. Unlike the broad strokes of goals, objectives are precise, often measurable, and typically come with a defined timeline for achievement.

3. **Mitigation Actions**: The Mitigation Strategy in Section 6 provides detailed explanations of specific tasks the participating jurisdictions can take to reduce risk associated with each hazard profiled in the plan and to achieve the plan's overall goals and objectives.

To ensure that the 2024 goals reflect contemporary conditions, the goal evaluation process included a review of the updated capability assessments and risk assessments, which included two new hazard profiles. Throughout the planning process, both counties and all municipalities were encouraged to thoroughly consider their natural and human-caused hazard risks and vulnerabilities. Based on this review, the Planning Team determined that the revised goals reflect the Lehigh Valley's desire for a more disaster-resilient future. A mitigation technique matrix was completed to identify and evaluate possible mitigation actions for each hazard. Municipal actions were categorized and prioritized on a regional basis.

Goal 1: To minimize the risk to human life associated with natural and non- natural hazards (NFIP).

- Objective 1: Create a better understanding among the public and local governments of the benefits and opportunities associated with hazard mitigation planning and actions. (NFIP)
- Objective 2: Continuously promote and maintain better early warning and emergency communications.
- Objective 3: Provide added protection for vulnerable populations. (NFIP)

Goal 2: To promote hazard avoidance, especially in floodplains (NFIP).

- Objective 1: Minimize future risks of losses associated with structures, including repetitive loss structures. (NFIP)
- Objective 2: Reduce flooding potential through planning, training and outreach. (NFIP)

- Objective 3: Encourage and facilitate the development or revision of comprehensive plans and zoning/land use ordinances to limit development in high-hazard areas.

Goal 3: To reduce the damages and functional loss from natural and non- natural hazards to existing and future public and private assets, including structures, critical facilities and infrastructure (NFIP).

- Objective 1: Identify the current risks of critical facilities and infrastructure from hazards, and determine actions to lessen those risks in the future. (NFIP)
- Objective 2: Encourage and/or perform regular maintenance and upgrades of existing drainage systems potentially impacting critical facilities.
- Objective 3: Encourage and/or provide backup power resources (generators) for critical facilities.
- Objective 4: Encourage and/or perform maintenance and upgrades to reduce long-term vulnerability to high hazard potential dams.

Goal 4: To preserve and enhance the effectiveness of natural resources, including woodlands, streams, rivers, wetlands, floodplains and riparian buffers to provide resiliency benefits (NFIP).

- Objective 1: Encourage and/or provide maintenance and restoration of streams and rivers and associated floodplains to naturally provide flood mitigation.
- Objective 2: Encourage regulation of and/or regulate development in priority conservation areas, including floodplains, to minimize flood damage. (NFIP)

Goal 5: To develop, prioritize and implement cost-effective, long-term actions that will reduce the impacts of natural and non-natural hazards (NFIP).

- Objective 1: Thoroughly assess the community, established capabilities, and identify specific cost-effective actions for improvement, relative to existing and future hazard risks. (NFIP)
- Objective 2: Establish mitigation action priorities, encourage, and track progress. (NFIP)

Goal 6: To improve local regulations to reduce the impacts of natural and non- natural hazards (NFIP).

- Objective 1: Better integrate hazard mitigation planning with comprehensive planning and land use regulations. (NFIP)
- Objective 2: Identify and promote "best practices" for municipal regulation of land use in zoning and subdivision ordinances and official maps.
- Objective 3: Encourage proactive planning for potential hazard events and potential related property damage. (NFIP)
- Objective 4: Incorporate hazard mitigation planning into existing municipal policy.

Goal 7: To enhance planning and emergency response efforts among federal, state, county and local emergency management personnel to protect public health and safety.

- Objective 1: Continually improve communication capabilities, training and coordination for hazard events.

- Objective 2: Continually improve the planning for shelters, evacuation routes and disaster recovery.
- Objective 3: Continue the promotion of disaster resiliency in the business community.
- Objective 4: Maintain and/or upgrade emergency response equipment and resources.

Goal 8: To promote public awareness on both the potential impacts of natural and non-natural hazards and actions to reduce those impacts (NFIP).

- Objective 1: Encourage and/or provide education and outreach to increase awareness of hazards and opportunities for mitigation. (NFIP)
- Objective 2: Encourage and/or provide public education programs for businesses, households and individuals on mitigation, safety measures and preparedness.

For more information, see Section 6. Mitigation Strategy.

Plan Adoption, Maintenance, and Implementation

Plan Adoption

Adoption of the 2024 Lehigh Valley Hazard Mitigation Plan by Lehigh and Northampton counties and each participating municipality demonstrates their commitment to fulfill the mitigation goals, objectives, and actions outlined in the Plan. For this multi-jurisdictional plan to be approved, each jurisdiction included in the Plan must have its governing body adopt the Plan upon notification of approval pending adoption by the Federal Emergency Management Agency (FEMA). Once complete, county and municipal adoption resolutions will be provided in the Adoption Resolutions section of Appendix C.

In addition to the requirement set forth in the Disaster Mitigation Act of 2000, adoption of a hazard mitigation plan is an important step because:

- It lends authority to the plan to serve as a guiding document for all local and state government officials
- It certifies to program and grant administrators that the plan's recommendations have been properly considered and approved by the governing authority and jurisdictions' citizens
- It helps ensure the continuity of mitigation program and policies over time because elected officials, staff and other community decisionmakers can refer to the official document when making decisions

Plan Maintenance

The Lehigh Valley Hazard Mitigation Planning Team will largely remain intact as the group responsible for monitoring, evaluating and updating the 2024 Plan on an annual basis. The Planning Team will be co-chaired by the Lehigh County Office of Emergency Management Director or their designee and the Northampton County Emergency Management Services Director or their designee.

Each participating municipality in the Lehigh Valley is expected to maintain a Planning Team point of contact, and the Planning Team co-chairs are responsible for maintaining an updated list of municipal points of contact who will assist in keeping the plan current. The current points of contact for the participating municipalities are identified in the municipal annexes. Each municipality is responsible for informing the Planning Team co-chairs of any changes in their municipal representation. The co-chairs of the Planning Team will be responsible for selecting a replacement in the event that a Planning Team member can no longer fulfill their duties to the team.

Plan Implementation

Each participating municipality, the counties or any other ancillary organization are responsible for implementing their mitigation actions and informing the Administrative Planning Team annually of any progress made. This includes incorporating those actions into other planning documents, such as comprehensive plans, zoning ordinances, capital improvement plans and budgets, as necessary. It will remain the responsibility of the Lehigh and Northampton County Emergency Management Agencies to monitor grant opportunities to help the counties and municipalities fund their mitigation actions and inform the municipalities of those opportunities. To give the region enough time to perform the next five-year update, the counties will consider applying for Hazard Mitigation Planning grant funding in 2025-2026.

To promote continued involvement, the 2024 Lehigh Valley Hazard Mitigation Plan, including municipal annexes, will remain available to the public online on the Northampton County Emergency Management website. The website will include a place for members of the public to comment, and social media will be used as part of a continued outreach effort. Any media reports and public meeting notices will be posted online, as well as any progress reports and updates to the Plan. Annual progress reports or any proposed updates to the Plan will be open for public review online and during at least one public meeting each year. The co-chairs will assist in scheduling public meetings and Northampton County Emergency Management will be responsible for maintaining the Hazard Mitigation webpage. Over the next five years, municipal participation will continue to include assisting and promoting outreach to their community.

In addition, copies of the 2024 Plan will be made available for public access at each participating municipal building and at each agency's main location at:

Lehigh County Emergency Management Agency
640 W. Hamilton Street
Allentown, PA 18101

Northampton County Emergency Management Services
100 Gracedale Avenue
Nazareth, PA 18064

For more information, see Section 7. Plan Maintenance and Section 8. Plan Adoption.

1. Introduction

1.1 Background

Hazard mitigation is taking sustained action to reduce or eliminate long-term risks to life and property from hazards and create successive benefits over time. The creation of a comprehensive hazard mitigation plan and actionable strategy may allow a community to anticipate potential threats and tackle them head on. Emerging weather patterns, demographic transitions, and rapid technological advancements mean that these plans need to be routinely updated to remain relevant. Northampton and Lehigh Counties in the Lehigh Valley are committed to the maintenance of their plan, as reflected in this 2024 update.

Pennsylvania has experienced 63 significant disasters and emergencies since 1955, with the Lehigh Valley directly impacted by 24 of these events. Reducing the impacts of these events on critical infrastructure and facilities makes a community safer and more resilient, reducing the burden on first responders' post-event and keeping residents safe. When these disasters occur, critical resources - money, effort, and time - have to be reallocated to recovery, but hazard mitigation and reducing the impact of disasters can also reduce the need for these resources. The Federal Emergency Management Agency (FEMA) has found that every dollar spent on hazard mitigation saves, on average, seven dollars in the long term.

1.2 Purpose

The mission and purpose of this plan is to reduce the loss of life, property, and resources in communities in the Lehigh Valley caused by natural and human-caused disasters. This plan intends to accomplish this mission by developing and/or strengthening:

- The depth of knowledge of hazards and threats present in the region
- A community-wide understanding of the hazards and threats
- A more sustainable, disaster-resilient urban fabric across the Lehigh Valley
- Economic tailwinds resulting from innovative solutions and reduced costs associated with post-disaster efforts
- Partnerships with local businesses and non-profit organizations that emphasize community resilience
- Prioritization of actions which will widen the range of pre- and post-disaster grant funding that Lehigh Valley communities are eligible to receive
- Commitment to adhere to, monitor, and update the Hazard Mitigation Plan

1.3 Scope

Emergency Management Services Code, 35 Pa. C.S. Section 7503, as amended, gives specific authority to each political entity to prepare and implement plans that benefit the health and wellbeing of Pennsylvania citizens. In addition to the value that they provide to the community, these plans also meet the federal statutory requirement that enable communities to receive the full range of post-disaster assistance or mitigation grants. This plan is guided by the best practices and recommendations from FEMA and the Pennsylvania Emergency Management Agency (PEMA). To create this plan, Lehigh County Emergency Management Agency, Northampton County Emergency Management Services, and Witt O'Brien's collaborated with all 62 municipalities in the region and a wide variety of community stakeholders to improve upon the foundations established in the 2006, 2013, and 2018 plans.

1.4 Authority and Reference

Authority for this document originates from the following federal sources:

- Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C., Section 322, as amended.
- Disaster Mitigation Act of 2000, Public Law 106- 390, as amended.
- Code of Federal Regulations (CFR), Title 44, Parts 201 and 206.
- National Flood Insurance Act of 1968, as amended, 42 U.S.C. 4001 et seq.
- National Flood Insurance Reform Act of 1994, 42 U.S.C. 4101

Authority for this document originates from the following Pennsylvania sources:

- Pennsylvania Emergency Management Services Code. Title 35, Pa. C.S. Section 101.
- Pennsylvania Municipalities Planning Code of 1968, Act 247, as reenacted and amended.
- Pennsylvania Stormwater Management Act of October 4, 1978. P.L. 864, No 167.

The following FEMA guides and reference documents were referenced to prepare this Plan:

- *Local Mitigation Planning Policy Guide (fema.gov)* April 2023.
- *FEMA Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards*, January 2013.
- *FEMA Integrating Hazard Mitigation Into Local Planning*, March 2013.
- *FEMA Hazard Mitigation Assistance Program and Policy Guide*, March 2023
- *FEMA Plan Integration: Linking Local Planning Efforts*, July 2015.

- *FEMA Integrating Hazard Mitigation into the Local Comprehensive Plan*, July 2017.
- *FEMA Resilience and Climate Change Adaptation* Job Aide, 2018.
- *FEMA Hazard Mitigation Assistance Mitigation Action Portfolio*, 2020.
- *FEMA Building Community Resilience with Nature Based Solutions*, June 2021.
- FEMA's *Guides to Expanding Mitigation*, 2020-2021.
    - Making the Connection with Arts and Culture, 2020.
    - Making the Connection with Public Health, 2020.
    - Making the Connection to Transportation, 2020.
    - Making the Connection to Municipal Financing, 2020.
    - Making the Connection to Electric Power, 2020.
    - Making the Connection to Equity, 2020.
    - Making the Connection to People with Disabilities, 2021.
    - Making the Connection to Wildlife, 2021.
    - Making the Connection to Codes and Standards, 2021.
    - Making the Connection to the Whole Community, 2021.
    - Making the Connection to Communications Systems, 2021.

The following PEMA guides and reference documents were referenced to prepare this Plan:

- *PEMA All-Hazard Mitigation Planning Standard Operating Guide*, 2020.
- *Commonwealth of Pennsylvania 2023 Hazard Mitigation Plan*, August 2023.
- *PEMA Do It Yourself Hazard Mitigation Plan Update*, 2017.
- PEMA Mitigation Ideas: Potential Mitigation Measures by Hazard Type; a Mitigation Planning Tool for Communities, March 2009.

2. Community Profile

2.1 Geography and Environment

Situated in the heart of the Commonwealth, the Lehigh Valley spans across two counties: Lehigh and Northampton. Together, they cover 726 square miles. This region boasts a prime location approximately 65 miles from Philadelphia, 90 miles from New York City, and within a 350-mile radius of 46 prominent metropolitan areas in the Northeast and Mid-Atlantic.

The Valley is home to 62 municipalities, including three bustling cities — Allentown, Bethlehem, and Easton. Additionally, there are 27 boroughs and 32 townships. This conglomerate of counties is at the heart of the Allentown-Bethlehem-Easton Metropolitan Statistical Area, holding the distinction of being Pennsylvania's third-largest metropolitan hub.

2.1.1 Topographical Features

The Blue Mountain delineates the Valley's northern frontier, stretching southwest to Maryland. The southern boundary of Allentown is marked by two iconic ridges: Lehigh Mountain and South Mountain. To the east, the Delaware River acts as the natural boundary, whereas the west transitions into undulating hills separating the basins of the Lehigh and Schuylkill rivers. The region between Blue Mountain and South Mountain hosts a sprawling seven-mile limestone valley, the primary residential and commercial area for the Valley's populace.

Elevation in the Valley varies, ranging from 200 feet near the Lehigh and Delaware rivers to soaring heights of 1,695 feet on the Blue Mountain and 1,042 feet on the South Mountain. Particularly steep terrains can be found lining the northern and southern edges of both counties, most prominently on the Blue and South Mountains.

2.1.2 Water Systems

The Lehigh Valley is crisscrossed by two primary rivers: the Lehigh and Delaware. These rivers are accompanied by a vast network of tributaries including the Jordan Creek, Little Lehigh Creek, Hokendauqua Creek, Monocacy Creek, and Saucon Creek. Additionally, the Delaware River Basin, spanning 13,539 square miles across four states, accommodates tributaries like the Bushkill Creek and Martins Creek.

The Valley is also drained by 16 unique watersheds, with tributaries leading to the Schuylkill River, the Lehigh River, and the Delaware River. Some regions of the Valley have direct drainage into the Lehigh and Delaware rivers without traversing any specific streams.

2.1.3 Geology

For hazard mitigation, the Valley's defining geological feature is its carbonate bedrock, made up of limestone and dolomite. This bedrock spans beneath nearly every urban area in the Valley. Out of the 62 municipalities in the Lehigh and Northampton counties, 47 are built over this carbonate rock. Apart from being integral to the cement industry, these formations are also the ground for the region's most fertile soils. However, a noteworthy trait of carbonate rock is its susceptibility to sinkholes, a phenomenon not uncommon in the Valley.

2.1.4 Climatic Conditions

The Lehigh Valley experiences a relatively moderate climate. Annually, the average temperature hovers around 51°F. Extreme temperatures, both highs over 100°F and lows under 0°F, are rarities. The region receives consistent and ample precipitation, providing a growing season that lasts between 170 and 185 days.

2.2 Community Facts

2.2.1 Local History

Before the arrival of European settlers, the Delaware and Lenape tribes inhabited the valley, and hunted the bear, fish and other wildlife thriving in the area's natural environment. In the 1730s, Scotch-Irish and German settlers began the agricultural development of the Lehigh Valley. Early industry in Lehigh County consisted primarily of agriculture and small-scale, water-powered gristmills, served by a network of roads and covered bridges. The Lehigh Valley was an important region during the Revolutionary War, as communities in the region were directly involved in many significant events during this period. One such event was the concealment of the Liberty Bell; the bell was hidden under the floorboards of the Zion's Reformed Church for nine months to prevent it from being seized and melted down by the British for munitions.

Local entrepreneurs constructed the Lehigh Canal between 1818 and 1820 to capitalize on the Lehigh Valley's strategic location between the Pennsylvania Coal Region to the north and the major commercial ports of New York and Philadelphia. By 1855, the canal was supplemented and quickly supplanted by the Lehigh Valley Railroad.

In the late 19th century, the mining of iron ore fueled the rise of iron and steel production along the banks of the Lehigh River at Catasauqua, Allentown and, most notably, Bethlehem. The discovery of significant limestone deposits also launched the Lehigh Valley's cement industry, while the northern Lehigh Valley developed into a major center for slate production. The silk-weaving industry thrived into the early 20th century. As the weaving industry began to sunset locally, the region's heavy manufacturing grew, and in 1905, Mack Trucks relocated its truck-building operation from Brooklyn to the City of Allentown.

In the decades after World War II, the Lehigh Valley experienced growth trends that were similar to those in other metropolitan areas throughout the country.

Construction of Routes 22 and 378, as well as a new terminal building for the Lehigh Valley International Airport, spurred the region's post-war suburban expansion, particularly in the townships surrounding the region's three cities.

2.2.2 *Economy*

The Lehigh Valley Economic Development Corporation (LVEDC) estimates the number of members of the labor force within the Lehigh Valley to be near 349,000, and the labor force within a 1-hour drive is estimated to be 1.7 million.[1] The median household income within the Lehigh Valley is $78,300, which is higher than both the Pennsylvania and U.S. median income.[2] The economic output of the Lehigh Valley is approximately $50 billion USD, which exceeds the Gross Domestic Product of the states of Wyoming and Vermont in 2022.[3] Healthcare, manufacturing, and retail trade are the largest sectors in the Lehigh Valley by total employment, and the unemployment rate in the Lehigh Valley, as of September 2023, is only 3.4%.

2.3 Population and Demographics

In 2022, the Lehigh Valley had a total population of 694,843. This population was fairly evenly distributed between Northampton and Lehigh counties, with Northampton County having 318,526 residents and Lehigh County having 376,317. The City of Allentown, with an estimated 125,105 residents, is the most populous municipality in the Lehigh Valley and the third most populous city in Pennsylvania.[4] As of 2022 the median age in Lehigh County was 39, while the median age in Northampton County was 42. Around 22% of the population in Lehigh County and 19% in Northampton County are below 18 years of age. Conversely, 17% of individuals in Lehigh County and 20% in Northampton County are aged 65 and above.

Among the 376,317 individuals living in Lehigh County, approximately 75% identify as white, 10% as Black or African American, 4% as Asian, and 1.3% as American Indian or Alaska Native. Of the 318,526 residents in Northampton County, approximately 83% identify as white, 9% as Black or African American, 4% as Asian, and 1% as American Indian or Alaska Native. 15% of the population in Lehigh County and 9% of Northampton County identify as multiracial.[5]

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[1] Lehigh Valley Economic Development Corporation. “Get the Data - Lehigh Valley, PA - Lehigh Valley Economic Development.” lehighvalley.org. Accessed January 3, 2024. https://www.lehighvalley.org/get-the-data/.

[2] Lehigh Valley Economic Development Corporation. “Lehigh Valley Economic Development.” lehighvalley.org, 2024. https://www.lehighvalley.org/home/.

[3] Lehigh Valley Economic Development Corporation. “Get the Data - Lehigh Valley, PA - Lehigh Valley Economic Development.” lehighvalley.org. Accessed January 3, 2024. https://www.lehighvalley.org/get-the-data/.

[4] American Community Survey and U.S. Census Bureau. “S0101: Age and Sex.” data.census.gov, 2022. https://data.census.gov/table/ACSST1Y2022.S0101?g=050XX00US42077,42095.

[5] American Community Survey and U.S. Census Bureau. “DP05: ACS Demographic and Housing Estimates,” 2022. https://data.census.gov/table/ACSDP1Y2022.DP05?g=050XX00US42077,42095.

There are approximately 480,921 individuals aged 25 and above in the Lehigh Valley, and nearly 91% of these individuals have attained a high school graduate or higher education. This is marginally higher than the national average of 90%. Approximately 33% of individuals aged 25 and above in the Lehigh Valley have attained a bachelor's degree or higher education, and this is slightly lower than the national average of 36%.[6] More than 25% of the overall population in Lehigh County and 17% of the overall population in Northampton County speak a language other than English.

Around 23.5% of Lehigh County's workforce and 25% of Northampton County's workforce travel to a different county for their jobs.[7] In the wake of the COVID-19 pandemic, more individuals are working from home, and as of 2022 approximately 12.4% of the workforce in Lehigh County and 13.2% of the workforce in Northampton County work from home.

2.4 Land Use and Development

2.4.1 Population Growth

The Lehigh Valley ranks as one of Pennsylvania's most rapidly expanding areas, with an expected population growth of 14.4% by 2050. This surge is fueled by an influx of individuals moving into the area, attracted by its blend of natural beauty and historical significance, alongside a high quality of life, cost-effectiveness, and strategic positioning. Concurrent with this growth, there is a noticeable shift in demographic patterns. By 2050, the segment of the population over 65 years is projected to increase by 33%, and there will be a 14.8% rise in the number of adults aged 25-64. However, the youth population is anticipated to remain relatively stable in the upcoming years.[8]

The population trend in the Lehigh Valley indicates a continuous influx of working-age adults, including those from the Millennial and Generation X cohorts. These groups are expected to experience steady growth, contributing to the region's demographic balance and stability in the future. For the past seventy years, the area has seen a consistent and sustainable increase in population, averaging over 4,000 new inhabitants annually. This pattern is expected to persist, with the Valley continuing to gain thousands of residents each year, even as other parts of Pennsylvania experience population declines. Much of this projected growth is anticipated to stem from both domestic and international migration.

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[6] American Community Survey and U.S. Census Bureau. "S1501: Educational Attainment." data.census.gov, 2022. https://data.census.gov/table/ACSST1Y2022.S1501?q=education&g=010XX00US_050XX00US42077,42095.

[7] American Community Survey and U.S. Census Bureau. "S0801: Commuting Characteristics by Sex." data.census.gov, 2022. https://data.census.gov/table/ACSST1Y2022.S0801?g=050XX00US42077,42095.

[8] Lehigh Valley Planning Commission and Lehigh Valley Transportation Study. "2023 FutureLV The Regional Plan," November 15, 2023. https://drive.google.com/file/d/12oez71k4EV1c2npS-Su6liTT0cZLvl_h/view.

This influx is supported by the municipal, business, government, and planning leaders, who are focused on fostering sustainable job creation and economic development.[9]

2.4.2 *Extent of Developed Area*

Most urban development in the region has occurred in the area around Route 22 and I-78 from Route 100 east to the Delaware River. Interchange locations in this corridor have been popular sites for business and industrial locations since the late 1950s. The corridor is also bounded by rapidly developing suburbs such as Hanover and Bethlehem townships in Northampton County and Upper and Lower Macungie townships in western Lehigh County. Development in western Lehigh County grew quickly after the building of a long sewer interceptor from western Allentown to the industrial area around the I-78/Route 100 interchange in the late 1960s. Since its completion in 2002, Route 33 has also spurred significant commercial and industrial growth in Northampton County.

Expanses of farmland and other open space still exist in northwestern Lehigh County, southwestern Lehigh County, northeastern Northampton County and southeastern Northampton County. There is also an area of prime farmland south of Bath and Nazareth boroughs. However, industrial and residential development has greatly reduced farmland. Rural single-family subdivisions on large lots served by on-lot sewer and water are scattered throughout the region. In the less developed areas, individual lots or small groups of lots are found along existing roads and at rural road intersections.

2.4.3 *Development Trends*

Subdivision, development and zoning regulation in Pennsylvania, as well as comprehensive planning, is delegated through the Municipalities Planning Code (MPC). County planning agencies, such as the Lehigh Valley Planning Commission (LVPC), are tasked with the creation of the comprehensive plan to set the overall vision, goals, policies and actions for Lehigh and Northampton counties.

Within the *2023 FutureLV: The Regional Plan,* the Lehigh Valley Planning Commission (LVPC) sets out 5 major goals which it views as being key for ensuring a prosperous future for the Lehigh Valley. These 5 goals are[10]:

1. **Efficient and Coordinated Development Pattern**
   Growth in the Lehigh Valley should be directed toward a series of centers and corridors which will help create dynamic communities of the future while preserving the region's natural beauty, history, and agricultural land.

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[9] Lehigh Valley Planning Commission and Lehigh Valley Transportation Study. "2023 FutureLV The Regional Plan," November 15, 2023. https://drive.google.com/file/d/12oez71k4EV1c2npS-Su6liTT0cZLvl_h/view.

[10] Lehigh Valley Planning Commission and Lehigh Valley Transportation Study. "2023 FutureLV The Regional Plan," November 15, 2023. https://drive.google.com/file/d/12oez71k4EV1c2npS-Su6liTT0cZLvl_h/view?usp=embed_facebook.

2. **Connected Mixed-Transportation Region**
   Transportation in the Lehigh Valley should be supported by a seamless network where roads, rails, sidewalks, and technology connect everyone to every place. The system must be welcoming to drivers, walkers, and everyone in between.

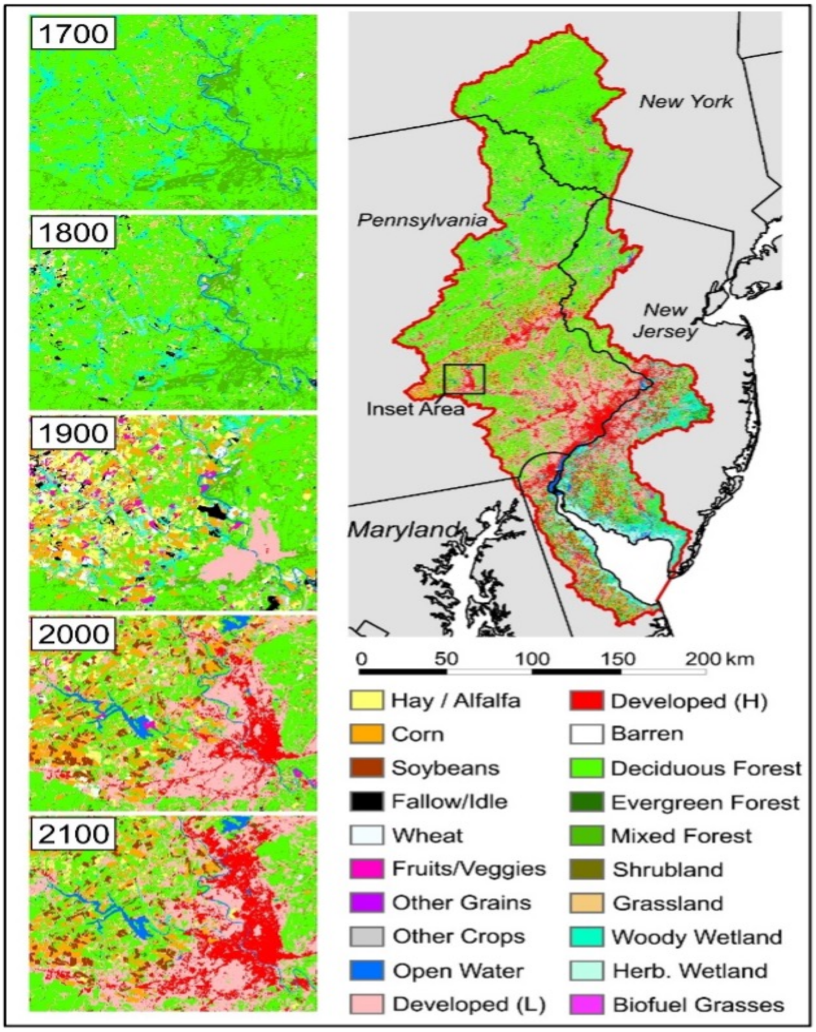
3. **Protected and Vibrant Environment**
   The Lehigh Valley should protect its land, water, and air preservers to ensure the region continues to be an attractive place to live, work, and visit.

4. **Competitive, Creative, and Sustainable Region**
   To maintain the region's advantage in a global economy, the Lehigh Valley should support agriculture and natural resources as economic assets and strive to give everyone equal access to attainable housing, jobs, and transportation. Cooperation among local governments and institutions will be essential to achieve this.

5. **Safe, Healthy, Inclusive, and Livable Communities**
   The Lehigh Valley should utilize targeted investments, innovated community designs, and the integration of housing, jobs, and transportation to help ensure the region remains a safe and inclusive place where housing is attainable and public assets are designed for everyone.

The following figure shows modeled land cover change in the Delaware River Basin from 1700 to 2100. The Forecasting Scenarios of land use (FORE-SCE) model was used to reconstruct historical landscapes back to 1700, and project future landscapes through 2100. The resultant long-term landscape database can be used to assess the impacts of land use on water quality, biodiversity, carbon and greenhouse gases, and other processes. Historical landscape reconstruction enables analyses of past relationships between landscape change and these processes, while future scenarios facilitate planning and mitigation efforts.

Figure 1: Map of the Delaware River Basin from 1700 to 2100



2.4.4 Housing

The Lehigh Valley has an estimated 277,414 housing units, with 149,548 in Lehigh County and 127,584 in Northampton County. Lehigh County has an occupancy rate of 95.4%, and Northampton County has an occupancy rate of 94.9%. Therefore, the Lehigh Valley has 263,985 households, with 142,970 in Lehigh County and 121,015 in Northampton County. More than half of the region's housing units are single-family detached homes. About 46% of residences were built after 1970, and one in four residences was built before 1940.

Homeowners occupy the majority of Lehigh Valley houses, while just under a third of residents are renters. Owner-occupied households dominate rural townships, while the region's cities and boroughs have higher shares of renter-occupied households. Vacancy rates are highest in the cities of Allentown and Easton and in northern Northampton County. However, the region's cities and exurban townships are experiencing an apartment-building boom.

2.4.5 Highways, Roadways and Associated Systems

The roadway network is by far the dominant system of travel infrastructure in the Lehigh Valley. It serves passenger vehicles, trucks and public bus transportation needs in the region. In 2016, there were 14,164,373 daily vehicle miles of travel on the entire regional road network. By 2030, this figure is anticipated to grow to 19,600,000. Six expressways, two of which are interstate highways, serve the Lehigh Valley. The interstate roads are I-78 and I-476. Other expressways are Route 22, a portion of Route 33, a portion of Route 309 and a portion of Route 378 through the City of Bethlehem. The area is also served by several smaller highways, including Route 222 and Route 145.

The Lehigh Valley's 912 bridges are owned by several entities that include the Commonwealth of Pennsylvania, Lehigh County, and Northampton County, municipalities, Pennsylvania Turnpike Commission, Delaware River Joint Toll Bridge Commission, railroad companies and private entities. Bridges with high traffic volumes in the area include the Route 22 Lehigh River Bridge, Route 33 Lehigh River Bridge, Route 329 Cementon Bridge, and the Route 145 Treichlers Bridge. Also, the Hamilton Street and Tilghman Street bridges in the City of Allentown, Hill-to-Hill, Fahy, and Minsi Trail bridges in the City of Bethlehem, 25th Street Bridge in Palmer Township, and the 3rd Street Bridge in the City of Easton. The average age of a bridge in the Lehigh Valley is 50 years old. More than 300 miles of multi-use pathways, which include the D&L and Appalachian trails, are balanced by a highway network that provides easy access to much of the Northeast, the Jersey Shore and the Ports of New York and New Jersey.

2.4.6 Railways

The dominant Class 1 freight carrier in the Lehigh Valley is the Norfolk Southern Railroad. The railroad's Newark, New Jersey to Harrisburg main line passes through the two counties. This line is part of the Central Corridor, the largest of the six priority freight corridors in the state. A secondary line extends north from Allentown to the Scranton area.

Multiple Norfolk Southern branch lines provide service to the shipping industry in the area, including the Cement Secondary line (serving the Forks industrial area) and the C&F Secondary (serving the Fogelsville area). A second Class 1 carrier, Canadian Pacific, also uses trackage rights to serve the Lehigh Valley. Canadian Pacific Rail has assumed the operations once provided by the Delaware and Hudson Railway.

The area is served by six short line railroads:

- RJ Corman – Allentown
- East Penn Railroad
- Northampton Development Corp. Railroad
- Belvidere & Delaware River Railroad
- Delaware Lackawanna Railroad

- Lehigh Valley Rail Management Railroad

These railroads operate several significant rail facilities within the Lehigh Valley. The Allentown Classification Yard is one of the major yards in the Norfolk Southern System. The Lehigh Valley Rail Management operates an intermodal terminal and container terminal, both in the City of Bethlehem.

2.4.7 Airports and Heliports

Lehigh and Northampton counties are served by air passenger carrier, air cargo and general aviation services. The Lehigh Valley International Airport (LVIA), located on a 789-acre site in Hanover Township, Lehigh County, provides passenger, general aviation, and air cargo services. The Lehigh-Northampton Airport Authority operates LVIA. In addition, the Queen City Airport in Allentown, Braden Airpark in Forks Township, the Slatington Airport, and the Flying "M" Aerodrome in Heidelberg Township also serve general aviation aircraft needs.

2.4.8 Public Transportation

The Lehigh and Northampton Transportation Authority (LANTA) operates the LANTA bus and LANTA van systems. The LANTA bus division provides fixed-route services along 28 routes and operates about 4.9 million trips annually. It serves the Lehigh Valley metropolitan area, including the cities of Allentown, Bethlehem and Easton and their surrounding municipalities. The LANTA van division provides more than 400,000 door-to-door trips a year for the region's elderly and those with disabilities.

In the 1980's, an intermodal center was developed in the City of Bethlehem to serve as a transportation hub. In the summer of 2007, a transportation hub was developed in Center City Allentown. A similar facility opened in 2015 on S. 3rd Street in Easton and is used by Trans-Bridge Lines, Inc., Greyhound, New Jersey Transit, LANTA and Fullington Trailways.

2.4.9 Non-Motorized Travel

The Lehigh Valley has a robust sidewalk and trail network that is used for recreation, and increasingly for commuting. The D&L Trail, in particular, connects the three cities, passing through several population and employment zones along the way.

2.5 Data Sources and Limitations

An extensive list of data sources was used to develop the 2024 Plan is provided in Appendix A. Sources used for the Plan include national, state and county data as well as published material.

Primary sources of data for the Community Profile section include the US Census Bureau for population and demographic data. The Lehigh Valley Planning Commission (LVPC) provided data on population and employment projections, development trends and transportation infrastructure. Existing GIS layers from the LVPC were used to create the mapping. Data from the 2018 Plan was reviewed and updated as appropriate with the best available data.

The risk assessment, loss estimates, exposure assessments and hazard-specific evaluations rely on the best available data and methodologies. Lehigh and Northampton counties provided existing spatial data, including tax parcels and building footprints for the hazard vulnerability assessments.

To assess the vulnerability of different jurisdictions to hazards, historical disaster event data was obtained from a variety of sources, including the National Climatic Data Center, Lehigh and Northampton WebEOC databases, and Pennsylvania Emergency Management Agency, among many others. The most current countywide FEMA flood maps for Lehigh County, effective July 2004, and Northampton County, effective July 2014, were used in the flood hazard risk assessment to evaluate exposure and determine potential future losses.

As additional data becomes available, estimates of vulnerabilities to natural and non-natural hazards can be refined for future plan updates.

3. Planning Process

3.1 Update Process and Participation Summary

This chapter provides a narrative description of the 2024 planning process. The steps taken to update the plan ensures the County's mitigation strategy is informed by input from key departments, community partners, residents, and stakeholders. Due to the timing of fund allocations, the imminent expiration of the 2018 bi-county plan, and a significant flooding event experienced mid-update, the 2024 update process was truncated to be completed in under eight months. However, this process maintained strategies for inclusive engagement and integration with existing planning efforts.

The 2024 Lehigh Valley Hazard Mitigation Plan meets the requirements of the 44 Code of Federal Regulations (CFR) Part 201 Mitigation Planning and the Federal Emergency Management Agency (FEMA) procedures dictated in its Local Mitigation Planning Policy Guide (FP 206-21-0002), effective April 19, 2023. This document was also developed in accordance with the 2020 Pennsylvania Emergency Management Agency (PEMA) Standard Operating Guide, in alignment with community input and involvement.

This update builds upon progress established and expanded upon by the 2018 update, which was accomplished through a 12-month process in collaboration with the Lehigh Valley Planning Commission. In 2018 more than two dozen presentations were delivered to community groups and the Lehigh Valley Planning Commission, regular media stories, a dedicated webpage, television appearances, public service radio announcements and an advertising campaign that included ads – in English and Spanish – on mass transit buses in the region were also incorporated. While five public meetings were also hosted, no members of the community attended. Due to this lack of participation, and in response to a change in community expectations following the COVID-19 Pandemic, the 2024 planning process moved to an entirely virtual public engagement strategy.

Completing the 2024 Lehigh Valley Hazard Mitigation Plan update involved numerous strategy meetings with the Steering Committee and a total of 15 Planning Team meetings. Three virtual public surveys were offered, a dedicated webpage hosted the plan for formal comment, and a virtual public meeting was held to facilitate awareness and discussion of the planning effort.

Summary of Changes

Significant and considerable changes have been made to both the layout and formatting of this Hazard Mitigation Plan update, as well as the presentation of content. Focus was directed toward consistent and clear alignment with the 2020 PEMA Standard Operating Guide and written with comprehension by the general public in mind.

Table 3 – Summary of Changes

Planning Process	While the 2018 planning process focused on broad, community engagement across a multitude of local committees, the 2024

	Planning Team meetings were intended to directly engage with municipal decision makers and engage these representatives in make positive, actionable steps toward more resilient communities. Focus of the process was on reconnecting with municipalities and reengaging entities across all EMA functions. The 2018 plan included in this chapter a discussion on Integration/Coordination with Existing Plans and Programs, which has been moved to the Capability Assessment section and a summary chart was added.
Data Presentation	Plan documents the summary of the data collection efforts and results, and less raw information. Detailed flood mapping and other data have been moved to appendices to facilitate readability and assist in the development of an actionable strategy.
Formatting	All formatting has been altered. • Document changed from landscape to Portrait Orientation • Document changed from grey scale and green lettering to blue and black • Increased used of visuals, diagrams, and tables make the information in the plan easier to read

3.2 The Planning Team

The 2024 Plan update began in 2023 with the creation of the Steering Committee that includes Lehigh and Northampton County Emergency Management officials, with guidance from PEMA and FEMA Region III. The Steering Committee is responsible for guiding overall direction of the planning effort, making day-to-day decisions, and developing a public outreach program. After Northampton County secured a FEMA planning grant on behalf of the region, the counties contracted with Witt O'Brien's through competitive selection to support the Lehigh Valley Hazard Mitigation Plan Update.

The Steering Committee outlined expectations and provided significant data to support the update. Under their direction, the Planning Team was established comprising all 62 municipalities and two regional Authorities. A full list of the more than 130 participants in the planning team is contained in Appendix C. Diligent efforts were made to assure broad regional, county and local participation during the planning process. Regional stakeholders were invited to participate on the Planning Team, including officials from hospitals, churches, transportation organizations, public utilities, economic development organizations, businesses, non-profit organizations, universities, school districts, neighboring counties and environmental groups, as well as officials from local, county, state and federal agencies.

Table 4: Steering Committee Members

Jurisdiction	Name	Agency	Title
Northampton County	Todd K. Weaver, ENP	Northampton County Emergency Management Services	Deputy Director, Systems Management
Northampton County	Thomas Guth	Northampton County Emergency Management Services	Hazard Mitigation /Disaster Recovery Manager
Lehigh County	Tanya Hook	Lehigh County Office of Emergency Management	Director
Lehigh County	John Semonich*	Lehigh County Office of Emergency Management	Community Outreach Manager
Lehigh County	Kevin Krotzer	Lehigh County Office of Emergency Management	Special Operations Team Coordinator
Lehigh County	Nicole Burton	Lehigh County Office of Emergency Management	Planning Coordinator

**No longer in this position.*

3.3 Meetings and Documentation

Municipalities and stakeholders met as needed to review the planning process, update and assess critical facilities and capabilities, provide information and input on hazards and risks, and to develop goals, objectives and mitigation actions. Hazard event history, changes in hazard risk, including new and anticipated development and mitigation actions over the last five years were considered. Revised goals and new mitigation actions resulted from the strategic, collaborative effort. Further description of these meeting events is detailed below, with a full accounting of the update schedule following.

Kick Off Meeting

Two virtual Kickoff meetings were held on June 15, 2023 from 10:30 to 12:30 ET (with 28 municipal attendees) and 6pm to 8pm ET (5 municipal attendees). Since many municipal representatives function in a volunteer capacity or have other full-time work, this schedule allowed attendees to select the meeting that fit their schedules best. During each kickoff, the Planning Team completed an Evaluation of Hazards worksheet, identified any significant hazard events since the last update, documented any increase or decrease in the regularity of events, and discussed the addition of new hazards. Planning Team Members were introduced to the request for validation of community assets and asked for recommended entities and points of contact to meet element A2.a for stakeholder incorporation.

Capability Workshops

During the kickoff meetings, the Planning Team was asked to register for one of four Capability workshops to be held in-person on June 28th and 29th. Due to travel impacts due to weather, the workshops were led virtually, but all attendees participated in-person. The Northampton County Emergency Operations Center (EOC) hosted two meetings from 9am-11am (22 municipal attendees) and 4pm-6pm (10 municipal attendees) on June 28th. Lehigh County hosted two matching sessions on June 29th at the Cetronia Ambulance Corps (with 12 and 5 municipal attendees). Representatives from FEMA Region III and PEMA performed a site visit between the planning team meetings on June 28th to discuss process, timelines, and expectations with representatives from both counties and Witt Obrien’s.

During the workshops participants:

- Revisited “Critical Facilities”, “Community Lifelines”, and “Community Assets”.
- Validated assets pulled from Hazus and supplemented by data from both county GIS offices.
- Were asked to provide updates to development, populations, underserved communities, climate change, and municipal authority or policies.
- Reviewed the FEMA Region III Community Capability Assessment Worksheet.
- Updated the capability sections of the HMP annexes.
- Discussed opportunities for public and stakeholder outreach.

Municipalities were specifically asked to identify opportunities for public outreach events throughout the fall, beginning in August. Unfortunately, late July storm impacts derailed this targeted outreach and Emergency Management focus shifted to response, recovery, and post-disaster impact assessments.

However, due to the nature of post-disaster community assessments significant public outreach did occur during this period, specifically around flood mitigation, flood insurance, Substantial Damage, NFIP compliance, and adherence to building standards.

Planning Alignment with THIRA/SPR

On August 23rd, members of the Witt O'Brien's team conducted two, three-hour intensives to finalize each County's update to their Threat Hazard Identification and Risk Assessment – Stakeholder Preparedness Review. Capabilities, as well as gaps or needs, in alignment with the Hazard Mitigation Plan were also captured and incorporated where appropriate throughout the Hazard Mitigation Plan. Updates to the SPR were turned over to the Counties in September and appropriately routed through the Regional Task Force ahead of their October 31st state deadlines.

HIRA Meeting

On October 19th, the Northampton EOC was made available for in-person, drop-in, "office hours" to discuss the plan, worksheet opportunities, and to discuss and update all aspects of the municipal annex. "Office hours" were held from 12pm-4pm ET (with 18 municipal participants) followed by the first of two Hazard Identification and Risk Assessment Review Meetings from 4pm to 6pm (with 16 attendees). On October 20th, the second HIRA review meeting was held from 9am-11am ET (with 19 municipal attendees), followed by the second "office hour" session at the Cetronia Ambulance Corps from 11am to 3pm (with 2 municipal participants).

Following the HIRA meeting, planning team members were given a virtual "worksheet" opportunity that served several needs. With 38 municipal respondents, it functioned as an additional way for municipalities to contribute data to the plan, it also facilitated municipal understanding of their own jurisdictional authority and processes by requiring them to identify key positions in their governments (like floodplain managers, public works directors, engineers, and legal and fiscal authority), as well as allowing the Counties to update municipal point of contact lists for future engagements.

Mitigation Strategy Meetings

On January 18th, a single Hazard Mitigation Strategy Meeting was presented at the Cetronia Ambulance Corps to 38 attendees through hybrid participation. Following the 1-hour meeting, two Strategy and Action Development Workshops were held at Cetronia Ambulance Corps from 10am-11am (9 participants) and 4pm-6pm ET (6 participants). Due to winter weather impacts, only one of the two planned in-person workshops were held at the Northampton EOC on January 19th. From 9am to 12pm (with 6 participants), while 6 planning team members accepted a virtual one-on-one option and completed their consultations between 9am and 2pm ET. All members of the planning team were emailed three worksheets following the end of the Strategy Meeting and each workshop participant was handed paper versions. These worksheets covered Hazard Ranking, Goal and Objective review, and Mitigation Actions Assessment.

The activities of the Planning Team were facilitated by Witt O'Brien's. Among various duties, the consultant was responsible for coordinating and conducting regular Steering Committee meetings, developing and hosting scheduled public engagements, compiling existing data sets to assess the risks posed to community assets by natural hazards, responding to the concerns raised by Planning Team members and other constituents, and ultimately producing a full draft of the bi-county Hazard Mitigation plan in compliance with PEMA and FEMA standards.

Table 5 – List of Plan Update Meetings

Date	Attendees	Location/Delivery	Topics
May 22, 2023	Steering Committee	Virtual – Teams	Timeline and Process. Review Planning Team Invitation
May 24, 2023	Steering Committee	Virtual – Teams	Kickoff meeting and initial workshop finalization Participant invitation list 1) Element A2.a 2) Utility and lifeline providers 3) Quasi-governmental entities 4)Finalize community contacts Public Participation Technical Approach 1) HHPD 2) Climate Change 3) Updated Assets List 4) HAZUS 5) Hazards to be profiled Format and organization of the planning document 1) Font 2) Layout 3) Graphics 4) Color Scheme
June 5, 2023	Steering Committee	Virtual – Teams	Review Kickoff meeting content. Review critical facility lists provided 5/26/23 and data collection progress. SPR workbook discussion. Public Survey – draft provided to Counties on 6/6/23.
June 15, 2023	Planning Team Coordination call with PEMA	Virtual – Teams Phone	Kickoff Meeting 1 Kickoff Meeting 2 Sub-grant documentation requirements, timeline, state

			expectations.
June 20, 2023	Steering Committee Meeting	Virtual – Teams	Review workshop content and slide deck, make edits. Review sign-up progress. Review data collection and validation progress and status of data request made to County GIS.
June 28, 2023	Planning Team PEMA and FEMA RIII Steering Committee meeting.	Northampton EOC (moderated virtually via Teams) Northampton EOC (consultant participation virtually via Teams)	Capability Workshop 1 Capability Workshop 2 • Review the State's expectations and ensure all mandatory items are addressed. • Review the updated timeline and set expectations. • Review the public outreach strategy and discuss modification to the SOW. • Discuss the incorporation of socially vulnerable populations. • Review the sub-grant agreement and required documentation.
June 29, 2023	Planning Team	Cetronia Ambulance Corps	Capability Workshop 3 Capability Workshop 4
July 13, 2023	Steering Committee	Virtual – Teams	1) Confirm if any municipality will seek BRIC or FMA funding 2) Provide a list of stakeholders and contact information for a relevant POCs 3) Review the list of critical facilities and update 4) Provide County GIS information 5) Review the new survey draft and provide any feedback 6) Next meeting scheduling
July 18, 2023	Steering Committee	Virtual – Teams	Met briefly to discuss current

			emergent situation. All other topics placed on hold.
August 7, 2023	Steering Committee	Virtual – Teams	1) Provide stakeholder contact information for a relevant POCs 2) Review the list of critical facilities and update 3) Provide County GIS information 4) Release Public Survey 5) NFIP, RL and SRL data. 6) e911 data table updates
August 23, 2023	Lehigh County EMA Northampton County EMA Steering Committee	Cetronia Ambulance Corps Northampton EOC Northampton EOC (participation by Lehigh virtually via Teams)	SPR Workbook workshop and updates SPR Workbook workshop and updates Discus and finalize schedule. Plan for the 3rd Hazard Mitigation Planning Team Meeting (tentatively targeting October 18th) Public Survey (preliminary results may be available depending on release) Review any items that require consensus, like data collection cut-off dates
August 28 – September 30, 2023	Public Survey #1	Virtual - SurveyMonkey	Hazards and Impacts
September 11, 2023	Steering Committee	Virtual – Teams	Review any remaining SPR concepts. Review any remaining HMP data items. Lehigh Valley Planning Commission PEMA Lehigh Northampton Finalize Public Outreach Strategy Discuss Stakeholder Incorporation
September 20, 2023	FEMA Region III	Virtual – Zoom	National Presentation “Coffee Break” on Providing Clarity on the New Hazard Mitigation Planning Guidance
September 21, 2023	Lehigh County GIS	Virtual – Teams	Review outstanding requests and discuss resolutions.
September 25,	Steering Committee	Virtual – Teams	Finalize SPR and submission

2023			to the Task Force. Scheduling steering Committee meetings Sending Planning Team invitations Gisa and data validation progress.
September 27, 2023	Lehigh Valley Planning Commission	Virtual – Teams	Data collection and validation
October 5, 2023	Steering Committee	Virtual – Teams	Review Meeting slide deck and content.
October 15 – 17, 2023	Steering Committee, County one-on-ones	Altoona Convention Center	Coordination with county-wide representatives.
October 19, 2023	Steering Committee Planning Team	Northampton EOC Northampton EOC	NFIP data, HHPD data. Formatting and timelines updates Participant "office-hours" HIRA meeting
October 20, 2023	Planning Team	Cetronia Ambulance Corps	HIRA meeting Participant "office-hours"
November 15, 2023	Steering Committee	Virtual – Teams	Review Public Survey #2 Next Planning Team Meeting Scheduling Upcoming Planning Team Worksheets SurveyMonkey Actions Prioritization Worksheet Executive Summary Strategy and Actions
November 29 to December 14, 2023	Public Survey #2	Virtual – Survey Monkey	
December 7, 2023	Steering Committee	Virtual – Teams	
January 11, 2023	Steering Committee	Virtual – Teams	Municipal Participation Update
January 18, 2024	Planning Team Steering Committee Planning Team	Cetronia Ambulance Corps Cetronia Ambulance Corps Cetronia Ambulance Corps	Mitigation Strategy meeting. Action Development Workshop Hazard impacts. Draft plan review comments. Timeline. Action Development Workshop
January 19, 2024	Planning Team	Northampton EOC	In person and virtual Action Development Workshops
February TBD	Steering Committee	Virtual – Teams	Public Meeting content review. Municipal participation review.

February 12-February 26, 2024	General Public and Community Stakeholders	Virtual - SurveyMonkey	Public Survey #3
February 13, 2024	General Public and Community Stakeholders	Virtual – Teams	Public Review Meeting
February or March TBD	Steering Committee	Virtual – Teams	TBD

3.4 Public & Stakeholder Participation

The two counties, along with the sixty-two municipalities, have an extensive library of existing documents, plans, and datasets – listed below - which were reviewed and incorporated into the 2018 plan. Data was collected and synced with the previous version of the Plan. Any newly discovered data has been incorporated into the 2024 update. To the extent possible, long-range data consistent with climate change trends was incorporated into the overall risk assessment with special attention given to hazards for which climate change is expected to accelerate.

The counties also assist in planning for facilities and events in an ongoing capacity that are either shared or have multijurisdictional involvement and/or boundaries such as Lehigh Valley International Airport, County Prisons, medical facilities, dams, power stations, plans that involve multiple jurisdictions such as EOPs and mass casualty plans, etc. A full listing of these associated planning efforts is found in Appendix __.

- FutureLV (Comprehensive Plan Update)
- One Lehigh Valley
- Climate and Energy Element
- One Water (County Planning Directors Association of Pennsylvania)
- Livable Landscapes: an Open Space Plan for Northampton County
- Livable Landscapes: A Park, Recreation, Open Space, Agricultural and Historic Lands Plan for Lehigh County
- Lehigh Valley Return on Environment
- Lehigh Valley Greenways Plan
- Natural Resources Plan
- Natural Heritage Inventory of Lehigh and Northampton Counties
- Floodplain Guide/Model Regulation
- Riparian and Wetland Buffers Guide/Model Regulation
- Woodlands Guide/Model Regulation
- Steep Slopes Guide/Model Regulation
- Conservation Subdivisions Model Ordinance
- Lehigh Valley Capital Improvement Plan
- Northampton Capital Improvement Plan
- Municipality Capital Improvement Plans

- Continuity of Operations Plans
- Open Space Management Plans
- Natural Resource Protection Plans
- Municipal Transportation Plans
- MoveLV Long Range Transportation Plan
- Municipal Historic Preservation Plans
- Municipal Evacuation Plans
- Municipal Disaster Recovery Plans
- Municipal Subdivision and Land Development Ordinances
- Municipal Zoning Ordinances and Regulations
- Pennsylvania Uniform Construction Code
- Municipal Fire Codes
- Lehigh Valley Act 167 Stormwater Management Plan
- Green Infrastructure Guidelines
- Monocacy Creek Watershed Act 167 Stormwater Management Plan Update
- Recommended Procedures for Act 167 Drainage Plan Design
- Technical Best Management Practice Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed
- Emergency Operations Plans

Public Survey #1

The first public survey was released via social media by both Northampton and Lehigh Counties and ran from August 28 to September 30, 2023. There were 379 respondents with 74.93% of respondents reporting living in Northampton and 24.54% in Lehigh. A total of 2 respondents were from outside the valley. Within Northampton respondents came from 33 municipalities with the majority residing within Wilson Borough (33.33%) and Forks Township (14.89%). While in Lehigh 22 municipalities were represented and only one municipality represented more than 5% of respondents (South Whitehall Township with 5.51%).

Questions in the survey included quantifying the level of concern about community impacts due to natural hazards. Responses followed a bello cure with a slight majority (30.11%) reporting feeling “Somewhat Concerned”. Concern for impacts due to climate change were evenly distributed (22.57% to 20.86%) between “Not at all concerned” and “Moderately concerned” reflecting the politically purple landscape of the region.

Following another bell curve, a majority of respondents (28.2%) ranked municipal disaster preparedness at “Somewhat prepared” and County preparedness also as “Somewhat prepared” at 31.69%. The top three natural hazards as ranked by the public were:

1. Flood – 57.88%
2. Winter Storm – 55.45%
3. Sinkhole – 49.09%

Following reflection by the planning team and follow up questions in Public Survey #2, it was determined that the relatively high ranking of sinkholes reflects general public fear, lack of public awareness on susceptibility, and the hazard's ability to overwhelmingly both impact personal safety and cause property damage.

The top three human-caused hazards as ranked by the public were:

1. Utility Interruption – 56.8%
2. Transportation Crashes – 41.99%
3. Drug Overdose – 38.37%

Relatively high rankings for both transportation crashes and drug overdose are to be expected. While specific recorded instances may be due to actions taken by an individual or small groups on individuals, harmful impacts can be far reaching, require significant monetary investment, and long-term systemic change to make progress. Utility interruptions, on the other hand, are a common cascading impact due to both natural and human caused hazards. Power failure also has the potential to both impact personal safety and cause property damage.

The survey also asked for the number of hazard impacts respondents had experienced while residing within the Counties, and asked if any independent steps had been taken to make homes, businesses, or neighborhoods more resilient. 41.67% indicated they had taken resiliency steps, while 58.33% had not. 46.88% of respondents indicated interest in future residential mitigation programs, with 16.32% responding “No” and 36.81% responding “I don't know”. When asked to indicate which types of programs they had interest in 52.17% indicated property tax breaks for residential mitigation with five other suggests receiving at least 24% interest.

When asked if the respondents would prefer a future in-person or virtual public meetings 26.23% responded as “None of the above” and 52.46% selecting “Virtual”. Only 21.31% of respondents indicated a preference for in-person meetings. This response helped shaped the public outreach strategy for the remainder of the update process.

The majority of respondents to the first public survey had either some college experience or had completed a bachelor's degree, but charted across all educational ranges from high school to PHD. Respondents were from all age ranges, under 20 to over 70, with 23.57% as the majority between 60-69 years old. Income and gender were also evenly distributed, with 2 respondents selecting “non-binary”. Race had the largest discrepancy with 86.74% identifying as “White or Caucasian”. This data point was discussed with the Steering Committee as an item for improvement in future outreach strategies. This indicts that social media updates from the Counties may not be reaching some sectors of the population, creating a vulnerability gap.

Public Survey #2

The second public survey was open from November 29 to December 14, 2023. Public Survey #2 quantified public perception of each hazard and provided valuable data on actions that the public may be receptive to. Of the 400 respondents to this survey, 46.5% worried about disasters “Several times a year”. If an evacuation notice was issued 66.75% of respondents would not know where to go. Across 4 hazards (extreme temperatures, floods, winter storms, wind) cascading impacts to utilities were by far the number one concern, and ranked high for 9 additional hazards (drought, sinkholes, wildfire, lightning, earthquake, hailstorms, landslides, urban fire, building collapse) followed in most cases by personal safety.

83.15% of respondents indicated positive opinion and interest in programs to utilize native vegetation and decrease water utilization, with 59.39% interested in rain gardens, surprising the planning team. Another 71.86% expressed support for daylighting and naturalizing stream beds and floodplains. Of note, 55.05% indicated support for hurricane straps and 62.27% in other building code improvements, with 36.86% expressing interest in code standards that could increase flood insurance discounts (if the community applies and maintains credits under the Community Rating System). Community perception of building codes was perceived by the Planning Team to be a complete nonstarter. 45,27% indicated interest in joining a community group to foster emergency preparedness, community support, and discuss future mitigation opportunities.

While 57.96% indicated no interest whatsoever in flood insurance, in alignment with planning team expectations. Numerous Mitigation Actions were developed during the planning process to providing community education on insurance, flooding, and NFIP compliance. While respondents did indicate some interest in other types of flood mitigation, there was no general consensus for a single program. The Planning team's perception that flood mitigation is first an education issue, and second requires nuanced, case-by-case solutions was supported by these results.

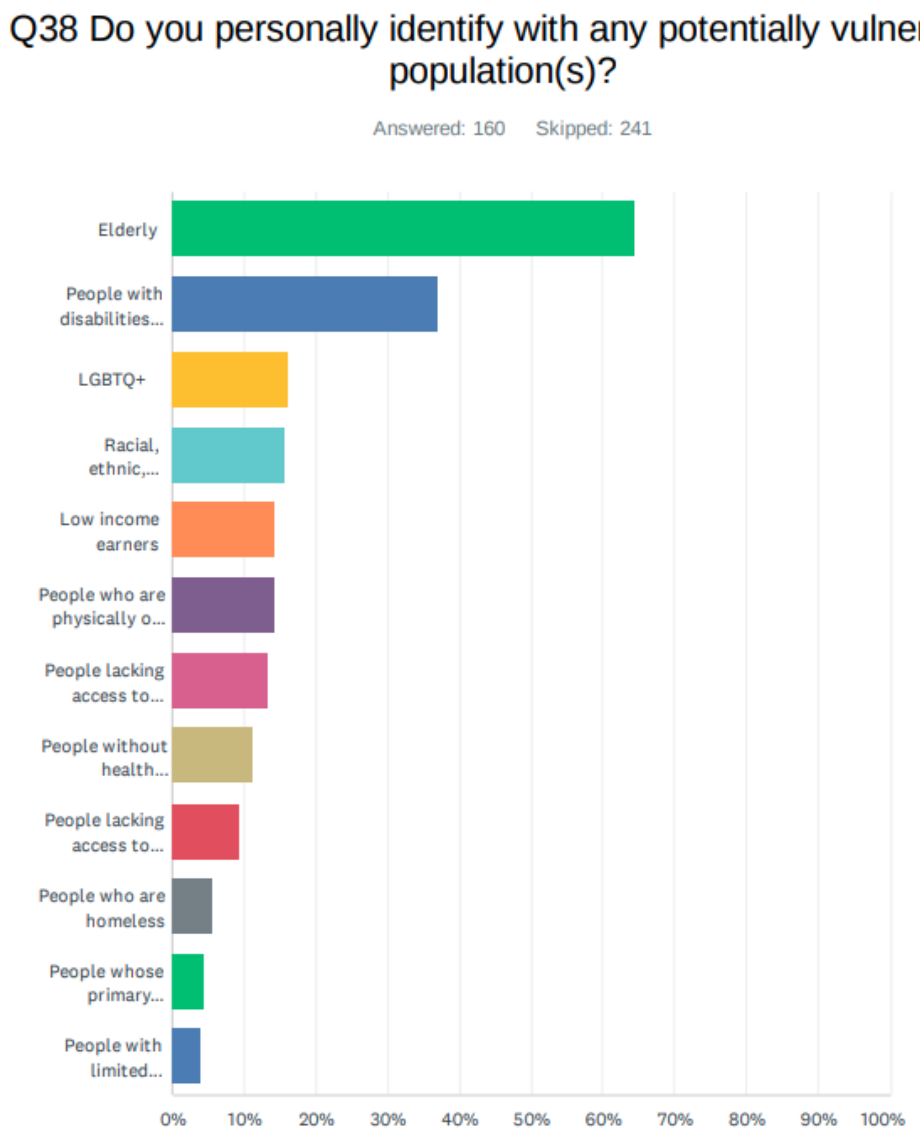
When asked to assess concern due to dam or levee failure, concern was split almost equally across all sectors. This leads to the analysis that the general public is not aware what is at risk due to this kind of failure, and may be unaware of the hazard entirely. Across most human-caused hazards, personal safety was generally of utmost concern.

When asked to identify which vulnerable populations respondents felt were most at risk to natural hazards, the top three selected were:

1. Elderly – 96.54%
2. People with disabilities or functional needs – 86.51%
3. People who are homeless – 74.74

Respondents were then asked to self-identify with any of the following groups. Results are listed below.

Figure 2: Public Survey #2 – Vulnerable Populations



Respondents once again were from all age ranges, from 20 to over 70, with a 25.84% tie between 50-59 and 60-69 years old. Most had completed a bachelor's or Master's degree, but charted across all educational ranges from high school to PHD. Income was skewed higher this time, with the majority 23.31% calculating their annual household income above $100k, 54.36% were women and 88.93% were "White of Caucasian". 86.58% also indicated they were homeowners.

Public Survey #3

A final Public Survey was released, along with the draft version of the Plan for virtual public review and comment on February 12, 2024. The results of that survey are pending. Social media and the LVPC homepage were used to promote comment to the Plan. The Plan was altered to reflect those comments.

In-the field discussion of flooding issues, mitigation, insurance, and future hazard events due to flooding in July 2023 and recovery efforts throughout August 2023.

Stakeholder incorporation focuses primarily on quasi-governmental entities like the Lehigh Northampton Airport Authority, Lehigh Water Authority, and Lehigh Valley Planning Commission. However, data coordination and integration conversations were held with the Penn State Extension team, an institution of higher learning.

Representatives from these stakeholder organizations participated in the planning process by attending Planning Team or public meetings and providing input:

- American Red Cross of the Greater Lehigh Valley
- Allentown Health Bureau
- Bethlehem Health Bureau
- Borton – Lawson Engineering
- Citizen's Climate Lobby
- Community Action Committee of the Lehigh Valley
- Jewish Federation of the Lehigh Valley
- J.G. Petrucci Co.
- Lehigh County Authority
- Lehigh University
- Hanover Engineering
- Northampton County Council
- Nurture Nature Center
- Office of Congressman Cartwright
- PA One Call System
- Parkland School District
- Partnership for Disability Friendly Community
- Pennsylvania Department of Environmental Protection
- Pennsylvania Emergency Management Agency
- Penn State Extension
- St. Luke's Hospital
- US Transportation Security Administration
- Wildlands Conservancy

The comment period for the draft Lehigh Valley Hazard Mitigation Plan began DATE and continued through DATE.

3.5 Multi-Jurisdictional Planning

All municipalities participated in the 2006 and 2013 plans, with all adopting the 2006 Plan, but only 37 adopting the 2013 Plan. All 62 municipalities adopted the 2018 plan. The goal for the 2023 update was to reestablish connections between municipal points of contact and County EMA that were strained by the priorities and lack of access due to the COVID-19 pandemic. Throughout the planning process, each municipality was emailed a reminder prior to every Planning Team meeting. The County points of contact personally called municipalities that had not responded to invitations and also offered one-on-one technical assistance to facilitate collaboration. Unfortunately, 6 Northampton municipalities and 6 Lehigh municipalities failed to respond to these combined efforts.

Following the approval of the 2018 Hazard Mitigation Plan, the County leads faithfully and diligently maintained the Hazard Mitigation Plan. The following is an account of maintenance activities since the 2019.

- **August 15, 2019**: First Annual Review Meeting was held. Members of 62 participating municipalities along with members of the Planning and Administrative Teams were invited to attend.
- **September – December 2019**: Gathered information documented via municipal partners on the annual questionnaire provided at the annual review meeting. Also documented all updates requested to each respective municipal annex and the other plan documents, appendixes.
- **December 2019 – January 2020**: Supplied PEMA and FEMA both emails with files outlining the changes / updates made to the Lehigh Valley Hazard Mitigation Plan and all of its documents during the annual review period.
- **October – November 2020**: Due to COVID-19 mitigation efforts and ongoing potential recovery process due to Tropical Storm Isaias the team was unable to establish an in person Annual Review Meeting with the municipalities and stakeholders. The volume of possible attendees also made it difficult to find a date / time to schedule a "virtual" Annual Review Meeting.
    - In absence of a formal in person Annual Review Meeting, the chairpersons (Lehigh & Northampton County EM offices) created an online questionnaire/survey that was sent out electronically to the municipalities and stakeholders.
    - With this questionnaire/survey we also provided the municipalities and stakeholders information on the current FMA / BRIC grant opportunities, areas to review of each of their municipal annexes, Tropical Storm Isaias news (as of the date of the emails sent), COVID-19 recovery process information specific to DR-4506 and other pertinent information.
- **December 2020 – February 2021**: Gathered information documented via municipal partners on the annual questionnaire. Also documented all updates requested to each respective municipal annex and the other plan documents, appendixes.
- **March 2021**: Supplied PEMA and FEMA both emails with files outlining the changes / updates made to the Lehigh Valley Hazard Mitigation plan and all of its documents during the annual review period.
- **September - October 2021**: Due to COVID-19 mitigation efforts and ongoing potential recovery process due to Tropical Storm Ida the team was unable to establish an in person Annual Review Meeting with the municipalities and stakeholders. The volume of possible attendees also made it difficult to find a date / time to schedule a "virtual" Annual Review Meeting.

    - In absence of a formal in person Annual Review Meeting, the chairpersons (Lehigh & Northampton County EM offices) created an online questionnaire/survey that was sent out electronically to the municipalities and stakeholders.
    - With this questionnaire/survey we also provided the municipalities and stakeholders information on the current FMA / BRIC grant opportunities, areas to review of each of their municipal annexes, Tropical Storm Ida news (as of the date of the emails sent), COVID-19 recovery process information specific to DR-4506 and other pertinent information.
- **December 2021 – January 2022**: Gathered information documented via municipal partners on the annual questionnaire. Also documented all updates requested to each respective municipal annex and the other plan documents, appendixes.
- **February 2022**: Supplied PEMA and FEMA both emails with files outlining the changes / updates made to the Lehigh Valley Hazard Mitigation plan and all of its documents during the annual review period.
- **October – November 2022**: Provided all municipal annex point-of-contacts a copy of the review guide to go over their respective annexes and return any requested edits, updates or changes to us by November 1st.
    - Held an in-person Annual Review Meeting at the ArtsQuest facilities in Bethlehem, PA on Friday, November 4th.
    - Also held a virtual Annual Review Meeting for all stakeholder, partners, etc. on Monday, November 14th.
- **December 2022**: Completed the update of all the municipal annexes including the county Master Plan, and the county annex within the document. Supplied PEMA and FEMA both emails with files outlining the changes / updates made to the Lehigh Valley Hazard Mitigation plan and all of its documents during the annual review period.

A full chart detailing the level of participation by each jurisdiction over the 5-year maintenance period, as well as the participation of each municipal representative in this update process in contained in Appendix C.

Municipalities were informed throughout that only municipalities that participate – attend at least one meeting and complete at least one data contribution or worksheet effort - in the 2023-2024 update process, and adopt the Plan, would be eligible for hazard mitigation project grant funding.

In the months after the Plan receives FEMA and PEMA approval, an outreach campaign will be launched to prompt Plan adoption by all municipalities. The County leads will provide each municipality with a summary of the Plan and a copy of their municipal annex.

4. Risk Assessment

4.1 Update Process Summary

As mentioned in section 3.1, changes made throughout this document since the 2018 version are significant. Of note, two additional hazards have been added to the profiled hazards list: Gas/Liquid Pipelines and Cyber-Terrorism. In addition, the risk assessment has been updated to reflect all requirements of the 2020 PEMA SOG, quantifies impacts to community lifelines, and documents changes since the last plan update.

Participating jurisdictions had opportunity to thoroughly review the results of the HIRA and discuss individual impacts to each jurisdiction through the in-person, drop-in, “office hours” in October, coordinated alongside two deliveries of formal HIRA review presentations. The Witt O’Brien’s team also aligned any information relevant to the development of the HIRA with the Threat Hazard Identification and Risk Assessment – Stakeholder Preparedness Review process completed in the fall.

4.2 Hazard Identification

4.2.1 Table of Presidential Disaster Declarations

The historic occurrence of disaster in the region provides key context for the estimation of those hazards’ future frequency and magnitude. There are several avenues through which a disaster can be officially recognized:

Federal

- Presidential Major Disaster or Emergency Declaration: A formal announcement by the President marking an event as a disaster or an emergency.
- Small Business Administration (SBA) Administrative Declaration: Agency-level declaration that recognizes the impact on local businesses and qualifies the area for specific assistance.

State

- Gubernatorial Disaster Declaration or Proclamation: The Governor's formal acknowledgment of a disaster within the state's boundaries.

Detailed records of all disaster declarations impacting both Lehigh and Northampton Counties since 1955 can be procured from FEMA, PEMA, and the SBA. Between 1955 and 2023, the combined data shows that these counties experienced 18 Presidential Disaster Declarations and 7 Emergency Declarations. Predominantly, these declarations were in response to floods, winter storms, and hurricanes or tropical disturbances.

Since the comprehensive update in 2018, FEMA records indicate two Presidential Major Disaster Declarations: the global COVID-19 pandemic in 2020 and Hurricane Ida in 2021. Before the Major Disaster Declaration, COVID-19 was also declared to be an Emergency.

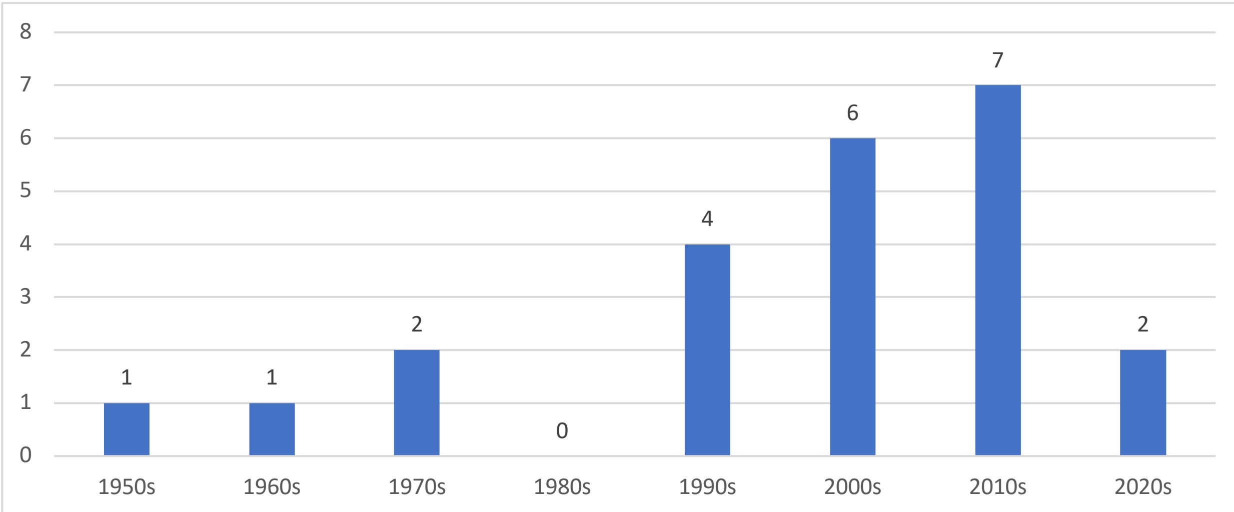
Table 6: Presidential Disaster Declarations & Emergency Declarations

Date	Event	Counties Affected
September 2021	Hurricane Ida (DR-4618)	Northampton
March 2020	COVID-19 (DR-4506 / EM-3441)	Lehigh & Northampton
August 2018	Flooding (DR-4408)	Northampton
March 2016	Winter Storm (DR-4267)	Lehigh & Northampton
January 2013	Hurricane Sandy (DR-4099)	Northampton
October 2012	Hurricane Sandy (EM-3356)	Lehigh & Northampton
September 2011	Tropical Storm Lee (DR-4030)	Northampton
September 2011	Tropical Storm Lee (EM-3340)	Lehigh & Northampton
September 2011	Hurricane Irene (DR-4025 / EM-3339)	Lehigh & Northampton
June 2006	Flooding (DR-1649)	Northampton
September 2005	Hurricane Katrina (EM-3235)	Lehigh & Northampton
April 2005	Flooding (DR-1587)	Northampton
September 2004	Tropical Depression Ivan (DR-1557)	Lehigh & Northampton
September 2004	Tropical Depression Frances (DR-1555)	Lehigh & Northampton

Date	Event	Counties Affected
February 2003	Winter Storm (EM-3180)	Lehigh & Northampton
January 1996	Flooding (DR-1093)	Lehigh & Northampton
January 1996	Blizzard (DR-1085)	Lehigh & Northampton
March 1994	Winter Storm (DR-1015)	Lehigh & Northampton
March 1993	Heavy Snowfall (EM-3105)	Lehigh & Northampton
July 1973	Flooding (DR-400)	Northampton
June 1972	Tropical Storm Agnes (DR-340)	Lehigh & Northampton
August 1965	Drought (DR-206)	Lehigh & Northampton
August 1955	Hurricane Diane (DR-40)	Lehigh & Northampton

According to the data, the months of September (seven) and March (six) have seen the most disaster declarations. As illustrated by the chart below, the number of federally-declared disasters by decade has increased over time.

Figure 3: Federal Disaster Declarations by Decade



4.2.2 Summary of Hazards

As part of the 2024 planning process, the Lehigh Valley Hazard Mitigation Planning Team reviewed the hazards of concern profiled in the 2018 Lehigh Valley Plan as well as those identified in the Pennsylvania 2023 State Hazard Mitigation Plan. The Planning Team also considered the history of hazard events that have occurred in the Lehigh Valley, including those that occurred since completion of the 2018 Plan.

The 27 hazards selected for profiling in the 2024 Plan are provided in the following table, along with hazard descriptions.

Table 7: List of Natural Hazards Profiled in the 2024 Lehigh Valley Hazard Mitigation Plan

Natural Hazards	
Profiled Hazards	**Description**
Extreme Temperatures 	Extreme temperature hazards are not tied to a specific temperature threshold; instead, these hazards occur when the temperature is extremely high or extremely low. Extreme heat often results in the highest number of annual deaths of all weather-related hazards. In most of the United States, extreme heat is defined as a long period (2 to 3 days) of high heat and humidity with temperatures above 90 degrees.[11] Extremely cold air comes every winter in at least part of the country and affects millions of people across the United States. The arctic air, together with brisk winds, can lead to dangerously cold wind chill values. People exposed to extreme cold are susceptible to frostbite and hypothermia in a matter of minutes.
Flood 	Flooding (includes Flood, Flash Flood, Ice Jam) is the temporary condition of partial or complete inundation of normally dry land and it is the most frequent and costly of all natural hazards in Pennsylvania.[12] Flash flooding is usually a result of heavy localized precipitation falling in a short time period over a given location, often along mountain streams and in urban areas where much of the ground is covered by impervious surfaces. Winter flooding can include ice jams which occur when warm temperatures and heavy rain cause snow to melt rapidly. Snow melt combined with heavy rains can cause frozen rivers to swell, which breaks the ice layer on top of a river. The ice layer often breaks into large chunks, which float downstream, piling up in narrow passages and near other obstructions such as bridges and dams.

[11] Ready.gov. "Extreme Heat." Ready.gov, September 6, 2023. https://www.ready.gov/heat.
[12] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Natural Hazards	
Profiled Hazards	**Description**
Winter Storm 	A winter storm is a storm in which the main types of precipitation are snow, sleet, or freezing rain. A winter storm can range from a moderate snowfall or ice event over a period of a few hours to blizzard conditions with wind-driven snow that lasts for several days. Most deaths from winter storms are not directly related to the storm itself, but result from traffic accidents on icy roads, medical emergencies while shoveling snow, or hypothermia from prolonged exposure to cold.[13] A winter storm can adversely affect roadways, utilities, business activities, and can cause loss of life, frostbite and freezing conditions. They can result in the closing of secondary roads, particularly in rural locations, loss of utility services and depletion of oil heating supplies.
Windstorm / Tornado 	A tornado is a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground. About 1,250 tornadoes hit the U.S. each year, with about 16 hitting Pennsylvania. Damaging winds exceeding 50-60 miles per hour can occur during tornadoes, severe thunderstorms, winter storms, or coastal storms. These winds can have severe impacts on buildings, pulling off the roof covering, roof deck, or wall siding and pushing or pulling off the windows.[14]

[13] NOAA and National Severe Storms Laboratory. "Winter Weather Basics." Text. NOAA National Severe Storms Laboratory. Accessed December 6, 2023. https://www.nssl.noaa.gov/education/svrwx101/winter/.

[14] National Oceanic and Atmospheric Administration. "Tornadoes." Accessed December 6, 2023. https://www.noaa.gov/education/resource-collections/weather-atmosphere/tornadoes.

Natural Hazards	
Profiled Hazards	**Description**
Invasive Species 	An invasive species is a species that is not indigenous to the ecosystem under consideration and whose introduction causes or is likely to cause economic, environmental, or human harm. These species can be any type of organism: plant, fish, invertebrate, mammal, bird, disease, or pathogen.[15] The magnitude of an invasive species threat is generally amplified when the ecosystem or host species is already stressed, such as in times of drought or after a wildfire, as the already weakened state of the native ecosystem causes it to succumb to an infestation more easily.
Drought 	Drought is defined as a deficiency of precipitation experienced over an extended period of time, usually a season or more. Drought events are defined by rainfall amounts, vegetation conditions, soil-moisture conditions, water levels in reservoirs, stream flow, agricultural productivity, or economic impacts. Droughts increase the risk of other hazards, like wildfires, flash floods, and landslides or debris flows. This hazard is of particular concern in Pennsylvania due to the prevalence of farms and other water-dependent industries, water-dependent recreation uses, and residents who depend on wells for drinking water.[16]

[15] National Invasive Species Information Center. "What Are Invasive Species?" invasivespeciesinfo.gov. Accessed December 6, 2023. https://www.invasivespeciesinfo.gov/what-are-invasive-species.

[16] National Integrated Drought Information System and National Oceanic and Atmospheric Administration. "Drought Basics." drought.gov. Accessed December 6, 2023. https://www.drought.gov/what-is-drought/drought-basics.

Natural Hazards	
Profiled Hazards	**Description**
Pandemic / Infectious Disease  	Pandemic is defined as a disease outbreak affecting or attacking a large number of people across an extensive region, including several countries, and/or continent(s). It is further described as extensively epidemic. Generally, pandemic diseases cause sudden, pervasive illness in all age groups on a global scale. Infectious diseases are also highly virulent and can be spread from person-to-person.
Radon  	Radon is a radioactive gas produced by the breakdown of uranium in soil and rock that can lead to lung cancer in people exposed over a long period of time. Most exposure comes from breathing in radon gas that enters homes and buildings through foundation cracks and other openings. According to the DEP, approximately 40% of Pennsylvania homes have elevated radon levels.[17]

[17] Pennsylvania Department of Environmental Protection. "Radon Division." dep.pa.gov. Accessed December 6, 2023. https://www.dep.pa.gov:443/Business/RadiationProtection/RadonDivision/Pages/default.aspx.

Natural Hazards	
Profiled Hazards	**Description**
Sinkhole / Subsidence 	Land subsidence is a gradual settling or sudden sinking of the ground surface due to the movement of subsurface materials. A sinkhole is a subsidence feature resulting from the sinking of surficial material into a pre-existing subsurface void. Subsidence and sinkholes are geologic hazards that can impact roadways and buildings and disrupt utility services. Subsidence and sinkholes are most common in areas underlain by limestone, and can be exacerbated by human activities such as water, natural gas, and oil extraction.[18]
Wildfire 	A wildfire is an unplanned fire that burns in a natural area. Wildfires occur throughout wooded and open vegetation areas of Pennsylvania. Open fields, grass, dense brush, and forest-covered areas are typical sites for wildfire events. Wildfires can cause injuries or death and can ruin homes in their path. Wildfires can be caused by humans or lightning, and can happen anytime, though the risk increases in period of little rain. In Pennsylvania, 98% of wildfires are caused by people.[19]

[18] U.S. Geological Survey. "Sinkholes." usgs.gov. Accessed December 6, 2023. https://www.usgs.gov/special-topics/water-science-school/science/sinkholes.

[19] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Natural Hazards	
Profiled Hazards	**Description**
Lightning Strike 	Lightning is a giant spark of electricity resulting from the build-up of positive and negative charges within a thunderstorm. The flash or "bolt" of light can occur within the thunderstorm cloud or between the cloud and the ground. Lightning is a leading cause of injury and death from weather-related hazards. Although most lightning victims survive, people struck by lightning often report a variety of long-term, debilitating symptoms.[20]
Earthquake 	An earthquake is the motion or trembling of the ground produced by sudden displacement of rock usually within the upper 10-20 miles of the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, or the collapse of underground caverns. Earthquakes can affect hundreds of thousands of square miles, cause damage to property measured in the tens of billions of dollars, result in loss of life and injury to hundreds of thousands of persons, and disrupt the social and economic functioning of the affected area.[21]

[20] Ready.gov. “Thunderstorms & Lightning.” ready.gov, August 8, 2023. https://www.ready.gov/thunderstorms-lightning.

[21] Ready.gov. “Earthquakes.” Ready.gov, September 6, 2023. https://www.ready.gov/earthquakes.

Natural Hazards	
Profiled Hazards	**Description**
Hailstorm 	Hailstorms occur when ice crystals form within a low-pressure front due to the rapid rise of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight, they fall as precipitation in the form of balls or irregularly shaped masses of ice greater than 0.75 inches in diameter. Hailstorms can cause significant damage to homes, vehicles, livestock, and people.[22]
Landslide 	In a landslide, masses of rock, earth or debris move down a slope. Landslides can be caused by a variety of factors, including earthquakes, storms, fire, and human modification of land. Areas that are prone to landslide hazards include previous landslide areas, areas on or at the base of slopes, areas in or at the base of drainage hollows, developed hillsides with leach field septic systems, and areas recently burned by forest or brush fires.[23]

[22] Federal Emergency Management Agency. "Hail | National Risk Index." hazards.fema.gov. Accessed December 6, 2023. https://hazards.fema.gov/nri/hail.

[23] Pennsylvania Department of Environmental Protection. "Landslides." Pennsylvania Department of Conservation & Natural Resources. Accessed December 7, 2023. https://www.dcnr.pa.gov:443/Geology/GeologicHazards/Landslides/Pages/default.aspx.

Table 8 List of Human-Caused Hazards Profiled in the 2024 Lehigh Valley Hazard Mitigation Plan

Human-Caused Hazards	
Profiled Hazards	**Description**
Environmental Hazards / Explosion  	Hazardous material releases can contaminate air, water, and soils and have the potential to cause injury or death. Dispersion can take place rapidly when transported by water and wind. While often accidental, releases can occur as a result of human carelessness, intentional acts, or natural hazards. Environmental hazards include the following: ▪ Hazardous material releases at fixed facilities or in transit; including toxic chemicals, infectious substances, biohazardous waste, and any materials that are explosive, corrosive, flammable or radioactive.[24] ▪ Mining incidents; including the release of harmful chemical and waste materials into water bodies or the atmosphere, explosions, fires, and other hazards and threats to life safety stemming from mining. ▪ Oil and gas well incidents; including the release of the release of harmful chemical and waste materials into water bodies or the atmosphere, explosions, fires, and other hazards and threats to life safety stemming from oil and gas extraction. Explosions are extremely rapid releases of energy that usually generate high temperatures and often lead to fires. The risk of severe explosions can be reduced through careful management of flammable and explosive hazardous materials.

[24] Hazardous Material Emergency Planning and Response Act (PL 1990-165, § 207(e)).

Human-Caused Hazards	
Profiled Hazards	**Description**
Utility Interruption  	Utility interruption hazards are hazards that impair the functioning of important utilities in the energy, telecommunications, public works, and information network sectors.[25] Utility interruption hazards include the following: • Geomagnetic Storms • Fuel or Resource Shortage • Electromagnetic Pulse • Information Technology Failure • Ancillary Support Equipment • Public Works Failure • Telecommunications System Failure • Transmission Facility or Linear Utility Accident • Major Energy, Power, Utility Failure
Gas / Liquid Pipelines  	Pipeline failures are low-probability, potentially high-consequence events. Although gas and liquid pipeline failures are infrequent, the hazardous and inflammable materials released by these events can pose a significant threat to public safety and the built and natural environment. Explosions associated with pipeline failures, for example, can cause severe injury to nearby residents and destroy homes and other property.

[25] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Human-Caused Hazards	
Profiled Hazards	**Description**
Drug Overdose 	Addiction occurs when an individual becomes physically dependent on a drug, including opiates and narcotics. Opioids are a synthetic substance found in certain prescription pain medications: morphine, codeine, methadone, oxycodone, hydrocodone, fentanyl, and hydromorphone, and street drugs like heroin. Opioids block the body's ability to feel pain and can create a sense of euphoria. Individuals often build a tolerance to opioid drugs, which leads them to take more of the medication than originally prescribed.
Urban Fires 	Urban fire and explosion hazards include vehicle and building/structure fires as well as overpressure rupture, overheat, or other explosions that do not ignite. This hazard occurs in denser, more urbanized areas statewide and most often occurs in residential structures. Nationally, fires cause over 3,000 deaths and approximately 16,000 injuries each year.[26]

[26] Hall, Shelby, and Ben Evarts. "Fire Loss in the United States During 2021," September 2022. https://www.darley.com/wp-content/uploads/2022/11/NFPA-2021-Report-and-Tables.pdf.

Human-Caused Hazards	
Profiled Hazards	**Description**
Transportation Crashes 	Transportation accidents are technological hazards involving the nation’s system of land, sea, and air transportation infrastructure. A flaw or breakdown in any component of this system can and often does result in a major disaster involving loss of life, injuries, property and environmental damage, and economic consequences. Transportation incidents are defined as incidents involving highway, air, and rail travel. These incidents are collectively the costliest of all hazards in the Commonwealth in terms of lives lost, injuries, and economic losses.
Building Collapse 	Buildings and other engineered structures, including bridges, may collapse if their structural integrity is compromised, especially due to effects from other natural or human-caused hazards. Older buildings or structures, structures that are not built to standard codes, or structures that have been weakened are more susceptible to being affected by these hazards.

Human-Caused Hazards	
Profiled Hazards	**Description**
Mass Gathering 	Civil disturbance is a broad term that is typically used by law enforcement to describe one or more forms of disturbance caused by a group of people. A civil disturbance is defined by FEMA as a civil unrest activity (such as a demonstration, riot, or strike) that disrupts a community and requires intervention to maintain public safety.[27]
Dam Failure 	Dam failure is the uncontrolled release of water (and any associated wastes) from a dam. This hazard often results from a combination of natural and human causes, and can follow other hazards such as hurricanes, earthquakes, and landslides. The consequences of dam failures can include property and environmental damage and loss of life.[28]

[27] Department of Homeland Security. "Mass Gatherings: Security Awareness for Soft Targets and Crowded Places," n.d. https://www.fema.gov/sites/default/files/2020-03/fema_faith-communities_mass-gatherings-security-awareness.pdf.

[28] Association of State Dam Safety Officials. "Dam Failures and Incidents." damsafety.org. Accessed December 7, 2023. https://damsafety.org/dam-failures.

Human-Caused Hazards	
Profiled Hazards	**Description**
Levee Failure 	A levee is a human-caused structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water to provide protection from temporary flooding. A levee failure or breach occurs when a levee fails to prevent flooding on the landside of the levee. The consequences of a sudden levee failure can be catastrophic, with the resulting flooding causing loss of life, emergency evacuations, and significant property damage.[29]
Terrorism 	Terrorism is the use of force or violence against persons or property with the intent to intimidate or coerce. Acts of terrorism include threats of terrorism; assassinations; kidnappings; hijackings; bomb scares and bombings; cyber-attacks (computer-based); and the use of chemical, biological, nuclear and radiological weapons. Cyber-attacks have become an increasingly pressing concern.[30]

[29] U.S. Army Corps of Engineers. "Dam Safety Facts and Figures." usace.army.mil, 2019. https://www.usace.army.mil/Media/Fact-Sheets/Fact-Sheets-View/Article/2523036/dam-safety-facts-and-figures/https%3A%2F%2Fwww.usace.army.mil%2FMedia%2FFact-Sheets%2FFact-Sheets-View%2FArticle%2F2523036%2Fdam-safety-facts-and-figures%2F.

[30] Federal Bureau of Investigation Public Affairs. "Terrorism." Federal Bureau of Investigation. Accessed December 7, 2023. https://www.fbi.gov/investigate/terrorism.

Human-Caused Hazards	
Profiled Hazards	**Description**
Cyber-Terrorism 	Cyber terrorism refers to acts of terrorism committed using computers, networks, and the Internet. The most widely cited definition comes from Denning's Testimony before the Special Oversight Panel on Terrorism: "Cyberterrorism… is generally understood to mean unlawful attacks and threats of attacks against computers, networks, and the information stored therein when done to intimidate or coerce a government or its people in furtherance of political or social objectives. Further, to qualify as cyberterrorism, an attack should result in violence against persons or property, or at least cause enough harm to generate fear." (Denning, 2000)
Nuclear Incident 	Nuclear explosions can cause significant damage and casualties from blast, heat, and radiation. The primary concern following a nuclear accident or nuclear attack is the extent of radiation, inhalation, and ingestion of radioactive isotopes which can cause acute health effects (e.g. death, burns, severe impairment), chronic health effects (e.g. cancer), and psychological effects.[31]

4.3 Hazard Profiles

The following hazard profiles investigate the impact, historical occurrence, and probability of future occurrence for hazards that might affect the community. These profiles describe the unique characteristics of individual hazards and which areas within the community may vulnerable to each type of hazard event. The community risk assessment includes a description of the location and extent of impact for all natural and human-caused hazards that can affect the community. It will also include information on previous occurrences of hazard events and the probability of those events occurring in the future.

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[31] CDC. "Non-Ionizing Radiation." Centers for Disease Control and Prevention, December 7, 2015. https://www.cdc.gov/nceh/radiation/nonionizing_radiation.html.

Natural Hazards

4.3.1 Drought

4.3.1.1. Location and Extent

The Lehigh Valley and the broader Commonwealth of Pennsylvania generally enjoy a water-rich climate compared to many other U.S. states. However, like other parts of the country, the Lehigh Valley sometimes faces droughts, which can challenge the region's water supply. Droughts are climatic anomalies affecting vast areas, sometimes stretching from a few Pennsylvania counties to the entire mid-Atlantic region. Regions dominated by agricultural activities can be especially hard-hit.

Droughts represent a notable deficiency of water – usually for a season or more – primarily caused by below-average rainfall. Since rainfall sustains both ground and surface water in the Commonwealth, a decline in precipitation often signals an impending drought. Droughts are a usual, albeit irregular, feature of the climate and are present in almost all climatic zones, regardless of their general wetness or dryness. Their characteristics and duration can vary widely across regions. Additionally, human activities, like increased water consumption and suboptimal water management, can intensify the effects of a drought on a particular area.

For the drought hazard, the entire Lehigh Valley has been identified as the hazard area and the entire population in the Lehigh Valley is vulnerable to drought events. Overall, the Lehigh Valley's vulnerability has not changed since the 2018 Plan, and the entire region continues to be exposed and vulnerable to the drought hazard.

4.3.1.2. Range of Magnitude

Droughts, depending on their location, severity, and duration, can lead to a variety of consequences. Some primarily affect agriculture, and even brief periods of drought, paired with extreme temperatures, can have significant impacts on crop health. Others might influence water supplies or water-related activities, like recreation. Droughts are characterized by factors such as rainfall levels, vegetation and soil moisture conditions, reservoir water levels, stream flows, agricultural outputs, and even economic repercussions.

Hydrologic droughts lead to decreased stream flows, reduced lake and reservoir storage, and lowered groundwater levels. These reductions can severely affect public water supplies for human and livestock consumption, harm agricultural processes, deteriorate water quality, and deplete soil moisture. They also create conditions ripe for wildfires and disrupt water routes for navigation and leisure activities. PEMA oversees drought management, with substantial support from PA DEP. As outlined in "Drought Management in Pennsylvania," PEMA and PA DEP employ a three-tiered system to define and tackle droughts, listed from mild to most severe:

- **Drought Watch**: A period to alert government agencies, public water suppliers, water users and the public regarding the potential for future drought-related problems. Drought Watches are invoked when three or more drought indicators are present for a county or group of counties.

The focus is on increased monitoring, awareness and preparation for response if conditions worsen. A request for voluntary water conservation is made. The objective of voluntary water conservation measures during a drought watch is to reduce water uses by 5% in the affected areas. Due to varying conditions, individual water suppliers or municipalities may ask for more stringent conservation actions.

- **Drought Warning:** This phase involves a coordinated response to imminent drought conditions and potential water supply shortages through concerted voluntary conservation measures to avoid or reduce shortages, relieve stressed sources, develop new sources, and if possible, forestall the need to impose mandatory water use restrictions. The objective of voluntary water conservation measures during a drought warning is to reduce overall water uses by 10-15 percent in the affected areas. Due to varying conditions, individual water suppliers or municipalities may be asking for more stringent conservation actions.
- **Drought Emergency**: This stage is a phase of concerted management operations to marshal all available resources to respond to actual emergency conditions, to avoid depletion of water sources, to assure at least minimum water supplies to protect public health and safety, to support essential and high priority water uses, and to avoid unnecessary economic disruptions. It is possible during this phase to impose mandatory restrictions on non-essential water uses that are provided in the Pennsylvania Code (Chapter 119), if deemed necessary and if ordered by the Governor of Pennsylvania. The objective of water use restrictions (mandatory or voluntary) and other conservation measures during this phase is to reduce consumptive water use in the affected area by 15 percent, and to reduce total use to the extent necessary to preserve public water system supplies, to avoid or mitigate local or area shortages and to assure equitable sharing of limited supplies.

Local municipalities may, with the approval of the PA Emergency Management Council, implement local water rationing to share a rapidly dwindling or severely depleted water supply in designated water supply service areas. These individual water rationing plans, authorized through provisions of the Pennsylvania Code (Chapter 120), will require specific limits on individual water consumption to achieve significant reductions in use. Under both mandatory restrictions imposed by the Commonwealth and local water rationing, procedures are provided for granting of variances to consider individual hardships and economic dislocations.

Pennsylvania uses five parameters to assess drought conditions: precipitation deficits, stream flows, reservoir storage levels, groundwater levels and soil moisture.

Precipitation Deficits: Because rainfall provides the basis for ground and surface water resources, measuring the difference in precipitation from the normal (30-year average) tends to be the earliest indicator that a drought is possible in an area. The PA DEP will compare the cumulative precipitation for varying time periods (minimum of 3 months, maximum of 12 months) each month against the normal, 30-year average value for each same time-period. Any duration that has less than the normal is considered to have had a deficit, represented by a percentage less than the normal precipitation. The table below shows what the deficit values need to be for each period to qualify for each drought stage.

Table 9: Precipitation deficit indicators for Pennsylvania[32]

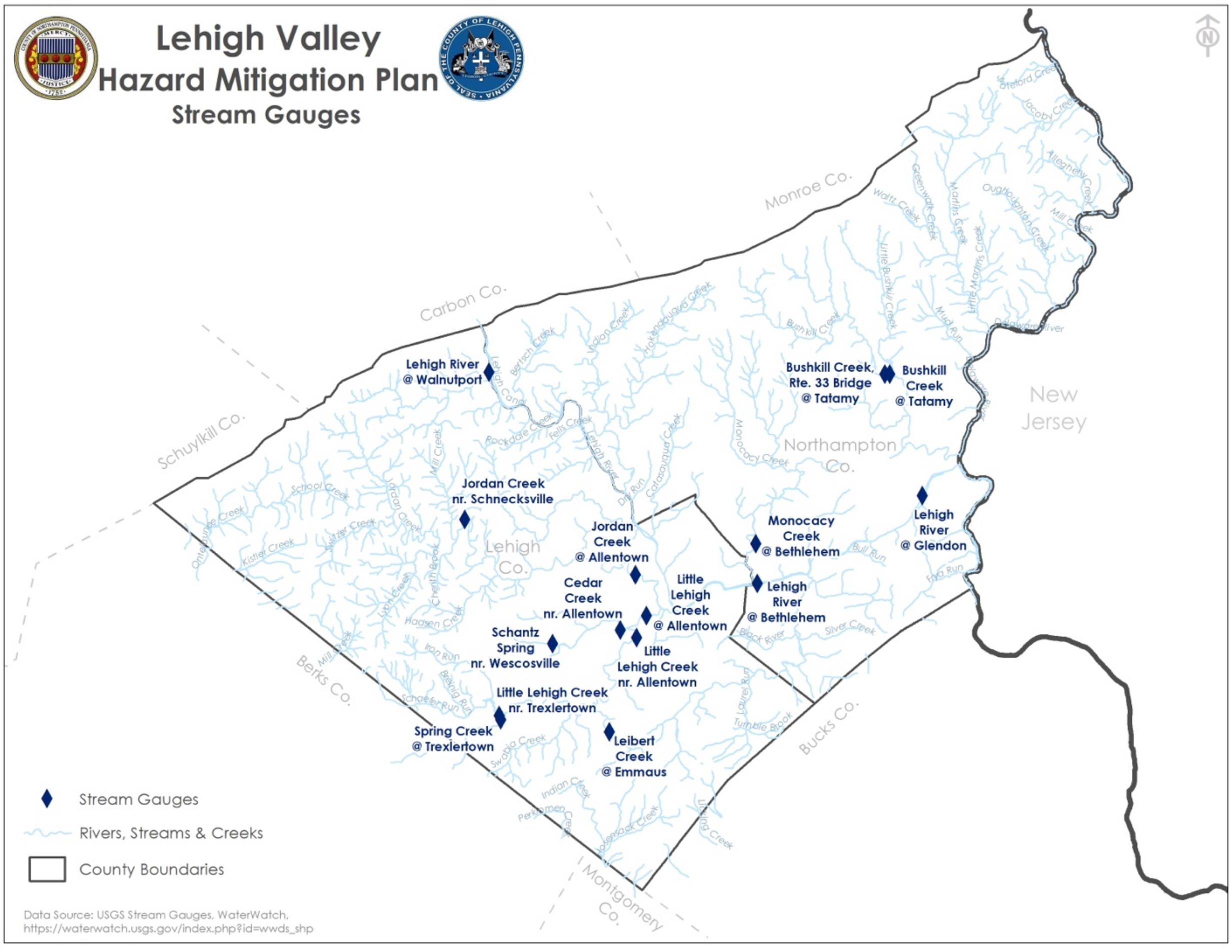
DURATION OF DEFICIT ACCUMULATION (months)	DROUGHT WATCH (deficit as percent of normal precipitation)	DROUGHT WARNING (deficit as percent of normal precipitation)	DROUGHT EMERGENCY (deficit as percent of normal precipitation)
3	25	35	45
4	20	30	40
5	20	30	40
6	20	30	40
7	18.5	28.5	38.5
8	17.5	27.5	37.5
9	16.5	26.5	36.5
10	15	25	35
11	15	25	35
12	15	25	35

Stream Flows: The next earliest indicator that a drought is developing is stream flow measurements. The figure below shows the USGS stream gages that the DEP currently uses to monitor droughts across the state. The DEP calculates and maintains 30-day average values for stream flow based on the entire period of recording for each gage. Compared to precipitation, stream flow measurements lag by about a

[32] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

month or two when signaling a drought. For example, the Susquehanna River gage at Harrisburg has more than 110 years of record from which the long-term 30-day average, or normal, flows are now determined.[33]

Figure 4: Stream Gages in Lehigh Valley



Drought status is determined from stream flows based on percentiles, or exceedances, rather than percentages. Exceedances are similar to percentiles; a 75-percent exceedance flow value means that the current 30-day average flow is exceeded in the stream 75-percent of the time; in other words, the 30-day average flow in the stream is less than that value only 25-percent of the time. Similarly, with a 90-percent exceedance flow value, the 30-day average flows in the stream would be less than that value only 10-percent of the time, and only 5-percent of the time for a 95-percent exceedance. For stream

[33] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

flows, the 75-, 90-, and 95-percent exceedance 30-day average flows are used as indicators for drought watch, warning, and emergency, respectively.

Groundwater Levels: Groundwater levels can be an indicator of a developing drought. USGS also maintains groundwater-monitoring wells in each county throughout the Commonwealth. Groundwater measurements taken from these wells at exceedances of 75, 90, and 95% are used to indicate drought watch, warning and emergency status, respectively.[34]

Soil Moisture: Soil moisture is measured using an algorithm calibrated for relatively homogeneous regions which measures dryness based on temperature and precipitation in the area, information which is provided by NOAA. This generates a value called the Palmer Drought Severity Index (PDSI), which is compiled by the Climate Prediction Center of the National Weather Service on a weekly basis. A PDSI of -4.00 or less indicates a drought emergency; a value between -3.00 and -3.99 indicates a drought warning, and a value between -2.00 and -2.99 indicates a drought watch.

Reservoir Storage Levels: Water level storage in several large public water supply reservoirs (especially three New York City reservoirs in the Upper Delaware River Basin) is the fifth indicator that the PA DEP uses for drought monitoring. Depending on the total quantity of storage and the length of the refill period for the various reservoirs, PA DEP uses varying percentages of storage draw down to indicate the three drought stages for each of the reservoirs.

Table 10: Palmer Drought Severity Index (PDSI) Classifications

Severity	PDSI Value	Drought Status
Extremely Wet	4.0 or more	None
Very Wet	3.0 to 3.99	None
Moderately Wet	2.0 to 2.99	None
Slightly Wet	1.0 to 1.99	None
Incipient Wet Spell	0.5 to 0.99	None

[34] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Severity	PDSI Value	Drought Status
Near Normal	0.49 to -0.49	None
Incipient Dry Spell	-0.5 to -0.99	None
Mild Drought	-1.0 to -1.99	None
Moderate Drought	-2.0 to -2.99	Watch
Severe Drought	-3.0 to -3.99	Warning
Extreme Drought	-4.0 or less	Emergency

Drought impacts on the economy and environment can be significant. Economic impacts include losses to the agriculture industry, recreation/tourism industry, fishery production, water suppliers and timber production, as well as increased food prices. Environmental impacts of drought include:

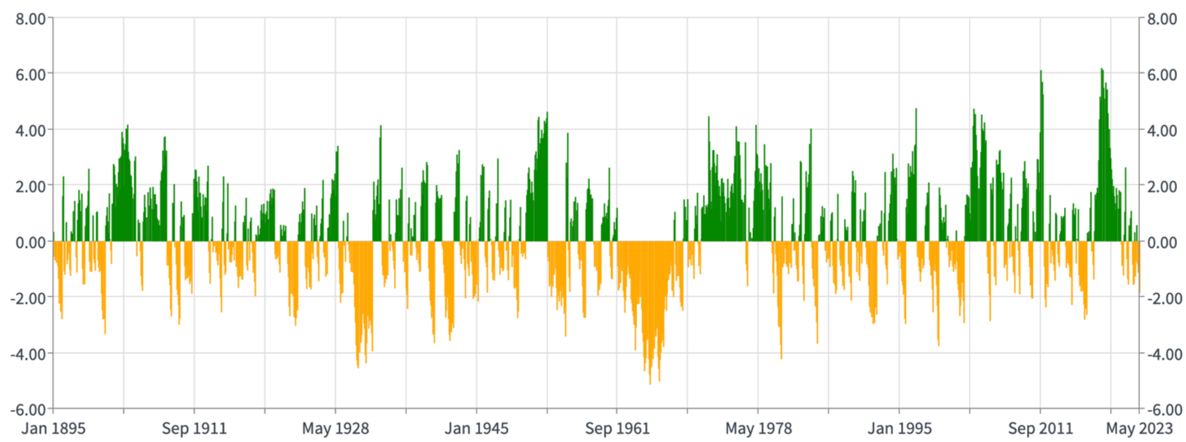
- Damage to animal species in the form of reduced water and feed availability, degradation of fish and wildlife habitat, migration and concentration issues (too many or too few animals in a given area), stress to endangered species and loss of biodiversity
- Lower water levels in reservoirs, lakes and ponds
- Reduced stream flow
- Loss of wetlands
- Increased groundwater depletion, land subsidence, and reduced groundwater recharge
- Water quality impacts like salinity, water temperature increases, pH changes, dissolved oxygen or turbidity
- Loss of biodiversity
- Loss of trees
- Increased number and severity of fires
- Reduced soil quality and erosion issues

- Increased dust or pollutants

4.3.1.3. Past Occurrence

According to NOAA's National Centers for Environmental Information (NCEI) Storm Events Database, the Lehigh Valley experienced 43 drought events between April 30, 1950, and March 31, 2023. Additionally, an estimated 14 drought events occurred in the Lehigh Valley between 1895 and 1942, with PDSI values ranging from -3.27 to -4.95, according to data accumulated from the Northeast Regional Climate Center (NRCC), Drought Impact Report (DIR), PEMA, and FEMA about droughts that occurred prior to 1950.

Figure 5: Pennsylvania, East Central Mountains PDSI 1895-2023[35]



Since 1950, Pennsylvania has endured 12 significant drought incidents leading to either a gubernatorial proclamation or a declaration of disaster or emergency by the Federal Emergency Management Agency (FEMA). Out of these, the Lehigh Valley was affected by five. Notably, a FEMA disaster declaration was made due to a drought and water shortage event from 1964-1966, which included Northampton County.

Furthermore, between 1980 and 2009, the PADEP reports indicate:

- Lehigh County had 16 drought watches, 20 drought warnings, and 12 drought emergency declarations.

- Northampton County had 16 drought watches, 20 drought warnings, and 14 drought emergency declarations.

[35] National Centers for Environmental Information. "National Time Series | Climate at a Glance." ncei.noaa.gov. Accessed December 11, 2023. https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/national/time-series.

A detailed account of drought events in the Lehigh Valley is provided in the table below.

Table 11: Past Occurrences of Drought Events from 1950 - 2023[36] [37]

Date of Event	Event Type	FEMA Declaration Number	County Designated	Losses/Impacts	Source(s)
September - November 1957	Drought	N/A	N/A	Lowest PDSI of -3.07	NRCC
August 1964 – January 1966	Drought, Water Shortage	DR-206	Northampton	In August, the Delaware River Basin was included in a FEMA disaster declaration. Lowest PDSI of -4.95	NRCC, PEMA, FEMA
June - November 1966	Drought	N/A	N/A	Lowest PDSI of -4.21	NRCC
January - February 1967	Drought	N/A	N/A	Lowest PDSI of -3.40	NRCC
August 1980 - January 1981	Drought	N/A	N/A	The Lehigh Valley was under a declared drought emergency in November. Lowest PDSI of -5.07	NRCC, PADEP, PEMA
March - July 1985	Drought	N/A	N/A	The Lehigh Valley was under a declared drought emergency between April and July. Lowest PDSI of -4.30	NRCC, PADEP, PEMA

[36] National Centers for Environmental Information. "Storm Events Database." ncdc.noaa.gov. https://www.ncdc.noaa.gov/stormevents/.

[37] Multiple sources: National Response Coordination Center, 2012; National Drought Mitigation Center Drought Impact Reporter, 2012; Delaware River Basin Commission, 2008; PEMA, 2010; PADEP, 2012; PADEP 2017

Date of Event	Event Type	FEMA Declaration Number	County Designated	Losses/Impacts	Source(s)
August 1991 - April 1992	Drought	N/A	N/A	Lowest PDSI of -3.58	PA HMP
September - November 1995	Drought	N/A	N/A	A drought emergency was declared for the Lehigh Valley in mid-September. Preliminary crop losses caused by the drought were $300 million statewide and $26,799 in the Lehigh Valley.	PADEP, PEMA
December 1998 –July 1999	Drought	N/A	N/A	The Lehigh Valley was under a drought warning. The precipitation in December at the Lehigh Valley International Airport (LVIA) was the second driest on record. In March 1999, the drought warning was downgraded to a drought watch. By June, the state declared a drought warning again, including all of eastern Pennsylvania. The drought intensified in July and was the driest on record at the LVIA.	PADEP
July - August 1999	Drought	N/A	N/A	The Lehigh Valley was under a drought emergency in July. Alfalfa cutting was one quarter of normal, the soybean crop one third of normal and the corn crop one half of normal. Low water levels made it difficult or impossible to use waterways for fishing and boating. Fish were dying due to low stream flows. By August, many farms in the Lehigh Valley reported corn losses around 9%. Crop loss figures in the Lehigh Valley were $214,388 for 1998 and $2.2 million for 1999. The continued lack of rain resulted in wells going dry. Lowest PDSI of -3.54.	NRCC

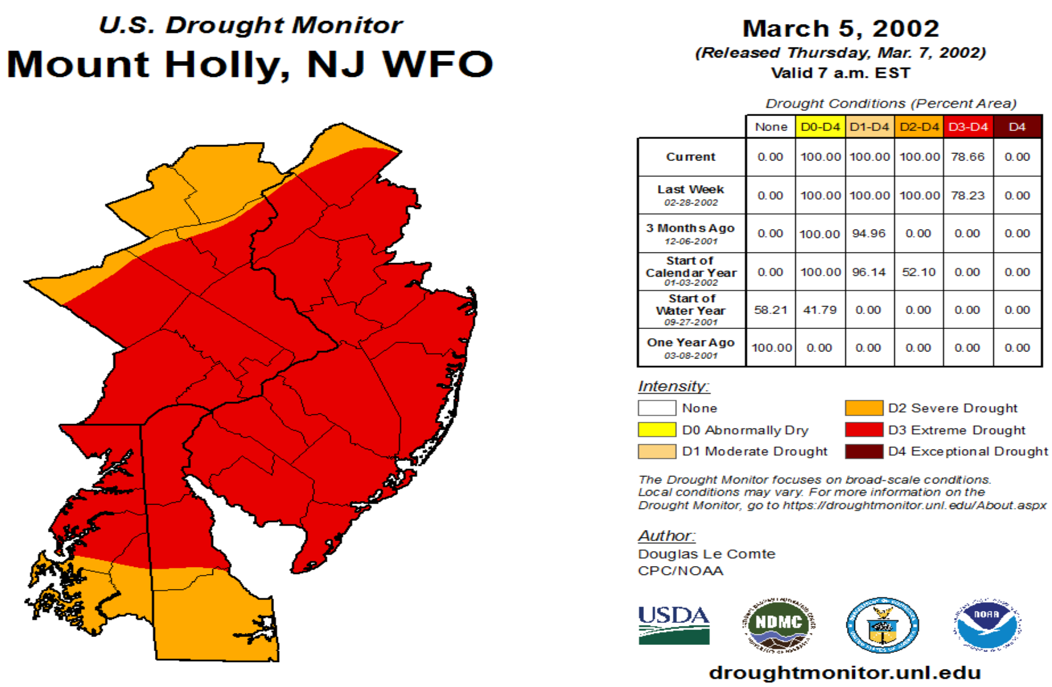
Date of Event	Event Type	FEMA Declaration Number	County Designated	Losses/Impacts	Source(s)
December 18, 2001 - November 25, 2002	Drought	N/A	N/A	In November 2001, a drought warning was issued for eastern Pennsylvania due to unseasonably dry weather. Due to low groundwater levels, a well in East Allen Township ran dry, cutting off water service to 73 area homes. Water was trucked in to restore water service between August and November. From February to September 2002, the Lehigh Valley was under a drought emergency. Groundwater levels were continuing to decline with streamflow levels reaching record low levels in some cases. In August 2002, water once again had to be trucked in to serve customers in East Allen Township. Crop losses due to drought in the Lehigh Valley for 2002 were $4.2 million.	DIR, PADEP, PEMA, PA HMP
June - November 2005	Drought	N/A	N/A	A drought warning was put into effect in September. The Pennsylvania governor asked for $128 million in subsidence for farmers who lost a majority of their soybean, corn, hay, and alfalfa crops. Farmers were then eligible for low interest loans from the USDA. The counties eligible for assistance included Lehigh County.	DIR
June 2007 - January 2008	Drought	N/A	N/A	As a result of a dry summer, the Lehigh Valley remained under a declared drought watch as of January 1, 2008. Surface and groundwater conditions had improved during the last quarter of 2007 and the trend continued during the first few weeks of 2008. In response to the improvement, PADEP lifted drought watch declarations in the Lehigh Valley on January 11, 2008.	DRBC

Date of Event	Event Type	FEMA Declaration Number	County Designated	Losses/Impacts	Source(s)
April - November 2010	Drought	N/A	N/A	The hot, dry summer and decreasing water supplies led Pennsylvania environmental authorities to issue a drought warning for 24 counties, including Lehigh and Northampton, and asked residents to reduce their water use by 10 to 15 percent. Sixteen counties in Pennsylvania were declared to be natural disaster areas by the USDA due to an ongoing drought that started in May, including Lehigh and Northampton. This declaration permitted impacted farmers, ranchers, and other agricultural producers to apply for low-interest emergency loans from the Farm Service Agency.	DIR, PADEP
June 17, 2015 – July 10, 2015	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley was under a drought watch.	PADEP
August 2, 2016 - November 3, 2016	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley was under a drought watch.	PADEP
November 3, 2016 -February 14, 2017	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley was under a drought watch.	PADEP
February 14, 2017 -May 16, 2017	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley was under a drought watch.	PADEP

Date of Event	Event Type	FEMA Declaration Number	County Designated	Losses/Impacts	Source(s)
August 31, 2022 – January 20, 2023	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley (Lehigh & Northampton Counties) was under a drought watch. Watch lifted in Lehigh County on October 17, 2022. Watch lifted in Northampton County on January 20, 2023.	PADEP
June 15, 2023 -	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley (Lehigh & Northampton Counties) was under a drought watch.	PADEP

The following figure depicts the Lehigh Valley and surrounding region on March 5th, 2002, during one of the region's most severe droughts of recent record. As is shown in the map, 78.66% of the WFO region was in a D3 Extreme Drought.

Figure 6: U.S. Drought Monitor Map of Mt. Holly, N.J WFO March 5, 2002



4.3.1.4. Future Occurrence

Predicting the frequency of droughts is challenging. However, droughts appear to be cyclical, implying they'll reoccur in the future. In fact, periodic droughts are commonplace in almost all U.S. climates.

From 1895 to 2023, the USDM data indicates that the Lehigh Valley experienced severe (14.27%), extreme (9.34%), and exceptional (4.60%) drought conditions. The East Central Mountains climate division, which encompasses the Lehigh Valley, registered an average PDSI (Palmer Drought Severity Index) of 0.13 during the same period. This marks a 0.38 improvement from the prior plan update.

Historical trends show a mild decline in the PDSI over recent decades, suggesting a heightened future risk of droughts. However, the Lehigh Valley witnessed a reduction in drought frequency between 2000 and 2023 compared to the entire period of 1895 to 2023.

Breaking down the data from 1895 to 2023 for the region:

- D2 Severe Drought: 14.27%
- D3 Extreme Drought: 9.34%
- D4 Exceptional Drought: 4.6%

In contrast, the 2000-2023 data for the Lehigh Valley reveals:

- D2 Severe Drought: 2.69%
- D3 Extreme Drought: 0.65%
- D4 Exceptional Drought: 0%.

Table 12: Percentage of Time Lehigh Valley Had Drought Status 1895 - 2023

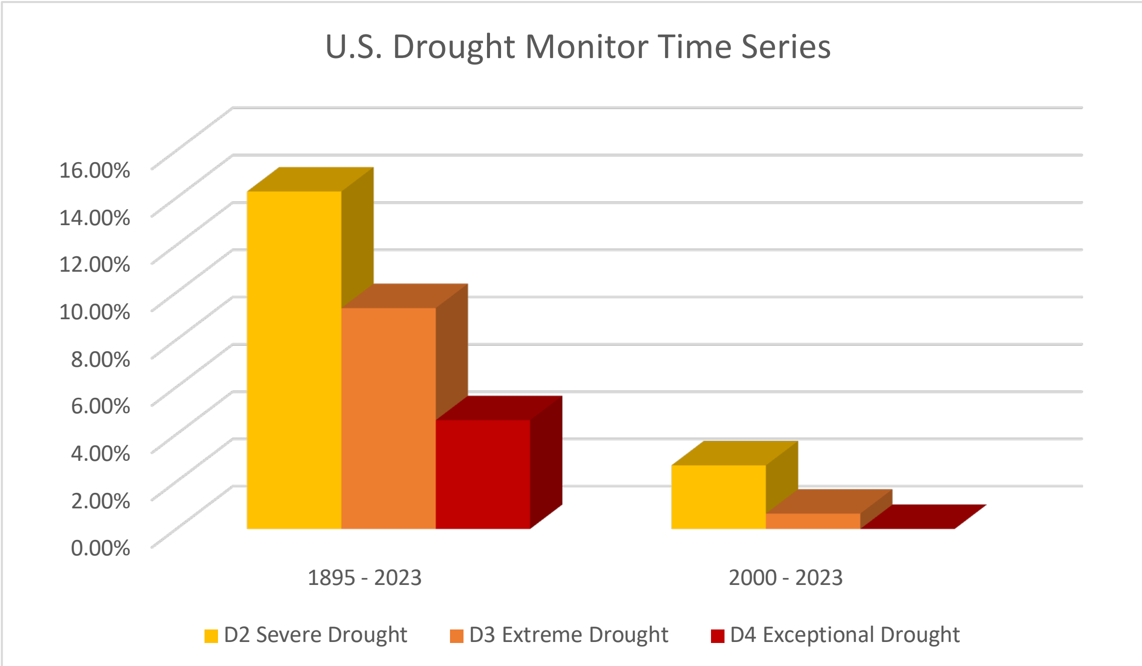
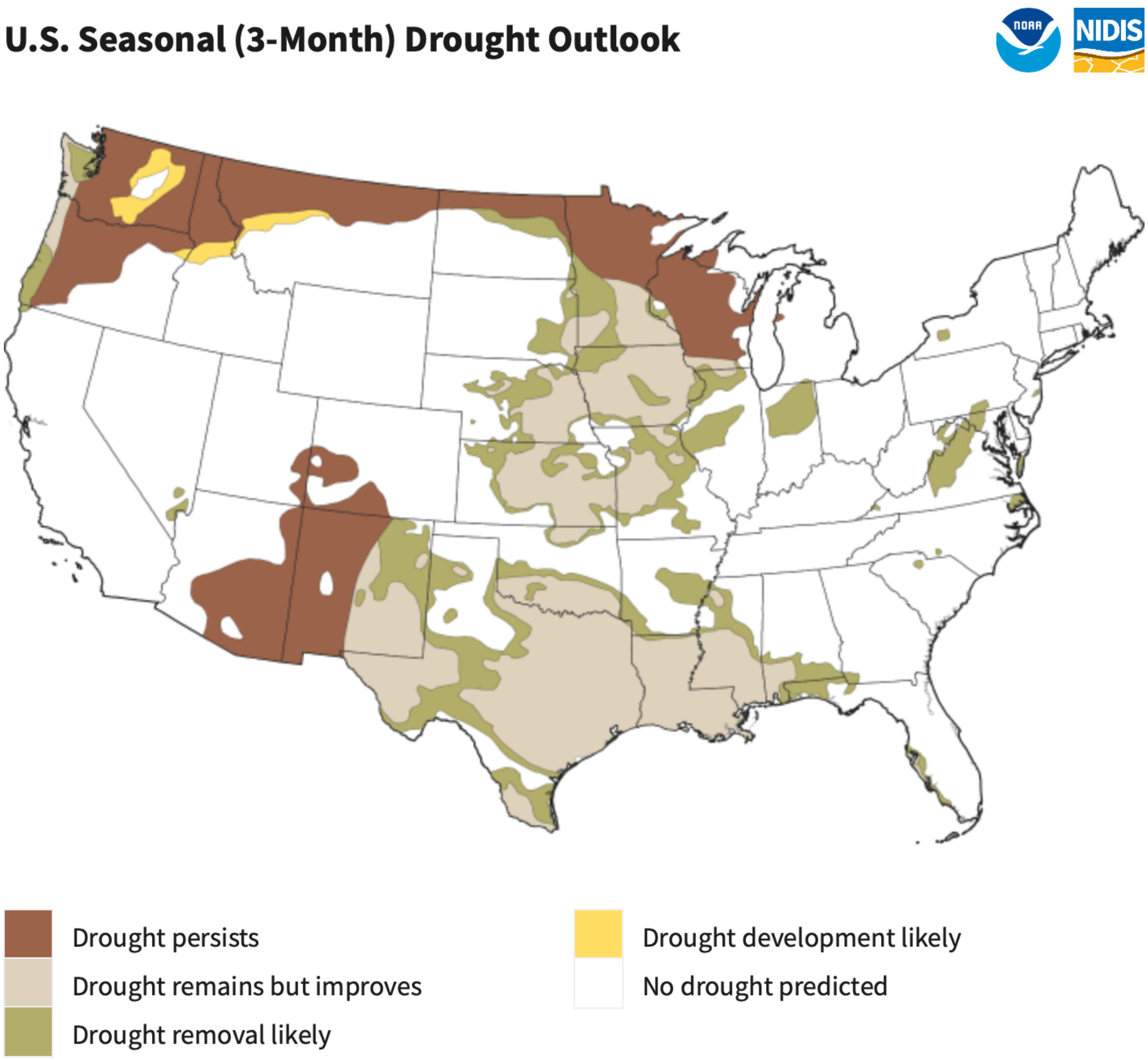


Figure 7: US. Seasonal Drought Outlook[38]



The National Weather Service Climate Prediction Center's Seasonal (3-Month) Drought Outlook is issued on the third Thursday of each month. The outlook predicts whether drought will persist, develop, improve, or be removed over the next three months or so. Source(s): Climate Prediction Center

Source(s): Climate Prediction Center
Updates Monthly: 09/21/23

Drought.gov

Probability of Future Occurrences

Predicting future droughts is difficult as these events are cyclical in nature. The first half of the 1960s was an exceptionally dry period for the Lehigh Valley and surrounding region, and as such, remains somewhat of an outlier. Based on a combination of data, considering PDSI, NCEI, as well as watches and warnings issued by PADEP, the probability of a drought occurring in the Lehigh Valley is ***Possible*** (between 1% & 49.9% annual probability) as defined in the Methodology Section.

Future Considerations for Climate Change

As climate change continues to reshape global weather patterns, regions like the Lehigh Valley in Pennsylvania may experience altered drought dynamics. Current climate models suggest that while overall precipitation might increase in certain areas, the distribution and intensity of rainfall events could change, leading to longer periods of dry conditions interspersed with heavy rainfall. This can result in an increase in the frequency and intensity of droughts, even if the annual rainfall doesn't drastically reduce.

For the Lehigh Valley, the increasing average temperatures associated with global warming may intensify evaporation rates from surface water sources, placing additional stress on already depleted reservoirs and groundwater. Furthermore, higher temperatures could boost water demand for agriculture, industrial processes, and residential consumption. Communities in the Lehigh Valley should, therefore, prioritize adaptation strategies that focus on efficient water use, sustainable agriculture, and enhanced water storage capacities. Embracing these approaches can help mitigate the impacts of prolonged drought periods and ensure a resilient future for the region in the face of changing climate conditions.

4.3.1.5. Vulnerability Assessment

A drought event in the Lehigh Valley would impact several community lifelines, which are essential services and functions that, when stabilized, enable a community to recover from a disaster. The key community lifelines likely to be affected by a severe drought are shown in the table below.

Table 13: Potential Vulnerabilities of Lifelines to Drought

Lifelines	Impact Type	Description
Water & Wastewater Systems		This is the most directly affected lifeline. Drought conditions can significantly reduce water availability for domestic, agricultural, and industrial uses. Water quality may also be

[38] National Oceanic and Atmospheric Administration, National Weather Service, and National Centers for Environmental Prediction. “U.S. Seasonal Drought Outlook.” cpc.ncep.noaa.gov, November 30, 2023. https://www.cpc.ncep.noaa.gov/products/expert_assessment/season_drought.png.

Lifelines	Impact Type	Description
		affected, and wastewater treatment processes might be strained due to lower water volumes.
Food, Shelter, & Housing		Drought can impact agricultural production, leading to food shortages or increased food prices. If the drought is severe and prolonged, it could also lead to challenges in providing adequate shelter and housing, especially for vulnerable populations.
Health & Medical		Reduced water quality and quantity can lead to health issues, including dehydration and sanitation-related diseases. Healthcare facilities may also face challenges in maintaining operations with limited water supplies.
Energy		Energy production, particularly in facilities that rely on water for cooling or hydroelectric power, can be affected. There may also be increased competition for available water between energy producers and other users.
Safety & Security		Drought can increase the risk of wildfires, strain emergency services, and potentially lead to conflicts over scarce resources.

People

Impacts are typically categorized as either direct or indirect. Droughts bring about a range of significant consequences, primarily affecting agriculture, wildfire prevention, municipal water usage, commerce, tourism, recreation, and wildlife preservation. Additionally, there's the potential for reduced electric power generation and declining water quality. Drought conditions can also lead to soil compaction, inhibiting effective water absorption and increasing vulnerability to flooding. The severity of drought impacts escalates with the duration of the drought, as reservoir carry-over supplies deplete, and groundwater basin levels recede.

Drought conditions can cause a shortage of water for human consumption and reduce local firefighting capabilities. The drought hazard is a concern because private water supply sources in the Lehigh Valley come from local groundwater. Finally, vulnerable populations could be particularly susceptible to the drought hazard and cascading impacts due to age, health conditions, and limited ability to mobilize to shelter, cooling and medical resources.

If a drought is severe enough to deplete the water supply of an area, residents may be forced to leave the area for another location with ample water supply.[39] [40] The opposite may also occur in the Lehigh Valley. Areas outside of the planning area that are forced to leave due to lack of water supply might choose to migrate to the Lehigh Valley, which could have negative impacts on Lehigh and Northampton counties such as increased demand for drinking water and emergency and social services.

Systems & Structures

No structures are anticipated to be directly affected by a drought and all are expected to be operational during a drought event. However, droughts contribute to conditions conducive to wildfires. Assets at particular risk during drought or extreme heat would include any open land or structures located along areas in which wildlands and urban areas connect. Risk to life and property is greatest in the areas where forested areas adjoin urbanized areas. Therefore, all assets in and adjacent to these areas, including population, structures, critical facilities and businesses are considered vulnerable to wildfire as discussed in the Wildfire profile.

In addition, diminished water may supply negatively impacts the navigability of rivers, increasing transportation costs as products must be transported by alternative means such as rail or truck. Additionally, hydropower production may be significantly curtailed due to reduced water availability, affecting the energy sector and its ability to meet electricity demand.[41]

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[39] Elliott, Joshua, Delphine Deryng, Christoph Müller, Katja Frieler, Markus Konzmann, Dieter Gerten, Michael Glotter, et al. “Constraints and Potentials of Future Irrigation Water Availability on Agricultural Production under Climate Change.” *Proceedings of the National Academy of Sciences* 111, no. 9 (March 4, 2014): 3239–44. https://doi.org/10.1073/pnas.1222474110.

[40] McLeman, R., and B. Smit. “Migration as an Adaptation to Climate Change.” *Climatic Change* 76, no. 1–2 (June 1, 2006): 31–53. https://doi.org/10.1007/s10584-005-9000-7.

[41] Dolan, Flannery, Jonathan Lamontagne, Robert Link, Mohamad Hejazi, Patrick Reed, and Jae Edmonds. “Evaluating the Economic Impact of Water Scarcity in a Changing World.” *Nature Communications* 12, no. 1 (March 26, 2021): 1915. https://doi.org/10.1038/s41467-021-22194-0.

Natural, Cultural, & Historical Resources

There is no single factor or measure that can entirely represent the complexity of drought vulnerability. Water is the most essential natural resource.[42] With population growth, water resources will be exposed to many stressors to sustain and enhance world food production for their feeding.[43] Water sources have complex interactions with both social and ecological sub-systems. In addition to population growth, other stressors such as land cover changes, socio-economic growth, and climate change, have direct impacts on increasing water resources system vulnerability.

A prolonged drought can have serious direct and indirect economic impacts on a community or across the Lehigh Valley, especially on the agriculture industry. Lehigh County is threatened with higher agricultural losses than Northampton County. According to the U.S. Department of Agriculture's Farm Service Agency (FSA), in September 2022 there were 1,823 farms registered in the counties of Lehigh and Northampton with a total of 86,375 planted acres of crops.[44]

The primary direct economic impact of drought in the agricultural sector is crop failure and pasture losses. Increased costs are then passed on to consumers through increased prices, or may be offset through government disaster assistance programs. Indirect impacts of drought in the sector can include reduced supplies to downstream industries, such as food processors, and reduced demand for inputs, such as fertilizer and farm labor. The non-market impacts of production losses include mental health strain on farmers.[45] Drought ranks fourth in Pennsylvania among environmental phenomena associated with billion-dollar weather disasters since 1980, behind severe storms, tropical cyclones and winter

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[42] Vörösmarty, C. J., P. Green, J. Salisbury, and R. B. Lammers. "Global Water Resources: Vulnerability from Climate Change and Population Growth." *Science (New York, N.Y.)* 289, no. 5477 (July 14, 2000): 284–88. https://doi.org/10.1126/science.289.5477.284.

[43] Hering, Daniel, Laurence Carvalho, Christine Argillier, Meryem Beklioglu, Angel Borja, Ana Cristina Cardoso, Harm Duel, et al. "Managing Aquatic Ecosystems and Water Resources under Multiple Stress--an Introduction to the MARS Project." *The Science of the Total Environment* 503–504 (January 15, 2015): 10–21. https://doi.org/10.1016/j.scitotenv.2014.06.106.

[44] USDA. "Conservation Reserve Program Statistics." Page. fsa.usda.gov, September 25, 2020. https://fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index.

[45] National Oceanic and Atmospheric Administration National Integrated Drought Information System. https://www.drought.gov/sectors/agriculture

storms.[46] Across the United States, the cost of drought events averages over $9 billion per year, making it a serious hazard with substantial socioeconomic consequences.

The table below reflects the planted acres at exposure to drought conditions as well as the market value of planted crops and livestock according to the 2017 Census of Agriculture.

Table 14: Exposure Risk to Drought

County	Planted Acres Exposed	Market Value of Planted Crops	Market Value of Livestock, Poultry, and Products	Total Market Value
Lehigh[47]	39,339	$57,259,000	$21,957,000	$79,216,000
Northampton[48]	47,036	$27,588,000	$8,470,000	$36,058,000

Annualized Loss Estimates

According to the USDA Risk Management Agency, between 2010 and 2023 there has been $10,045,951 in reported losses to insured crops due to drought events. The following table shows these losses annualized.

[46] Smith, Adam B. "U.S. Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)." NOAA National Centers for Environmental Information, 2020. https://doi.org/10.25921/STKW-7W73.

[47] USDA – 2017 Census of Agriculture, Lehigh County Profile. Retrieved on 07/06/2023 from: https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Pennsylvania/cp42077.pdf

[48] USDA – 2017 Census of Agriculture, Northampton County Profile. Retrieved on 07/06/2023 from: https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Pennsylvania/cp42095.pdf

Table 15: Annualized Crop Loss Estimates for Drought Events in the Lehigh Valley[49]

Crop Losses According to USDA RMA 2010 - 2023	
Lehigh County[50]	$259,054
Northampton County	$513,711
Lehigh Valley Total	$772,765

[49] USDA – Risk Management Agency. Cause of Loss Historical Data. Retrieved on 07/19/2023 from: https://www.rma.usda.gov/Information-Tools/Summary-of-Business/Cause-of-Loss

[50] Sum of reported losses between 2010 – 2023 divided by number of years.

4.3.2 Earthquake

4.3.2.1. Location and Extent

An earthquake is a natural phenomenon characterized by the sudden shift in the Earth's crust, resulting in seismic waves that cause the ground to tremble and shake. This release of energy usually occurs because of stress built up within rocks or due to volcanic activity.[51] The point on the Earth's surface directly above the origin of the earthquake is known as the epicenter, while the actual location of the earthquake within the crust is called the hypocenter or focus.

The magnitude of an earthquake, which reflects the amount of energy released, is typically measured on the Richter scale or, more commonly now, the moment magnitude scale. Earthquakes can have significant impacts, ranging from ground shaking, surface rupture, and soil liquefaction, to triggering landslides and tsunamis. They are major natural hazards that can lead to loss of life, injury, and extensive property damage.

The Lehigh Valley, located in Pennsylvania, is not traditionally considered a high-risk earthquake zone like California. However, the region lies within the Appalachian Seismic Zone, where smaller, less frequent earthquakes have historically been recorded. While these tremors are typically of lower magnitude, they do pose risks to the area, mainly due to the age and design of many buildings which may not have been constructed with earthquake resistance in mind.

Additionally, the Lehigh Valley's topography, characterized by its valleys and ridges, could amplify the effects of seismic waves. The sediment-filled valleys can intensify ground shaking, making structures more susceptible to damage. Furthermore, the region's infrastructure, transportation networks, and dense population centers could be vulnerable to even moderate seismic activities. An earthquake in this region could potentially disrupt transportation, damage utilities, and impact historical landmarks, many of which date back to the 18th and 19th centuries. Thus, while the probability of a major earthquake might be lower compared to other parts of the country, the potential impact on the Lehigh Valley's communities, heritage, and infrastructure remains a concern.

The state has categorized regions into three earthquake hazard zones: very slight, slight, and moderate. The Lehigh Valley falls within the "moderate" category, encompassing other localities situated within 17.5 miles of a historically known epicenter. In such zones, minor damages from seismic events are anticipated.

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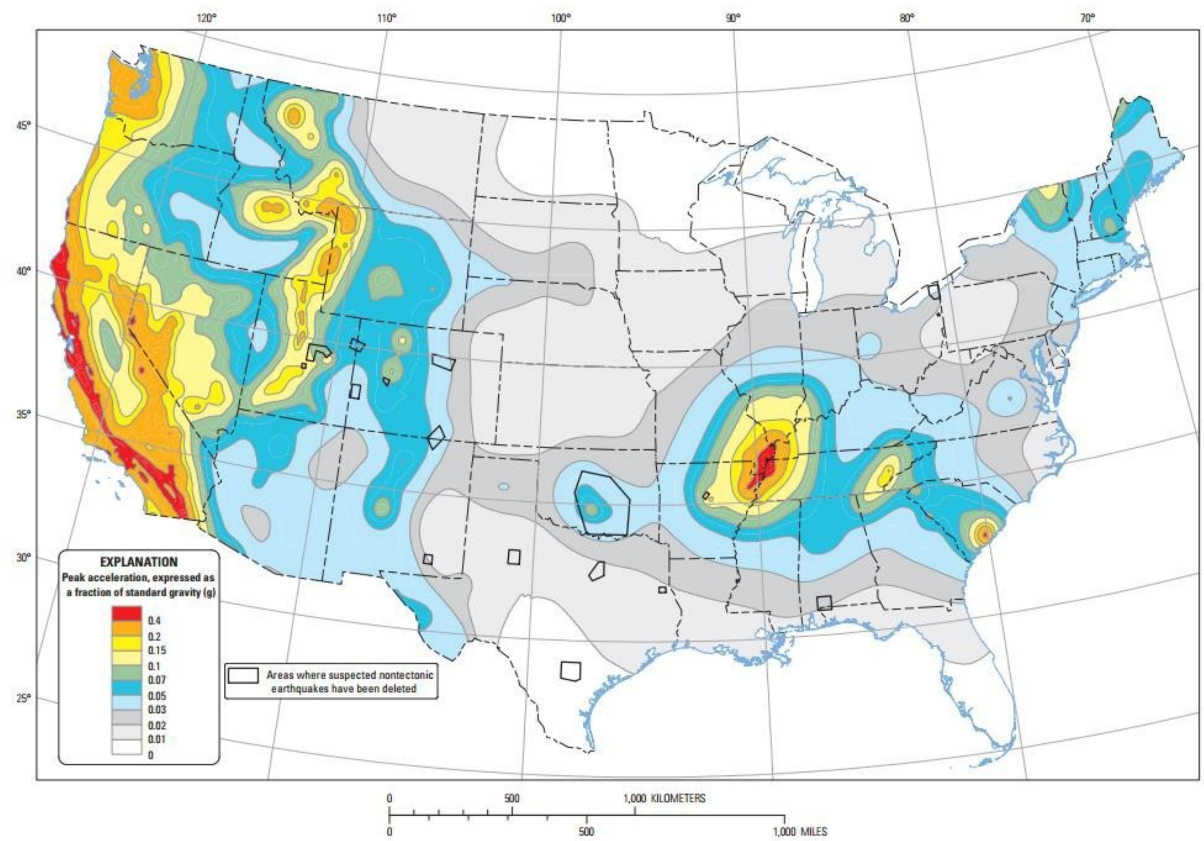
[51] U.S. Geological Survey. "What Is an Earthquake and What Causes Them to Happen?" usgs.gov. Accessed December 11, 2023. https://www.usgs.gov/faqs/what-earthquake-and-what-causes-them-happen.

Significantly, earthquakes registering above a magnitude of 5.0 can cause notable damages close to their epicenters. In Pennsylvania, seismic events tend to concentrate around the southeastern and northwestern extremities of the state.

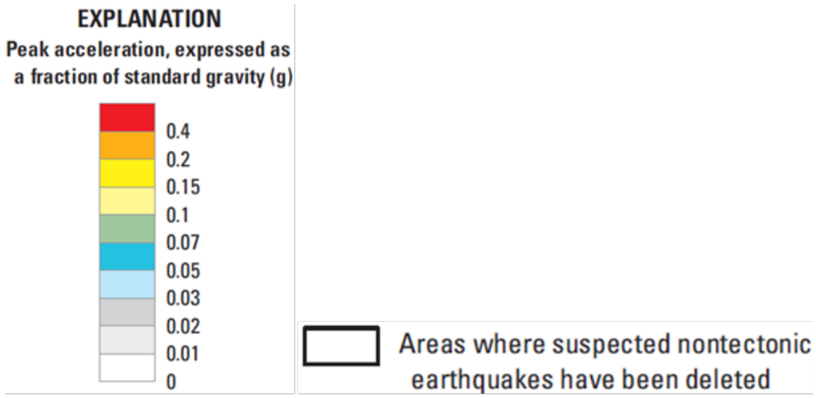
The accompanying figure, based on the USGS map, represents peak acceleration probabilities over a span of 50 years, detailing the likelihood of ground motion reaching specified levels during earthquakes. Specifically, this data highlights peak horizontal ground acceleration—a measure of the rapid change in speed for ground particles moving horizontally due to seismic activity. According to the U.S. Geological Survey's Geologic Hazards Team, the Lehigh Valley falls within a "3" to "5" ground acceleration range. This positions the county within a zone of moderate seismic risk.

Figure 8: Peak Acceleration with 10 Percent Probability of Exceedance in 50 Years[52]



Ten-percent probability of exceedance in 50 years map of peak ground acceleration

[52] Petersen, Mark D., Morgan P. Moschetti, Peter M. Powers, Charles S. Mueller, Kathleen M. Haller, Arthur D. Frankel, Yuehua Zeng, et al. "2014 Update of the United States National Seismic Hazard Maps." *Open-File Report*. U.S. Geological Survey, 2014. https://doi.org/10.3133/ofr20141091.



4.3.2.2. Range of Magnitude

The Richter scale, a widely recognized tool for quantifying earthquake magnitudes, is depicted in the table below. Notably, this scale doesn't cap the magnitude and doesn't convey damage levels. An earthquake might register the same magnitude on the Richter scale regardless of whether it strikes a bustling city, causing substantial damage and loss of life, or a remote, uninhabited region, causing little to no destruction.

Historical records suggest that most earthquake events lead to minimal damage. However, it's crucial to note that the most powerful earthquake ever recorded in Pennsylvania had a magnitude of 5.2. In a worst-case scenario, if an earthquake of comparable magnitude were to hit the Lehigh Valley or a neighboring county's border, it could result in visible signs of distress like swaying trees, objects tumbling from shelves, wall fissures, and crumbling plaster.

Table 16: Richter Scale

Richter Magnitude	Earthquake Effects
2.5 or less	Usually not felt, but can be recorded by seismograph
2.5 to 5.4	Often felt, but causes only minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas

Richter Magnitude	Earthquake Effects
7.0 to 7.9	Major earthquake; serious damage
8.0 or greater	Great earthquake; can destroy communities near the epicenter

Earthquake intensity refers to the observed effects of ground shaking on people, structures, and natural formations, and it can vary based on location. The Modified Mercalli Intensity (MMI) Scale is used to gauge this intensity. It provides a subjective measurement that describes the seismic shock experienced at a specific location, rating it on a scale from I to XII, as illustrated in the figure below. Unlike some regions where earthquakes originate from active faults, Pennsylvania's earthquakes arise deep within the earth's crust. As a result, they usually cause minimal to no damage. To date, the Lehigh Valley has fortunately not reported any injuries or significant damage due to seismic events.

Table 17: Modified Mercalli Intensity Scale with Associated Impacts

Scale	Intensity	Description of Effects	Corresponding Richter Scale magnitude
I	Instrumental	Usually detected only on seismographs.	<4.2
II	Feeble	Felt only by a few persons at rest, especially on upper floors of buildings.	
III	Slight	Felt quite noticeably indoors, especially on upper floors. Most people don't recognize it as an earthquake (i.e. a truck rumbling).	
IV	Moderate	Can be felt by people walking; dishes, windows, and doors are disturbed.	

Scale	Intensity	Description of Effects	Corresponding Richter Scale magnitude
V	Slightly Strong	Sleepers are awoken; unstable objects are overturned.	<4.8
VI	Strong	Trees sway; suspended objects swing; objects fall off shelves; damage is slight.	<5.4
VII	Very Strong	Damage is negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, and considerable in poorly built or badly designed structures; some chimneys are broken.	<6.1
VIII	Destructive	Damage is slight in specially designed structures; considerable in ordinary, substantial buildings. Moving cars become uncontrollable; masonry fractures, poorly constructed buildings damaged.	<6.9
IX	Ruinous	Some houses collapse, ground cracks, pipes break open; damage is considerable in specially designed structures; buildings are shifted off foundations.	
X	Disastrous	Some well-built wooden structures are destroyed; most masonry and frame structures are destroyed along with foundations. Ground cracks profusely; liquefaction and landslides widespread.	<7.3

Scale	Intensity	Description of Effects	Corresponding Richter Scale magnitude
XI	Very Disastrous	Most buildings and bridges collapse, roads, railways, pipes and cables destroyed.	<8.1
XII	Catastrophic	Total destruction; trees fall; lines of sight and level are distorted; ground rises and falls in waves; objects are thrown upward into the air.	>8.1

Earthquakes can lead to numerous, widespread, and devastating environmental impacts. These impacts may include, but are not limited to:

- Induced flooding or landslides
- Poor water quality
- Damage to vegetation
- Breakage in sewage or toxic material containments

Secondary impacts can include train derailments and spillage of hazardous materials and utility interruption.

4.3.2.3. Past Occurrence

Data from the Pennsylvania Department of Conservation and Natural Resources and USGS shows six recorded earthquakes occurred in the Lehigh Valley between the dates of 1871 and 2017, five with epicenters in the City of Allentown area and one near the City of Easton. Earthquake events in the Lehigh Valley as shown in the table below. The magnitude of these earthquakes ranged from 2.3 to 4.3 on the Richter Scale, suggesting relatively minor events. According to the USGS Incorporated Research Institutions for Seismology, almost 300 earthquakes were recorded within 100 miles of the Lehigh Valley from 1990-2017, including three that were between 4.00 and 4.99 in magnitude. However, no damages or injuries were reported in the Lehigh Valley.

Table 18: Earthquake Events Occurring in the Lehigh Valley Region, 1871 - 2023[53]

Date	Magnitude (Richter Scale)	Losses / Impacts
May 31, 1884	2.9	Epicenter near the City of Allentown. Maximum intensity of V. In Allentown, dishes were thrown from tables.
May 31, 1908	3.1	Epicenter near the City of Allentown. Maximum intensity of VI. In Allentown, the shock shook down chimneys.
June 22, 1928	2.4	Epicenter near the City of Allentown. Maximum intensity of III. No reference and/or no damage reported.
November 23, 1951	3.3	Epicenter near the City of Allentown. Maximum intensity of IV. No reference and/or no damage reported.
September 14, 1961	4.3	Epicenter near the City of Allentown. Maximum intensity of V. The earthquake shook buildings over a broad area. There was only one report of damage of loose bricks that fell from a chimney in Allentown. Other areas that were effected included Bethlehem, Catasauqua, Coplay, Egypt, Fountain Hill, Freemansburg, and Hellertown.
December 20, 2009	2.3	Epicenter approximately 3.2 miles from Raubsville (Williams Township, Northampton County).

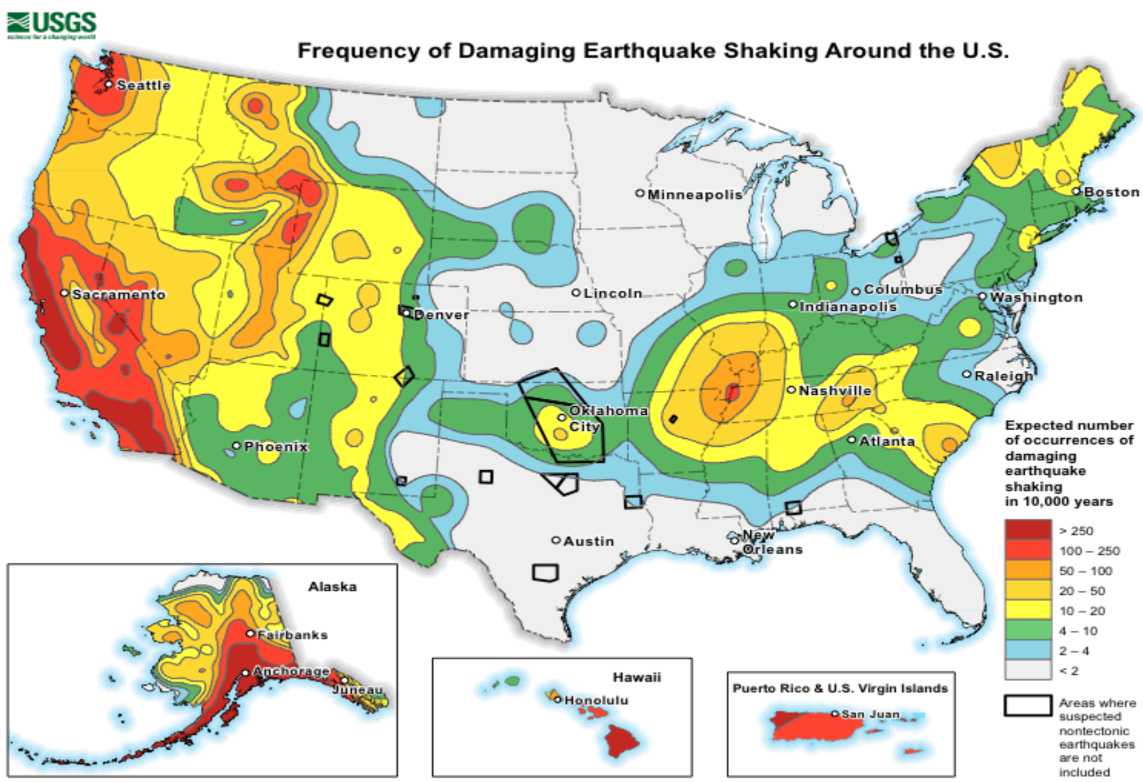
4.3.2.4. Future Occurrence

According to the Pennsylvania Bureau of Topographic and Geologic Survey, the risk of earthquakes in Pennsylvania is relatively low, based on analyses that account for potential earthquakes both within and

[53] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

outside the state's borders. The severity of an earthquake is often quantified by measuring the change in the earth's surface movement during the event compared to the standard acceleration rate due to gravity. This measure is termed Peak Horizontal Ground Acceleration (PHGA). To cause notable damage, the ground acceleration typically needs to surpass 15% of gravity. However, local soil conditions play a critical role in determining the extent of damage from a specific ground acceleration level. As per PEMA's findings, the greatest seismic risk in Pennsylvania lies in its southeastern region, where PHGA values are between 10-14%. Furthermore, there's a 90% likelihood that the maximum horizontal acceleration on rock won't exceed 10% of gravity over a span of 50 years.

Figure 9: Frequency of Damaging Earthquake Shaking Around the United States



Probability of Future Occurrences

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, as well as previous historical earthquake events, the probability of occurrence for earthquake events in the Lehigh Valley is considered ***Unlikely*** (less than 1% annual probability), as defined in the Methodology Section.

4.3.2.5. Vulnerability Assessment

An earthquake in a region like the Lehigh Valley would significantly impact various community lifelines. These lifelines are crucial services and functions that support the health, safety, and well-being of the population, and their stabilization is key to recovery from such a disaster. The primary community lifelines likely to be affected by an earthquake are shown in the table below.

Table 19: Potential Vulnerability of Lifelines to an Earthquake

Lifelines	Impact Type	Description
Water & Wastewater Systems		Earthquakes often damage water lines and sewage systems, leading to water shortages and sanitation issues. Restoring these services is crucial for public health and hygiene.
Food, Shelter, & Housing	 	The destruction of homes and businesses can displace people, creating an immediate need for shelter. Additionally, disruptions in supply chains can impact the availability and distribution of food.
Health & Medical		Healthcare facilities might suffer structural damage, and there could be an influx of injured individuals needing medical attention. Disruptions in utility services could also affect the operation of hospitals and clinics.
Energy		Power outages are common following earthquakes due to damage to power stations and distribution lines. This can affect not only homes and businesses but also critical facilities like hospitals and emergency response centers.

Lifelines	Impact Type	Description
Safety & Security		Earthquakes can cause significant damage to infrastructure, leading to hazardous situations like building collapses, gas leaks, and fires. Emergency services such as police, fire, and rescue teams would be heavily involved in immediate response efforts.
Transportation		Earthquakes can damage roads, bridges, and public transportation systems, impeding mobility and rescue efforts. Restoring transportation is vital for response operations and for the community to begin returning to normalcy.

The earthquake vulnerability of the Lehigh Valley remains consistent with the assessments from the 2018 Plan, meaning every jurisdiction remains at risk. Consequently, the entire population, infrastructure, and critical facilities might face the direct and indirect consequences of earthquakes. Using the HAZUS-MH v4.0 analysis, three earthquake probabilities were deduced: the 100-year, 500-year, and 2,500-year mean return periods, alongside an evaluation of annualized losses across eight return periods to gauge potential financial loss to buildings.

In the 2024 assessment, comprehensive data sources, including county building footprints, updated tax assessments, and 2018 RS Means building valuations, were utilized to ascertain the replacement cost of Lehigh Valley's general building stock. An enhanced inventory of critical facilities was also compiled, leveraging data from 2018 and newer spatial layers provided by the GIS Departments of Lehigh and Northampton County. All these data points were processed in HAZUS-MH v4.0 to project potential damages.

People

The entire Lehigh Valley, home to 687,508 residents, is potentially susceptible to earthquake impacts. The level of vulnerability hinges on multiple variables, including building age, construction methodology, and underlying soil conditions. While the risk to public safety and life is minimal, structures might sustain damage, and loose building components could pose threats to passersby. Secondary effects, such as business interruptions, road blockages, and utility failures, could further amplify an earthquake's impacts.

Certain demographics, notably individuals over 65 and those living under the poverty line, are particularly vulnerable due to factors like their physical capacity, financial resources, and housing conditions. A significant oversight in disaster planning is the lack of consideration for individuals with disabilities. A 2014 UNDRR report emphasized that only a mere 15% of disabled persons were consulted during community resilience planning. In the event of a major earthquake, the repercussions would be gravely felt by the Lehigh Valley's socially vulnerable groups. While affluent communities or business owners, especially in urban areas like Allentown, might incur more immediate losses, the long-term impact on economically challenged households would be profound due to their lack of financial buffers or insurance.

Post-disaster, many residents might need relocation or shelter, although the number seeking shelter might be less than the displaced, as some might opt for hotels or staying with acquaintances. HAZUS-MH's sheltering estimates, based on the 2010 US Census, are detailed in the table below.

Table 20: Estimated Sheltering Needs for Lehigh Valley

Scenario	Displaced Households	People Requiring Short-Term Shelter
100-Year Earthquake	0	0
500-Year Earthquake	740	471
2,500-Year Earthquake	40	20

In the event of a severe incident, residents might find themselves unable to return to their homes or communities for an extended duration. Neighboring regions to the affected areas could see a surge in population as individuals evacuate their homes in search of safety. Earthquakes, especially in regions like Lehigh and Northampton counties, can necessitate such evacuations. Even moderate earthquakes might cause minor structural damages, mandating safety inspections of buildings and residences. Until safety is assured, residents would need to vacate their premises.

For the 100-year event, no injuries or casualties are projected. However, using the HAZUS-MH 4.0 analysis, potential injuries and casualties for the 500-year and 2,500-year events are detailed in the subsequent tables.

Table 21: Estimated Injuries & Casualties: 500-year Earthquake Event

Level of severity	Time of Day		
	2 AM	2 PM	5 PM
Injuries	17	16	12
Hospitalization	2	2	1
Casualties	0	0	0

Table 22: Estimated Injuries & Casualties: 2,500-year Earthquake Event

Level of severity	Time of Day		
	2 AM	2 PM	5 PM
Injuries	118	111	86
Hospitalization	19	16	13
Casualties	3	2	2

Systems & Structures

The entirety of Lehigh Valley's building stock stands exposed to potential earthquake hazards. This analysis quantifies the anticipated losses to the building stock, categorizing damages by building type and occupancy class and evaluating total losses, including structural and content damages.

Beyond infrastructure damage, earthquakes can severely impact the economy. This encompasses business interruptions, inventory damages, relocation expenses, wage and rental losses stemming from building repairs or replacements. Economic loss projections for the 100-, 500-, and 2,500-year events indicate significant financial implications, with the Lehigh Valley potentially facing $26 million in income losses for the 500-year event and a staggering $166.9 million for the 2,500-year scenario.

Furthermore, we assessed potential damages to vital facilities and utilities, measuring their operational functionality post-event. Interestingly, the 100-year event showed no discernible impact on these facilities. On the transportation front, roads and rail tracks might bear the brunt of ground failures, potentially disrupting regional transport and material distribution. While HAZUS did not provide specific roadway damage estimates, it did project minimal bridge damages for the 500-year event, with losses pegged at $64,300 for the 2,500-year event.

An integral part of our analysis, using HAZUS-MH 4.0, was estimating potential debris volumes post-earthquake, aiding Lehigh Valley in its disaster response planning. Debris has been categorized into two types: (1) reinforced concrete and steel, which requires specialized equipment for disintegration and transport, and (2) materials like brick and wood, which can be directly loaded onto trucks. For the 100-year event, no debris generation is projected. However, the 500-year event might produce over 42,000 tons of debris, while the 2,500-year event could result in 238,000 tons.

Natural, Cultural, & Historic Resources

The Lehigh Valley is rich in natural, cultural, and historical resources, many of which are vulnerable to the impacts of an earthquake. Firstly, the valley's natural landscapes, including its distinctive ridges, waterways, and parks, could experience landslides, sediment disruption, and alteration of water flow due to seismic activities. Such changes might disrupt local ecosystems, affecting both flora and fauna, and potentially lead to long-term environmental consequences.

Moreover, the Lehigh Valley is home to a plethora of cultural and historical landmarks, many of which stand as testament to the region's rich industrial and colonial past. Buildings like the Moravian settlements in Bethlehem, historic mills, and colonial-era structures were not built to modern seismic standards. An earthquake could damage these irreplaceable structures, leading to loss of architectural heritage. Additionally, cultural institutions, such as museums housing valuable artifacts, could be at risk. Damage to these structures could mean loss of invaluable artifacts that tell the story of the Lehigh Valley's past.

Community Activities

An earthquake in the Lehigh Valley could significantly disrupt the rhythm of daily life and community activities. Public gatherings, school sessions, local events, and religious ceremonies might face abrupt cancellations or postponements due to safety concerns or infrastructure damages. Local businesses, including farmers' markets, shops, and eateries, which form the backbone of community interactions, could experience temporary closures, impacting local economy and livelihoods. Parks and recreational areas, often hubs for community bonding, might be deemed unsafe due to potential aftershocks or structural damages, depriving residents of essential communal spaces. Furthermore, transportation disruptions could isolate neighborhoods, making it challenging for residents to access essential services, workplaces, or even loved ones. In essence, an earthquake could momentarily halt the vibrant community spirit of Lehigh Valley, emphasizing the importance of preparedness and resilience in the face of such challenges.

4.3.3 *Extreme Temperature*

4.3.3.1. Location and Extent

Extreme temperature events, often referred to as extreme heat or cold events, are periods of unusually high or low temperatures that deviate significantly from the historical averages for a given region. These events can manifest as heatwaves or cold waves, and their intensity, duration, and frequency are critical factors in defining their extremity.[54] Extremely high temperatures cause heat stress along with heat rash, sunburn, heat cramps, heat exhaustion, heat stroke, and death. Cold temperatures can be extremely dangerous to humans and animals exposed to the elements as well. Without heat and shelter, cold temperatures can cause hypothermia, frost bite, and death.

Extreme cold temperature events, often referred to as cold snaps or polar vortex episodes, are meteorological phenomena characterized by a significant drop in temperature, typically well below the seasonal average, over an extended period.[55] In the context of the Lehigh Valley, located in eastern Pennsylvania, these events can bring bitterly cold and frigid conditions, with temperatures plummeting to sub-zero Fahrenheit levels. The dangers associated with extreme cold in this region are multifaceted. First and foremost, prolonged exposure to such severe cold can pose serious health risks, including frostbite and hypothermia, especially for vulnerable populations like the elderly and homeless. Additionally, extreme cold can strain infrastructure, leading to frozen pipes, power outages, and reduced transportation options. It can also disrupt daily life, causing school closures, business interruptions, and a heightened risk of accidents on icy roads.

Heatwaves are characterized by prolonged periods of excessively hot weather, which may be accompanied by high humidity, especially in coastal regions.[56] They are typically defined by temperatures that hover above the 90th percentile for a particular region over a specified period, often lasting for several days or weeks. Cold waves, conversely, are periods of abnormally low temperatures

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[54] Masson-Delmotte, Valérie, Panmao Zhai, Anna Pirani, Sarah L. Connors, Clotilde Péan, Sophie Berger, Nada Caud, et al., eds. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2021. https://doi.org/10.1017/9781009157896.

[55] Cybersecurity & Infrastructure Security Agency. "Extreme Cold." cisa.gov. Accessed December 11, 2023. https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/extreme-weather-and-climate-change/extreme-cold.

[56] US Department of Commerce and National Oceanic and Atmospheric Administration. "Heat Safety Tips and Resources." weather.gov. NOAA's National Weather Service. Accessed December 11, 2023. https://www.weather.gov/safety/heat.

that can result in frost, ice, and snow events, posing significant risks to human health, infrastructure, and ecosystems.[57]

The impact of extreme temperature events can be severe, leading to health emergencies, such as heatstroke or hypothermia, and exacerbating chronic health conditions. They can also strain energy systems, disrupt agriculture, and lead to increased mortality rates.

Extreme heat often results in the highest number of annual deaths of all weather-related hazards. In most of the United States, extreme heat is defined as a long period (2 to 3 days) of high heat and humidity with temperatures above 90 degrees.[58] Extremely cold air comes every winter in at least part of the country and affects millions of people across the United States. The arctic air, together with brisk winds, can lead to dangerously cold wind chill values. People exposed to extreme cold are susceptible to frostbite and hypothermia in a matter of minutes.[59]

During July, the warmest month, high temperatures in the Lehigh Valley normally range from the low-80s in the northern areas to the upper-70s/mid-80s in the central and southern areas. Minimum temperatures in the Lehigh Valley range from the upper-60s in the southeast to the lower-50s in the north-central mountains. During the colder months, most of the Lehigh Valley experiences low temperature averages ranging from 16°F in the north to as high as 21°F in urban areas.[60]

The Lehigh Valley can experience many different temperature extremes in the summer and winter seasons. Areas most susceptible to extreme heat are urban environments, which tend to retain the heat well into the night, leaving little opportunity for dwellings to cool. As these urban areas develop and change, so does the landscape. Buildings, roads and other infrastructure replace open land and vegetation. Structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies. Urban areas, where these structures are highly concentrated and greenery is limited, become "islands" of higher temperatures relative to outlying areas. These pockets of heat are referred to as "heat islands." Heat islands can form under a variety of conditions, including during the day or night, in small or large cities, in suburban areas, in northern or southern climates, and in any season.

A review of research studies and data found that in the United States, the heat island effect results in daytime temperatures in urban areas about 1–7°F higher than temperatures in outlying areas and

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[57] World Health Organization. "Heatwaves and Health: Guidance on Warning-System Development." who.int, June 30, 2016. https://www.who.int/publications/m/item/heatwaves-and-health--guidance-on-warning-system-development.

[58] Ready.Gov – Heat. Retrieved on 07/06/2023 from: https://www.ready.gov/heat

[59] Centers for Disease Control (CDC) – Hypothermia. Retrieved on 07/06/2023 from: https://www.cdc.gov/disasters/winter/staysafe/hypothermia.html

[60] National Centers for Environmental Information. "Dataset Search," 2023. https://www.ncei.noaa.gov/access/search/dataset-search.

nighttime temperatures about 2–5°F higher. Humid regions (primarily in the eastern United States) and cities with larger and denser populations experience the greatest temperature differences. Research predicts that the heat island effect will strengthen in the future as the structure, spatial extent, and population density of urban areas change and grow.[61]

Heat islands form because of several factors:

- **Reduced Natural Landscapes in Urban Areas.** Trees, vegetation, and water bodies tend to cool the air by providing shade, transpiring water from plant leaves, and evaporating surface water, respectively. Hard, dry surfaces in urban areas – such as roofs, sidewalks, roads, buildings, and parking lots – provide less shade and moisture than natural landscapes and therefore contribute to higher temperatures.

- **Urban Material Properties**. Conventional human-made materials used in urban environments such as pavements or roofing tend to reflect less solar energy, and absorb and emit more of the sun's heat compared to trees, vegetation, and other natural surfaces. Often, heat islands build throughout the day and become more pronounced after sunset due to the slow release of heat from urban materials.

- **Urban Geometry**. The dimensions and spacing of buildings within a city influence wind flow and urban materials' ability to absorb and release solar energy. In heavily developed areas, surfaces and structures obstructed by neighboring buildings become large thermal masses that cannot release their heat readily. Cities with many narrow streets and tall buildings become urban canyons, which can block natural wind flow that would bring cooling effects.

- **Heat Generated from Human Activities**. Vehicles, air-conditioning units, buildings, and industrial facilities all emit heat into the urban environment. These sources of human-generated, or anthropogenic, waste heat can contribute to heat island effects.

- **Weather and Geography**. Calm and clear weather conditions result in more severe heat islands by maximizing the amount of solar energy reaching urban surfaces and minimizing the amount of heat that can be carried away. Conversely, strong winds and cloud cover suppress heat island formation. Geographic features can also impact the heat island effect. For example, nearby mountains can block wind from reaching a city, or create wind patterns that pass through a city.

4.3.3.2. Range of Magnitude

Extreme temperatures can result in elevated utility costs to consumers and can cause human risks. Extremely high temperatures cause heat stress. Major human risks for these temperatures include heat cramps, heat syncope, heat exhaustion, heatstroke, and death. The impacts of high temperatures will

[61] U.S. Environmental Protection Agency – Learn About Heat Islands. Retrieved on 07/06/2023 from: https://www.epa.gov/heatislands/learn-about-heat-islands#_ftn1

vary from person to person based on individual age, health, and other factors. The very old and the very young are most vulnerable to health-related impacts of extreme temperatures. Without heat and shelter, cold temperatures can lead to hypothermia, frostbite and death. Wind chill temperatures are often used in place of raw temperature values due to the effect that wind can have on the body under cold temperatures. In Pennsylvania (including in the Lehigh Valley), wind chill warnings are issued when wind chills are forecasted to drop to -25°F or lower. Wind chill advisories are issued when wind chill values are forecasted to drop to -15°F.[62]

Temperature advisories, watches and warnings are issued by the National Weather Service relating the above impacts to the range of temperatures typically experienced in Pennsylvania. Exact thresholds vary across the region, but in general Heat Advisories are issued when the heat index will be equal to or greater than 100°F, but less than 105°F, Excessive Heat Warnings are issued when heat indices will attain or exceed 105°F, and Excessive Heat Watches, are issued when there is a possibility that excessive heat warning criteria may be experienced within twelve to forty-eight hours. The heat index is a measurement that considers both the temperature and relative humidity and is calculated as shown in the figure below.

While brief spells of extreme temperatures, whether hot or cold, might not cause major environmental disturbances, their health repercussions can be dire, especially in urban locales prone to the heat island effect. However, extended heatwaves can usher in drought-like conditions, harming vegetation, depleting rivers and streams, and compromising water quality. On the other hand, sustained exposure to extreme cold can be fatal for wildlife and vegetation.[63]

Extreme Heat

In the Lehigh Valley, the most severe scenario for extreme heat would be an intense heatwave coinciding with a major summer holiday, like Independence Day weekend. Such holidays tend to draw people outside, even when facing dangerous heat levels. A striking example occurred in July 1999. While temperatures first reached the 90s on July 3rd, the subsequent days, especially from July 4th to 6th, saw the mercury soaring to around 100°F coupled with oppressive humidity, resulting in heat indices nearing 110°F. Both the Lehigh Valley International Airport and the City of Easton recorded peak temperatures of 100°F on July 5th. Tragically, this heatwave resulted in two fatalities in the Lehigh Valley and caused 74 heat-related deaths and over 100 heat-related injuries in the affected Pennsylvania counties.

Extremely high temperatures can cause heat stress, which is divided into four categories. Each category is defined by apparent temperature, which is associated with a heat index value that captures the

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[62] US Department of Commerce and National Oceanic and Atmospheric Administration. "Wind Chill Questions." weather.gov. NOAA's National Weather Service. Accessed December 11, 2023. https://www.weather.gov/safety/cold-faqs.

[63] U.S. Environmental Protection Agency Office of Air and Radiation. "Learn About Heat Islands." Overviews and Factsheets, June 17, 2014. https://www.epa.gov/heatislands/learn-about-heat-islands.

combined effects of dry air temperature and relative humidity on humans and animals. Major human risks for these temperatures include heat cramps, heat syncope, heat exhaustion, heatstroke and death. The temperatures serve as a guide for various danger categories; the impacts of high temperatures will vary from person to person based on individual age, health and other factors.

Figure 10: National Weather Service's Heat Index Matrix

Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

NOAA's heat alert procedures are based mainly on heat index values. The heat index is given in degrees Fahrenheit (°F). It is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. To find the heat index temperature, the temperature and relative humidity need to be known. It is important to know that the heat index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F.[64]

Extreme Cold

The extent of extreme cold temperatures is generally measured through the Wind Chill Temperature (WCT) Index. Wind chill is the temperature that people and animals feel when outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body

[64] US Department of Commerce, NOAA. "Heat Forecast Tools." NOAA's National Weather Service. Accessed December 11, 2023. https://www.weather.gov/safety/heat-index.

is cooled at a faster rate causing the skin's temperature to drop.[65] The WCT Index includes a frostbite indicator, showing points where temperature, wind speed and exposure time will produce frostbite to humans, including how long a person can be exposed before frostbite develops as shown in the figure below.

Figure 11: National Weather Service Windchill Chart[66]

National Weather Service Wind Chill 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

The gravest extreme cold scenario for the Lehigh Valley would be marked by subzero temperatures and biting winds, further exacerbated by snow or ice accumulation and power outages. A vivid instance of this took place in January 2003, with temperatures plummeting between 8 and -11°F, leading to four fatalities.

[65] National Weather Service. Wing Chill. Retrieved on 07/10/2023 from: https://www.weather.gov/ama/WindChill#:~:text=Wind%20Chill%20is%20a%20term,skin%20if%20you%27re%20outside.

[66] NOAA, and National Weather Service. "National Weather Service Wind Chill Chart." weather.gov. Accessed December 11, 2023. https://www.weather.gov/media/unr/windchill.pdf.

4.3.3.3. Past Occurrence

The highest temperature ever recorded in the region was 105°F on the 4th of July weekend in 1966, while the lowest temperature ever recorded was -15°F on January 21, 1994. Since 1996, the Lehigh Valley was subject to more than 196 extreme temperature events.[67] These events have been responsible for 11 deaths and 75 injuries. Please note that extreme temperature data is regional, and the temperatures, deaths and injuries were not necessarily in Northampton or Lehigh County. The table below shows extreme temperature events recorded since 2012.

Table 23: Extreme Temperature Events in Lehigh Valley 2012 -2023

Date	Type	Actual Temperature °F*	Deaths	Injuries
6/20/2012	Heat	95	0	0
6/29/2012	Heat	96	0	0
7/4/2012	Heat	99	3	0
7/18/2012	Excessive Heat	98	0	0
7/26/2012	Heat	91	0	0
7/7/2013	Heat	92	0	0
7/18/2013	Excessive Heat	98	0	0
9/11/2013	Heat	92	0	0

[67] National Centers for Environmental Information. "Storm Events Database." ncdc.noaa.gov. https://www.ncdc.noaa.gov/stormevents/.

Date	Type	Actual Temperature °F*	Deaths	Injuries
1/4/2014	Cold/wind Chill	-4	0	0
1/7/2014	Cold/Wind Chill	-1	0	0
1/22/2014	Cold/Wind Chill	-1	0	0
7/2/2014	Heat	94	0	0
1/7/2015	Cold/Wind Chill	2	0	0
2/13/2015	Cold/Wind Chill	5	0	0
2/15/2015	Cold/Wind Chill	7	1	0
2/20/2015	Cold/Wind Chill	-3	1	0
2/24/2015	Cold/Wind Chill	-8	0	0
7/19/2015	Heat	93	0	0
2/14/2016	Cold/Wind Chill	2	0	0
07/01/2018	Heat	95	0	0

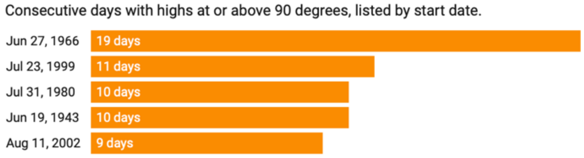
Date	Type	Actual Temperature °F*	Deaths	Injuries
06/29/2021	Heat	94	0	0
08/11/2021	Heat	95	0	0
12/24/2022	Cold	3	0	0
		Total	**5**	**0**

Figure 12: Temperature Extremes Reported in the Lehigh Valley[68]

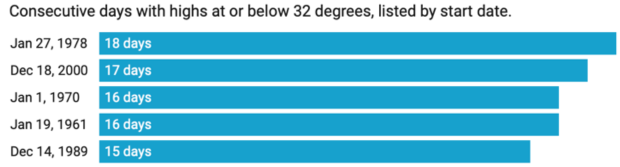
	HOTTEST DAY (daily high)	Date	HOTTEST MONTH (avg. high)	Date	HOTTEST YEAR (avg. temp.)	Date
1	103	Jul. 10, 1936	91	July 1966	54.4	2019
2	102	Jul. 2, 1966	89.7	July 1944	54.1	2017
3	104	Jul. 22, 2011	91.1	July 1955	54.6	2020
4	105	Jul. 3, 1966	91.3	July 1999	54.6	2012
5	103	Jul. 9, 1936	89.7	July 2011	54.3	2016

	COLDEST DAY (daily low)	Date	COLDEST MONTH (avg. low)	Date	COLDEST YEAR (avg. temp.)	Year - date
1	-15	Jan. 21, 1994	6.2	February 1934	49	1967
2	-12	Jan. 22, 1961	8.6	February 2015	49.3	1940
3	-12	Feb. 9, 1934	10.4	January 1945	49.6	1958
4	-11	Jan. 19, 1994	11	January 1977	49.6	1996
5	-11	Jan. 22, 1984	11.2	January 1948	49.9	1963

Consecutive days with highs at or above 90 degrees, listed by start date.



Consecutive days with highs at or below 32 degrees, listed by start date.



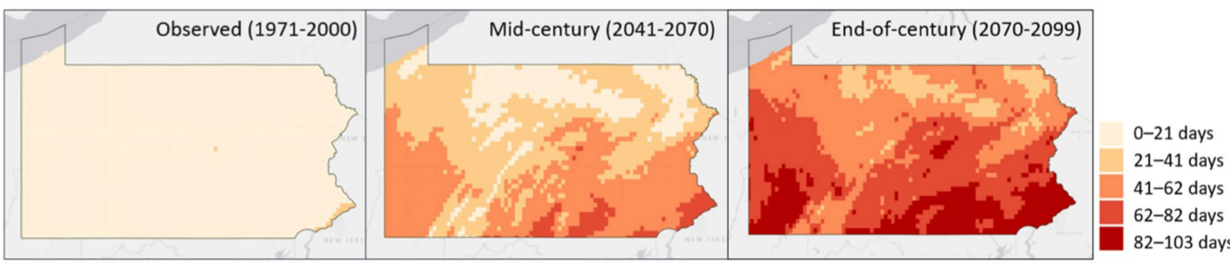
[68] Steve Novak. "The Lehigh Valley's Most Extreme Weather: Local Records for Heat, Cold, Floods and More." lehighvalleylive.com, January 26, 2019. https://www.lehighvalleylive.com/news/g66l-2019/01/290a67b7e01688/the-lehigh-valleys-most-extreme-weather-local-records-for-heat-cold-floods-and-more.html.

4.3.3.4. Future Occurrence

Due to its location and geography, the Lehigh Valley is more likely to encounter excessive heat than extreme cold weather. Topography and vegetation can impact temperature differentials across the Lehigh Valley. It is estimated that the entire Lehigh Valley will continue to experience temperature extremes annually that may induce secondary hazards such as potential snow, hail, ice or windstorms, thunderstorms, drought, human health impacts, utility interruptions and transportation crashes.

A 2021 study forecasts a significant warming trend for Pennsylvania, projecting an average annual temperature rise of 5.9°F (3.3°C) from the historical baseline. This warming is anticipated to bring about a marked increase in both the frequency and intensity of extreme heat events. The study predicts that the state will experience an average of 37 days per year with temperatures soaring to 90°F or higher, a substantial increase from the baseline average of 5 days. Additionally, days with temperatures exceeding 95°F and even 100°F are expected to become increasingly common.[69]

Figure 13: Observed and Projected Annual Days with Temperatures above 90F



Probability of Future Occurrences

Over the 27 years of record keeping of extreme temperature events (1996-2023), there have been 196 recorded events, an average of 7.25 events per year. In the last 10 years, 2013 – 2023, there has been an extreme temperature event in 7 of the 10 years. As such, the probability that the Lehigh Valley will experience an extreme temperature event in any given year is ***Highly Likely***.

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[69] Pennsylvania Department of Environmental Protection. "Pennsylvania Climate Impacts Assessment 2021." http://www.depgreenport.state.pa.us/elibrary/PDFProvider.ashx?action=PDFStream&docID=3667348&chksum=&revision=1&docName=PENNSYLVANIA+CLIMATE+IMPACTS+ASSESSMENT+2021&nativeExt=pdf&PromptToSave=False&Size=6739063&ViewerMode=2&overlay=0.

Future Considerations for Climate Change

According to the 2022 Global Climate Report[70] from NOAA National Centers for Environmental Information, every month of 2022 ranked among the ten warmest for that month, despite the cooling influence from the La Niña climate pattern in the tropical Pacific. The "coolest" month was November, which was 1.35 ˚F (0.75 ˚C) warmer than average. The year 2022 was the sixth warmest year since global records began in 1880 at 0.86°C (1.55°F) above the 20th century average of 13.9°C (57.0°F). This value is 0.13°C (0.23°F) less than the record set in 2016 and it is only 0.02°C (0.04°F) higher than the last year's (2021) value, which now ranks as the seventh highest. The 10 warmest years in the 143-year record have all occurred since 2010, with the last nine years (2014–2022) ranking as the nine warmest years on record.

Though warming has not been uniform across the planet, the upward trend in the globally averaged temperature shows that more areas are warming than cooling. According to NOAA's 2021 Annual Climate Report[71] the combined land and ocean temperature has increased at an average rate of 0.14 degrees Fahrenheit (0.08 degrees Celsius) per decade since 1880; however, the average rate of increase since 1981 has been more than twice as fast: 0.32 °F (0.18 °C) per decade.

4.3.3.5. Vulnerability Assessment

Extreme temperature events, encompassing both heatwaves and severe cold spells, can significantly impact a range of community lifelines. These events test the resilience and preparedness of communities like the Lehigh Valley. The key community lifelines likely to be affected by extreme temperature events are shown in the table below.

Table 24: Potential Vulnerabilities of Lifelines to Extreme Temperature Events

Lifelines	Impact Type	Description
Water & Wastewater Systems		In extreme cold, water lines can freeze and burst, causing significant disruptions. During heatwaves, there can be an increased demand for water, potentially leading to shortages or water conservation measures.

[70] NOAA – National Centers for Environmental Information (NCEI) – 2022 Annual Global Climate Change Report. https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202213.

[71] NOAA – National Centers for Environmental Information (NCEI) – 2021 Annual Global Climate Change Report. Retrieved on 07/06/2023 from: https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202113

Lifelines	Impact Type	Description
Food, Shelter, & Housing	 	Extreme temperatures can render homes uninhabitable without adequate heating or cooling, leading to a need for emergency shelters. Cold spells can affect the transportation and delivery of food supplies, while heatwaves can impact food storage and spoilage.
Health & Medical		Extreme temperatures, both hot and cold, can lead to a surge in health-related emergencies, such as heatstroke, dehydration, hypothermia, and respiratory conditions. Healthcare facilities might face increased demand, and the need for medical supplies and services may rise sharply.
Energy		High demand for heating or cooling during extreme temperature events can strain power grids, leading to outages. Fuel supply lines for heating systems could also be impacted, especially during cold spells.
Safety & Security		Emergency services may be in high demand, and there can be increased risks of accidents and injuries due to weather-related conditions. For example, cold spells can lead to increased incidents of fires from heating devices, while heatwaves can exacerbate conditions like droughts, leading to wildfires.
Transportation		Both extreme heat and cold can affect transportation infrastructure. Heat can cause roads and railways to buckle, while cold can lead to icy conditions and snow accumulation, disrupting road, air, and rail travel.

Most extreme temperature events involve a large region; therefore, the entire Lehigh Valley has been identified as the hazard area. All people, structures and critical facilities are exposed and potentially vulnerable. Overall, the Lehigh Valley's vulnerability has not changed since the 2018 Plan.

People

In the Lehigh Valley, extreme temperature events, both hot and cold, have multifaceted implications on the community's well-being. On one end, extreme heatwaves can lead to myriad health issues, including heat exhaustion, heatstroke, and exacerbation of pre-existing medical conditions, especially for vulnerable populations such as the elderly, infants, and those with chronic illnesses. High temperatures can also strain the local power grid, leading to power outages as residents ramp up the use of air conditioning, leaving many without a respite from the relentless heat and potentially compromising the safety of stored food and medications.

On the other end of the spectrum, extreme cold spells can be equally perilous. Prolonged exposure to frigid temperatures can result in hypothermia, frostbite, and other cold-induced ailments. The cold can also challenge the community's infrastructure: water pipes can freeze and burst, roads can become treacherously icy, and the demand for heating can again strain energy resources. Furthermore, elderly residents, those living in inadequately insulated homes, and the homeless are particularly at risk during these cold snaps. In both scenarios—intense heat and severe cold—the Lehigh Valley sees a tangible impact on its healthcare system, infrastructure, and the overall safety and well-being of its residents

Extreme temperature events have potential health impacts including injury and death. According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include:

1. The elderly, who may be less able to withstand temperature extremes due to age, health conditions and limited mobility to access shelters, especially urban-dwelling elderly without access to an air-conditioned environment for at least part of the day;
2. Infants and children up to four years of age;
3. Individuals who are physically ill (e.g., heart disease or high blood pressure),
4. Low-income persons who cannot afford proper heating and cooling; and
5. People who overexert during work or exercise during extreme heat or cold events.

Systems & Structures

Heatwaves put pressure on the electrical grid in several ways. They increase demand as people turn up air-conditioning and some appliances must work harder to maintain cool temperatures. At the same time, higher temperatures can also squeeze electricity supplies by reducing the efficiency and capacity of traditional thermal power plants, such as coal, natural gas and nuclear. Extreme heat can reduce the availability of water for cooling plants or transporting fuel, forcing operators to reduce their output. In some cases, it can result in power plants having to shut down, increasing the risk of outages. If the heat wave is spread over a wide geographic area, it also reduces the scope for one region to draw on spare capacity from its neighbors, since they must devote their available resources to meeting local demand.

A recent heat wave in Texas forced the grid operator to call for customers to raise their thermostats to conserve energy.[72] Power generating companies suffered outages at much higher rates than expected, providing an unwelcome reminder of the brutal cold snap in February 2021, when outages – primarily from natural gas power plants – left up to 5 million customers across the US without power over a period of four days.[73] Highways and railroad tracks can become distorted in high heat. Disruptions to the transportation network and crashes due to extreme temperatures represent an additional risk.

Natural, Cultural, & Historical Resources

Extreme temperature events also have impacts on the economy, including loss of business function and damage or loss of inventory. Those losses, the need for repairs or increased utility costs can increase the financial burden on business owners.

The agricultural industry is most at risk in terms of economic impact and damage. Temperature and duration of extreme cold can have devastating effects on trees and winter crops. Livestock is especially vulnerable to heat, and crop yields can be impacted by heat waves that occur during key development stages. Lehigh County is threatened with higher agricultural losses than Northampton County. If an extreme temperature event were to eliminate the entire Lehigh Valley's agricultural yield, total losses may exceed $115 million, which would be devastating to the local economy, as indicated in the Drought profile.

Like drought, changing temperatures are classified as a slow environmental changes. In response to this change, most likely driven by climate change, people adopt various migration patterns, from temporary migration for a few weeks or months, to longer-term seasonal migration each year and even permanent migration away from their homes. Historically, urban to rural migration usually occurs to minimize the health effects of heat during times of hot temperatures, while rural to urban migration is usually observed when people move to cities to find help and access basic services during heat-related events.[74]

In the Lehigh Valley, prolonged extreme temperature events have the potential to impact the agricultural industry, water supply for human consumption, power and utility supplies, water quality and

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[72] The New York Times – Texas Power Grid, Strained Last Winter, Now Faces and Early Heat Wave, June 15, 2021. Retrieved on 07/10/2023 from: https://www.nytimes.com/2021/06/15/climate/texas-heat-wave-electricity.html

[73] International Energy Association (IEA) – Severe power cuts in Texas highlight energy security risks related to extreme weather events, February 18, 2021. Retrieved on 07/10/2023 from: https://www.iea.org/commentaries/severe-power-cuts-in-texas-highlight-energy-security-risks-related-to-extreme-weather-events

[74] International Organization for Migration, and The United Nations Migration Agency. "Extreme Heat and Migration," July 28, 2017. https://publications.iom.int/system/files/pdf/mecc_infosheet_heat_and_migration.pdf.

natural habitats of plants and animals. If extreme heat or cold events coincide with power outages, residents may be forced to temporarily leave their homes and seek shelter that has comfort measures such as air conditioning or heat. If the Lehigh Valley does not have ample shelters, residents may need to leave the region to find shelter. The Lehigh Valley may also experience an increase in population during extreme temperature events impacting areas outside of the region. Those in other counties and states may temporarily move into the Lehigh Valley to find relief from temperature extremes.

According to the USDA Risk Management Agency, between 2010 and 2023 there have been $726,344 in reported losses to insured crops due to heat events. The following table shows these losses annualized.

Table 25: Annualized Loss Estimates for Heat Events in the Lehigh Valley[75]

Crop Losses According to USDA RMA 2010 - 2023[76]	
Lehigh County	$40,762
Northampton County	$15,110
Lehigh Valley Total	$55,872

Community Activities

In the scenic Lehigh Valley, extreme temperature events can significantly influence community activities and daily life rhythms. During intense heatwaves, outdoor activities such as community fairs, farmers' markets, and sporting events may need to be rescheduled, shortened, or even canceled to protect the health of participants and attendees. Playgrounds can become hazards with overheated equipment, and outdoor recreational facilities, such as pools or parks, may experience overcrowding as residents seek relief from the heat.

Conversely, extreme cold, snow and ice can hinder transportation, making it challenging for residents to attend social events, participate in group activities, or even commute to work or school. Annual winter festivities, like holiday parades or outdoor ice-skating rinks, might face postponement or cancellation. Furthermore, schools might see recurrent closures or shifts to remote learning due to the harsh weather, affecting students' learning experiences and forcing parents to make alternative childcare arrangements.

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[75] USDA – Risk Management Agency. Cause of Loss Historical Data. Retrieved on 07/19/2023 from: https://www.rma.usda.gov/Information-Tools/Summary-of-Business/Cause-of-Loss

[76] Sum of reported losses between 2010 – 2023 divided by number of years.

4.3.4 *Flood, Flash Flood, Ice Jam*

A flood is a temporary condition of partial or complete inundation of a normally dry area caused by rising water in an existing waterway, such as a river, stream, or drainage ditch. Flooding is a longer-term event than flash flooding: it may last days or weeks. Flash Flooding is caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours. Flash floods are usually characterized by raging torrents after heavy rains that can rip through riverbeds, urban streets, or mountain canyons, sweeping everything before them. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen if a levee or dam has failed, or after a sudden release of water by a debris or ice jam.[77] Ice Jams are caused by pieces of floating ice carried with a stream's current, which can accumulate at any obstruction to the stream flow. Ice jams occur when warm temperatures and heavy rain cause snow to melt rapidly. Snow melt combined with heavy rains can cause frozen rivers to swell, which breaks the ice layer on top of the river. The ice layer often breaks into large chunks, which float downstream and often pile up near narrow passages other obstructions, such as bridges and dams. These ice jams can develop near river bends, mouths of tributaries, points where the river slope decreases, downstream of dams and upstream of bridges or obstructions. The water that is held back may cause flooding or flash flooding upstream. If the obstruction suddenly breaks, then flash flooding may occur downstream.[78]

4.3.4.1. Location and Extent

Floods are one of the most common natural hazards in the United States and are the most prevalent type of natural disaster occurring in Pennsylvania.[79] It is also the most significant natural hazard in the Lehigh Valley.

Flooding in the Lehigh Valley occurs in all seasons from both extra-tropical (storms produced from the passage of either a cold front or a warm front) and tropical storms. Flood conditions may be aggravated

[77] U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. "Flood and Flash Flood Definitions." weather.gov. https://www.weather.gov/mrx/flood_and_flash.

[78] Niziol, Tom. "Ice Jams: A Winter and Spring Version of Flash Floods." wunderground.com, May 1, 2020. https://www.wunderground.com/cat6/ice-jams-a-winter-and-spring-version-of-flash-floods.

[79] Federal Emergency Management Agency. "Disaster Declarations for States and Counties." fema.gov, March 9, 2023. https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties.

by the rapid melting of an existing snowpack, and/or by the reduction in infiltration losses due to frozen ground. [80] [81]

Extra-tropical storms associated with cold fronts occur mostly during the warmer months of the year. Precipitation accompanying the passage of a cold front tends to be intense and of short duration, occurring in the form of thunderstorms or snowfall. Major basin-wide floods are rarely caused by cold-front rainfall; however, the majority of floods along the smaller tributaries and in the headwater areas of the main streams are produced by cold-front storms.

Extra-tropical storms associated with warm fronts may be expected at any time during the year, but they are more prevalent during the colder months of the year. Warm-front storms, producing less intense but more protracted rainfall, have produced most of the basin-wide floods. A special type of flooding associated with a warm-front storm is produced when rain falls on a winter snowpack. The rapid spring melting of a deep snowpack combined with heavy rainfall can be the cause of significant runoff.

Riverine, flash, storm water and ice jam floods occur around rivers, streams and creeks found throughout the Lehigh Valley. Stormwater/urban flooding occurs in areas of ditches, storm sewers, retention ponds and other facilities constructed to store runoff. Within Lehigh and Northampton Counties, the State has designated 16 watersheds for the purposes of Stormwater management. The Lehigh Valley has ordinances in place for all 16 watersheds.

Two major rivers, the Lehigh and Delaware, are located within the Lehigh Valley, along with the tributaries of these two rivers. The Lehigh River flows through Lehigh Gap at the northern boundary of Lehigh and Northampton counties southbound to Allentown where it turns eastward. The Lehigh River essentially splits the Lehigh Valley in half. From Allentown, the Lehigh River flows eastward to its confluence with the Delaware River at Easton. Major tributary streams flowing into the Lehigh River are Coplay Creek, Little Lehigh Creek, Hokendauqua Creek, Jordan Creek, Monocacy Creek and Saucon Creek.

The Delaware River flows along the eastern portion of Northampton County and eventually flows into the Atlantic Ocean. Bushkill Creek and Martins Creek flow directly into the Delaware River. In Lehigh and Northampton counties, all municipalities have areas prone to flooding along streams and/or rivers.

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[80] Federal Emergency Management Agency, Flood Insurance Study, Lehigh County, Pennsylvania (All Jurisdictions) Washington, D.C., 04/19/2004. https://map1.msc.fema.gov/data/42/S/PDF/42077CV001B.pdf?LOC=14f4a155a950039eef1e13ba0b5a2c64.

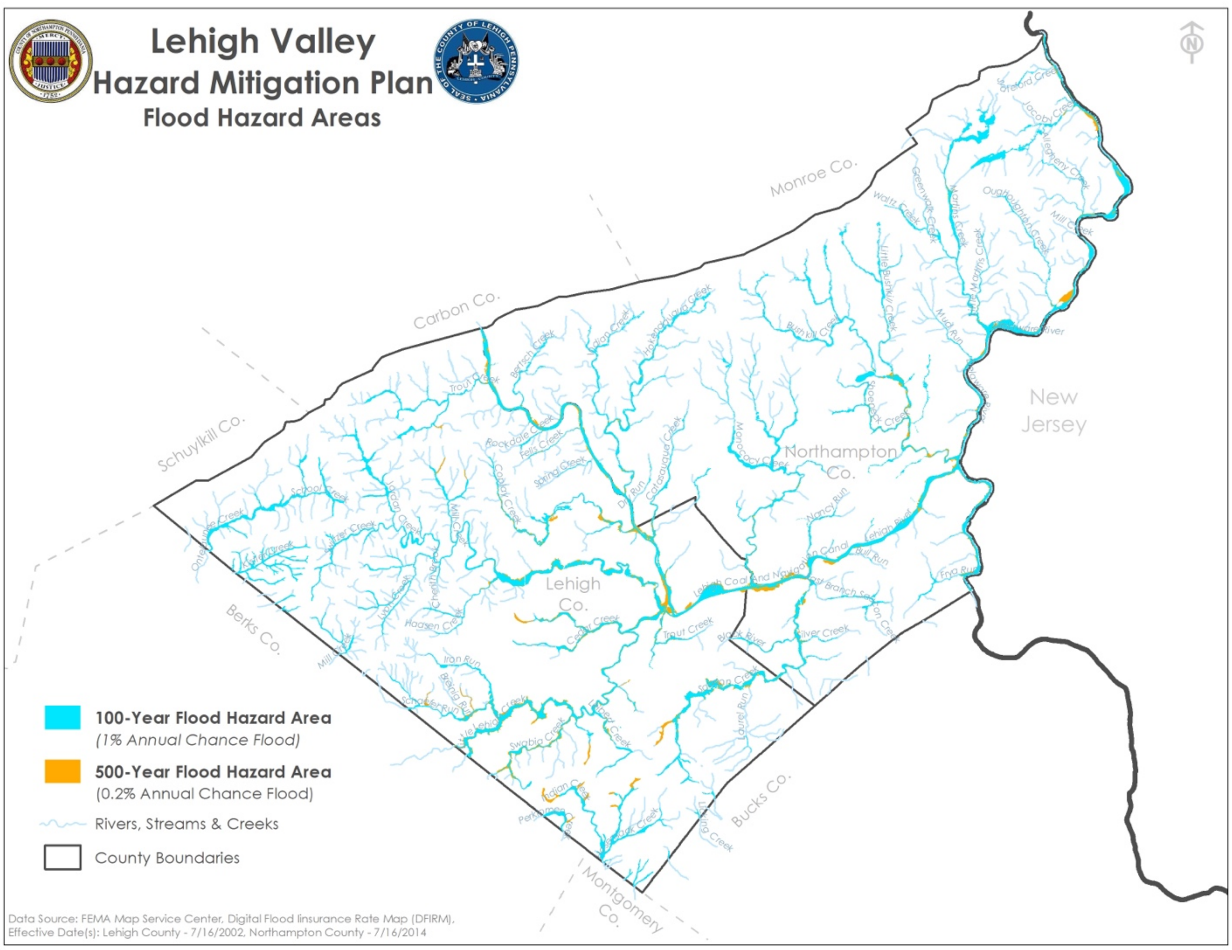
[81] Federal Emergency Management Agency, Flood Insurance Study, Northampton County, Pennsylvania (All Jurisdictions) Washington, D.C., 07/16/2014. https://map1.msc.fema.gov/data/42/S/PDF/42095CV001A.pdf?LOC=15acb26bfce95a5f5d6de9883e719807.

Ice jams are common in the northeastern US, and the Lehigh Valley is not an exception. Ice jams act as a natural dam, restrict flow of a body of water, and may build up to a thickness great enough to raise the water level and cause flooding. The Lehigh Valley has experienced ice jams in the past.

Flood hazard areas are identified on the FEMA Flood Insurance Rate Map (FIRM) and are identified as a Special Flood Hazard Area (SFHA). SFHAs are defined as the area that will be inundated by the flood event having a 1% chance of being equaled or exceeded in any given year. The 1% annual chance flood is also referred to as the base flood or 100-year flood. The FIRM also identifies areas of the 0.2% chance flood or 500-year floodplain. The SHFA is the area where the National Flood Insurance Program's (NFIP) floodplain management regulations must be enforced, and the area where the mandatory purchase of flood insurance applies.

At the time of this 2024 Plan, the 2004 Lehigh County digital FIRMs (DFIRMS) and the 2014 Northampton County DFIRMs are considered the best available and used for the risk analysis. Floodplains within the Lehigh Valley as shown below.

Figure 14: Floodplains in the Lehigh Valley



While the DFIRMs provide a credible source to document extent and location of the flood hazard, there are limitations to the accuracy of the data reflected on these maps. As such, it is noted that FIRMs are based upon the existing hydrology conditions at the time of the maps' preparation. FIRMs are not set up to account for the possible changes in hydrology that can occur over time, and flooding can and does occur outside of the mapped floodplain. According to the Environmental protection Agency (EPA), the alteration of natural hydrologic regimes is a consistent and pervasive effect of urbanization on stream ecosystems. Discharge patterns—the amount and timing of water flow through streams—change with urban development. Key aspects of urbanization affecting hydrology may include:[82]

- Decreased infiltration and increased surface runoff of precipitation associated with impervious (and effectively impervious) surfaces
- Increased speed and efficiency of runoff delivery to streams, via stormwater drainage infrastructure
- Decreased evapotranspiration due to vegetation removal
- Increased direct water discharges, via wastewater and industrial effluents
- Increased infiltration due to irrigation and leakage from water supply and wastewater infrastructure
- Increased water withdrawals and interbasin transfers

4.3.4.2. Range of Magnitude

The severity of a flood depends not only on the amount of water that accumulates in a period of time, but also on the time of year, the coverage area of the storm, and the land's ability to absorb the amount of water. Beginning in 2021 the NWS consolidated their flood products into more easily understood watches and warnings.

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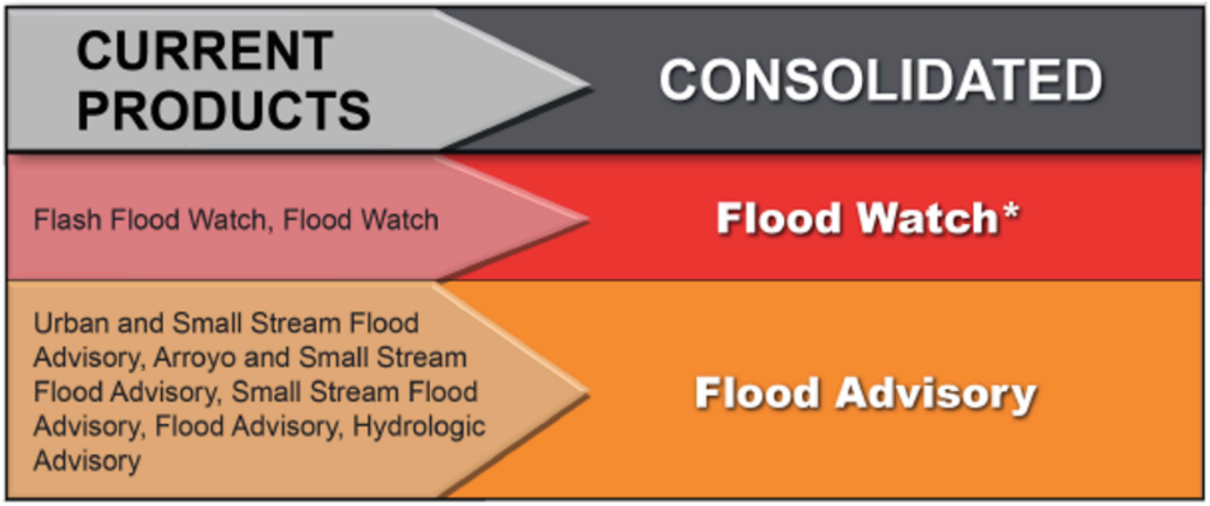
[82] US EPA, ORD. "Urbanization - Hydrology." Data and Tools, December 31, 2015. https://www.epa.gov/caddis-vol2/urbanization-hydrology.

Figure 15: NWS Consolidation of Flood Products



The National Weather Service (NWS) issues several different types of flood warnings and advisories, listed below.

- **Flood Watch**: Be Prepared: A Flood Watch is issued when conditions are favorable for a specific hazardous weather event to occur. A Flood Watch is issued when conditions are favorable for flooding. It does not mean flooding will occur, but it is possible.
- **Flood Advisory**: Be Aware: An Flood Advisory is issued when a specific weather event that is forecast to occur may become a nuisance. A Flood Advisory is issued when flooding is not expected to be bad enough to issue a warning. However, it may cause significant inconvenience, and if caution is not exercised, it could lead to situations that may threaten life and/or property.
- **Flood Warning**: Take Action! A Flood Warning is issued when the hazardous weather event is imminent or already happening. A Flood Warning is issued when flooding is imminent or occurring.

Each Flash Flood Warning (FFW) will contain a bulleted format of easily readable information describing the flash flood, the source of the information (e.g., radar, gauge, trained spotter, Emergency Manager), and a brief description of the impact of the flash flood. It will also include machine-readable tags to characterize the flash flood damage threat, source information, and causative event.[83]

One of the worst flooding events in the Lehigh Valley occurred in September 2004 with Tropical Storm Ivan. Rainfall totals averaged around five inches and caused widespread creek and river flooding throughout Lehigh Valley. In Lehigh County, the hardest hit municipalities in the County included the

[83] US Department of Commerce, NWS, and NOAA. "Flood Warning VS. Watch." weather.gov. NOAA's National Weather Service. Accessed December 11, 2023. https://www.weather.gov/safety/flood-watch-warning.

City of Allentown, Lower Macungie Township and Macungie Borough. It was estimated that 85 homes, 31 businesses and 5 public buildings and structures were damaged. Flash flooding along the Nancy Run, Monocacy, Bushkill, Saucon and Schoeneck creeks caused damage. Flooding of Jacoby Creek caused the failure of an old earthen dam at Lake Poco, leading to increased damage in the Borough of Portland, which was already flooded by the Delaware River. The Little Lehigh Creek within the Lehigh Parkway crested at 4.49 feet above flood stage. The Little Lehigh Creek at 10th Street in Allentown crested at 2.05 feet above flood stage. In Northampton County, nearly every municipality reported flood damages. Approximately 865 homes, businesses and structures were damaged, including several roads and bridges. The Lehigh River at Walnutport Borough crested at 4.32 feet above flood stage. The Lehigh River in Bethlehem crested at 2.79 feet above flood stage. In Glendon Borough, the Lehigh River crested at 0.82 feet above flood stage. The Monocacy Creek at Bethlehem crested at 5.17 feet above flood stage. The Delaware River at Easton crested at 11.45 feet above flood stage. Both counties were included in a presidential disaster declaration. Total PA-eligible damages for the counties were approximately $6 million.

Floods are naturally occurring events that benefit riparian systems that have not been disrupted by human actions. Such benefits include groundwater recharge and the introduction of nutrient rich sediment, which improves soil fertility. However, the destruction of riparian buffers, changes to land use and land cover throughout a watershed, and introduction of chemical or biological contaminants, which often accompany human presence, cause environmental harm when floods occur. Hazardous material facilities are potential sources of contamination during flood events. Other environmental impacts of flooding include: waterborne diseases, heavy siltation, erosion of stream banks and riverbeds, destruction of aquatic habitat, damage to water and sewer infrastructure located in floodplains, damage or loss of crops and drowning of both humans and animals.

4.3.4.3. Past Occurrence

The Lehigh Valley has a long history of flooding events. According to NOAA's National Centers for Environmental Information (NCEI) Storm Events Database, the Lehigh Valley experienced 235 flood events between January 1, 1996, and March 31, 2023. These floods resulted in one death, four injuries, an estimated $145.75 million in property damages, and approximately $2 million in crop damages.[84]

The table below provides a brief overview of notable flooding events that have occurred in the valley since 2012.

[84] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed July 14, 2023. https://www.ncdc.noaa.gov/stormevents/.

Table 26: Flooding Events in the Lehigh Valley, 2012 – 2023[85]

Dates of Event	Event Type	Losses / Impact	Source(s)
July 1, 2013	Flash Flood	Torrential rains caused flash flooding in northeastern Northampton County. The basements of several homes were flooded with 2 to 5 feet of water in Bangor, where one family had to be rescued. Streets were closed & some homes were without power. Numerous streets were also flooded in Pen Argyl Borough. Flooding also damaged several homes in East Bangor Borough. $100, 000 in property damage was reported. No injuries or deaths were reported.	NOAA-NCEI
August 29, 2013	Flash Flood	Very heavy rain caused roadway and small creek flash flooding in Allentown and Whitehall Township. About 43 vehicles were badly damaged in West Allentown and several businesses were flooded. A child was nearly swept away in floodwaters. Numerous roadways were flooded with some water rescues from trapped vehicles. Homes, garages and basements were damaged. $100,000 in property damage was reported. No injuries or deaths were reported.	NOAA-NCEI
June 15, 2015	Flood/Flash Flood	Slow-moving thunderstorms caused flash flooding in parts of Northampton County, with estimates exceeding four inches in south central Northampton County. Flash flooding in Bethlehem closed Easton Avenue at Willow Park Road. Flash flooding along Nancy Run washed out sections of Willow Park Road south through Walnut Street. $100,000 in property damage was reported. Flash flooding occurred along Monocacy Creek. Parts of Illick's Mill Road and locations behind Hotel Bethlehem were flooded. $50,000 in property damage was reported. Monocacy Creek at the Illick's Mill Road gage reached its 4.5-foot flood stage at 8:37 pm on the 15th and crested at 5.99 feet at 10:45 pm. No injuries or deaths were reported.	NOAA-NCEI

[85] Monetary figures within this table were US Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, monetary losses would be considerably higher due to inflation.

Dates of Event	Event Type	Losses / Impact	Source(s)
June 30, 2015	Flash Flood	Multiple thunderstorms with heavy rain caused flash flooding with two inches of rainfall estimated in the Lehigh Valley. Flash flooding occurred in Northampton Borough as the Dry Run flooded. About 12-14 homes were flooded. One home suffered structural damage. $100,000 in property damage was reported. Flash flooding also occurred in Coplay Borough. Several roadways were flooded with vehicles trapped in floodwaters. One water rescue was required. No injuries or deaths were reported.	NOAA-NCEI
February 24-25, 2016	Flash Flood	Strong to severe thunderstorms, heavy rain, flash flooding and stream flooding occurred in eastern Pennsylvania. Major flooding was reported on several roadways in and near downtown Bethlehem. Water rescues occurred at 33rd and Lehigh Streets. $200,000 in property damage was reported. Motorists were also stranded due to floodwaters in Lower Macungie Township and Allentown. No injuries or deaths were reported.	NOAA-NCEI
July 18, 2016	Flood	A cold front and associated pre-frontal trough led to the development of thunderstorms in the afternoon and evening hours. Some of the thunderstorms became severe with damaging winds. The thunderstorms also knocked out power to thousands of people.	NOAA-NCEI
April 6, 2017	Flood	Low pressure tracked from the Ohio Valley into the Western Great Lakes with a warm front surging northward ahead of the low which was followed by a cold front. Moisture and instability were drawn northwest ahead of the front which led to locally heavy showers and thunderstorms. Some of these thunderstorms were strong to severe with gusty winds.	NOAA-NCEI
July 1, 2017	Flood / Flash Flood	Strong to severe thunderstorms developed in the afternoon and evening hours of the 1st ahead of a cold front. Several of the storms produced damaging winds. Heavy rains from the storms did result in some localized flooding.	NOAA-NCEI

Dates of Event	Event Type	Losses / Impact	Source(s)
July 7, 2017	Flood	A stationary frontal boundary draped across the Delaware Valley lead to a period of heavy rainfall during the morning of July 7th. Widespread rainfall amounts over 2 inches occurred, with isolated amounts upwards of 4 to 6 inches in Carbon and Northampton Counties, which lead to flooding.	NOAA-NCEI
July 24, 2017	Flood / Flash Flood	A stalled frontal boundary caused several rounds of thunderstorms that produced damaging winds and flooding in spots. Over 8,000 people lost power.	NOAA-NCEI
August 2, 2017	Flood	A hot and humid airmass with weak boundaries led to slow moving strong to severe thunderstorms with damaging winds, hail and flooding. A few thousand people lost power.	NOAA-NCEI
July 4, 2018	Flash Flood	Severe thunderstorms caused wind damage in the Lehigh Valley Region of Pennsylvania. One to three inches of rainfall occurred in a short period of time.	NOAA-NCEI
July 22, 2018	Flash Flood	Showers with heavy downpours occurred in southeastern Pennsylvania during the afternoon and evening hours of July 22, 2018. Rainfall totals of 2 to 4 inches were reported.	NOAA-NCEI
August 11, 2018	Flash Flood	Several areas of flash flooding occurred due to heavy rain. Rainfall totals of 2 to 5 inches were reported in southeastern Pennsylvania. Additionally, severe thunderstorms impacted the area.	NOAA-NCEI
August 13, 2018	Flash Flood	Severe thunderstorms caused 4ainfall totals of 2 to 4 inches were common in southeastern Pennsylvania with some locations receiving 5 to 6 inches of rain. The heavy rain resulted in flash flooding.	NOAA-NCEI
August 21, 2018	Flash Flood	Heavy rain caused flash flooding in parts of southeastern Pennsylvania and the Lehigh Valley on the night of August 21-22. Some locations received up to 2.5 to 4.5 inches of rain.	NOAA-NCEI

Dates of Event	Event Type	Losses / Impact	Source(s)
November 2, 2018	Flash Flood	A swath of 2 to 5 inches of rain fell across parts of southeastern Pennsylvania on the night of November 2.	NOAA-NCEI
May 30, 2019	Flash Flood	Strong to severe thunderstorms brought 1 to 2 inches of rain to parts of eastern Pennsylvania and northern and central New Jersey during the late afternoon and evening hours of May 30.	NOAA-NCEI
June 18, 2019	Flash Flood	Showers and thunderstorms on the afternoon of June 18 brought a brief period of heavy rain to areas from the Lehigh Valley and upper Bucks County in Pennsylvania, to parts of northern and central New Jersey. Rainfall totals ranged from 1 to 2 inches with locally higher amounts.	NOAA-NCEI
July 11, 2019	Flash Flood	Thunderstorms brought 2 to around 5.5 inches of rain to parts of southeastern Pennsylvania on the afternoon and evening of July 11. The heaviest of the rain fell in southeastern Berks County, northern Chester County and upper Montgomery County.	NOAA-NCEI
July 21-22, 2019	Flash Flood	Thunderstorms brought 1.5 to around 2.5 inches of rain to parts of Lehigh County on the evening of July 21, and one to three inches on the afternoon and early evening of July 22.	NOAA-NCEI
October 31, 2019	Flash Flood	Showers and thunderstorms brought heavy rain to parts of eastern Pennsylvania and northern New Jersey on the night of October 31. Rainfall totals of 1.0 to 2.5 inches were common from Berks County, the Lehigh Valley and the Pocono Region in Pennsylvania into northwestern New Jersey.	NOAA-NCEI
August 4, 2020	Flash Flood	Tropical Storm Isaias brought high winds, heavy rain, several tornadoes, and coastal flooding to the mid-Atlantic region, becoming the most significant tropical cyclone to impact most of the region since Sandy in 2012. Heavy rain led to flash flooding that caused one death in Lehigh County.	NOAA-NCEI

Dates of Event	Event Type	Losses / Impact	Source(s)
August 18, 2021	Flash Flood	Heavy rain associated with Post-Tropical Cyclone Fred caused flash flooding in eastern Pennsylvania on the night of August 18-19, 2021. Three to five inches of rain were reported.	NOAA-NCEI
August 22, 2021	Flash Flood	Heavy rain associated with weakening Hurricane Henri caused flash flooding in Northampton County on the night of August 22. Rainfall totals were as high as 4 to 8 inches in the region.	NOAA-NCEI
September 1, 2021	Flash Flood	Post Tropical Cyclone Ida brought heavy rain to eastern Pennsylvania on September 1. Rainfall totals were as high as 5 to 10 inches. The heavy rain caused significant flash flooding, mainly in the southeastern part of the state. It resulted in widespread property damage. There were several fatalities. Widespread flash flooding occurred in Northampton County with many road closures. There was flooding along numerous waterways in the county, including the Lehigh River and the Monocacy Creek. Widespread flash flooding occurred in Lehigh County with many road closures. There was flooding along numerous waterways in the county, including the Lehigh River and Little Lehigh Creek.	NOAA-NCEI
September 8, 2021	Flash Flood	Thunderstorms brought locally heavy rain to the Lehigh Valley of Pennsylvania on the night of September 8. Rainfall totals were as high as 2 to 5 inches. A water rescue from a vehicle took place near the intersection of Mauch Chunk Road and Quarry Street in North Whitehall Township. A mudslide occurred along one of the access roads to the Portland-Columbia Toll Bridge in Portland.	NOAA-NCEI
July 9, 2023	Flash Flood	Widespread showers and thunderstorms brought heavy rain to eastern Pennsylvania on the afternoon and early evening of July 9. Rainfall totals were as high as 4 to around 6 inches. A vehicle became trapped in flood waters on Union Street at Cedar Creek in Allentown. Centre Street was closed at Palmer Street in Easton due to flooding.	NOAA-NCEI

Dates of Event	Event Type	Losses / Impact	Source(s)
July 14, 2023	Flash Flood	Thunderstorms brought locally heavy rain to the Lehigh Valley and the Pocono Region of eastern Pennsylvania from the late afternoon into the evening of July 14. Rainfall totals were as high as 3 to around 6 inches. Widespread roadway flooding in Bangor and in Washington Township. South Delaware Drive in Lower Mount Bethel Township became impassable due to flooding. Several vehicles were trapped in the flood waters. Some of their occupants required assistance.	NOAA-NCEI
July 16, 2023	Flash Flood	Widespread showers and thunderstorms produced locally heavy rain in eastern Pensylvania on July 16. Rainfall totals were as high as 3 to 5 inches. This flooding resulted in widespread road closures, bridge damage, and trapped vehicles, including in flood waters in Forks Township, Washington Township, Lower Mount Bethel Township, on PA Highway 33, and near Martins Creek. Flood waters reached the first floor of a house in Washington Township, causing a basement wall to collapse. Bushkill Creek overflowed its banks. Much of Bushkill Park in Forks Township was under water, and one apartment building needed to be evacuated.	NOAA-NCEI

The Ice Engineering Group at the USACE Cold Regions Research and Engineering Laboratory (CRREL) maintains an Ice Jam Database. Based on review of the CRREL database, the ice jam events that have occurred in the Lehigh Valley between 1948 and 2023 are identified in the table below. Information regarding losses associated with these reported ice jams is not available.

Table 27: Ice Jam Events in the Lehigh Valley[86]

Municipality	River	Jam Date	Gage Number
City of Allentown	Jordan Creek	2/20/1948	1452000
Walnutport Borough	Lehigh River	2/3/1970	1451000

86 US Army Corps of Engineers – Ice Jam Database. Retrieved on 10/26/2023 from: https://icejam.sec.usace.army.mil/ords/f?p=1001:2:::::

Municipality	River	Jam Date	Gage Number
Walnutport Borough	Lehigh River	2/14/1971	1451000
North Whitehall Township	Jordan Creek	2/6/2004	1451800
Walnutport Borough	Lehigh River	1/30/2004	1451000
Easton City	Lehigh River	1/8/2014	1454700

4.3.4.4. Future Occurrence

Given the history of flood events that have impacted Lehigh and Northampton counties, it is apparent that future flooding of varying degrees will occur. The fact that the elements required for flooding exist and that major flooding has occurred throughout the counties in the past suggests that many people and properties are at risk from the flood hazard in the future.

Probability of Future Occurrences

According to a 2021 study, Pennsylvania could experience more total average rainfall in the future, occurring in less frequent but heavier rain events. Extreme rainfall events are projected to increase in magnitude, frequency, and intensity. The following figure depicts the predicted number of days with very heavy precipitation through 2099.[87]

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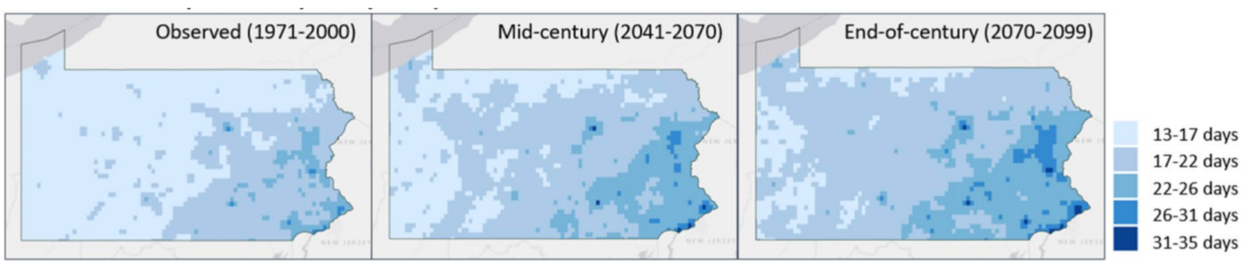
[87] Pennsylvania Department of Environmental Protection. “Pennsylvania Climate Impacts Assessment 2021.” 2021. http://www.depgreenport.state.pa.us/elibrary/PDFProvider.ashx?action=PDFStream&docID=3667348&chksum=&revision=1&docName=PENNSYLVANIA+CLIMATE+IMPACTS+ASSESSMENT+2021&nativeExt=pdf&PromptToSave=False&Size=6739063&ViewerMode=2&overlay=0.

Figure 16: Observed and Projected Annual Days with Very Heavy Precipitation



Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for flood events in the Lehigh Valley is considered ***Highly Likely*** with a higher than 90% probability of annual occurrences as defined in the Methodology Section.

4.3.4.5. Vulnerability Assessment

Flooding can cause widespread damage throughout rural and urban areas, including but not limited to: water-related damage to the interior and exterior of buildings; destruction of electrical and other expensive and difficult- to-replace equipment; injury and loss of life; proliferation of disease vectors; disruption of utilities, including water, sewer, electricity, communications networks and facilities; loss of agricultural crops and livestock; placement of stress on emergency response and healthcare facilities and personnel; loss of productivity; and displacement of persons from homes and places of employment.[88]

The impact of flooding on life, health and safety is dependent upon several factors, including the severity of the event and whether or not adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but everyone who may be affected by a hazard event, including emergency responders and people traveling into the area. The degree of that impact will vary and is not strictly measurable.

Lifeline Vulnerability

Flooding events can have a profound impact on various community lifelines, disrupting the normal functioning of affected areas like the Lehigh Valley. These lifelines are essential to the health, safety, and well-being of the community, and their quick restoration is crucial for recovery. The primary community lifelines likely to be affected by flooding are shown in the table below.

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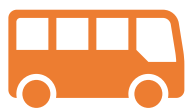
[88] Natural Resources Defense Council. "Flooding Facts, Causes, and Prevention." Nrdc.org, November 3, 2023. https://www.nrdc.org/stories/flooding-and-climate-change-everything-you-need-know.

Table 28: Potential Vulnerabilities of Lifelines to Flooding

Lifelines	Impact Type	Description
Water & Wastewater Systems		Flooding can contaminate water supplies and damage water infrastructure, leading to shortages and health hazards. Wastewater treatment facilities may also be overwhelmed or damaged, increasing the risk of waterborne diseases.
Food, Shelter, & Housing	 	Flooding can lead to the displacement of people, necessitating immediate shelter solutions. The disruption in supply chains can affect the availability and distribution of food, especially fresh produce.
Health & Medical		There is a heightened risk of injuries during floods, as well as increased potential for waterborne and vector-borne diseases. Healthcare facilities might be directly affected by floods, impacting their operational capabilities.
Communications		Communication networks may be disrupted, which can hinder the coordination of rescue and relief efforts as well as the dissemination of important information to the public.
Energy		Flooding can cause power outages by damaging electrical infrastructure. Fuel supply may also be disrupted, affecting not just transportation but also heating and power generation.

Lifelines	Impact Type	Description
Safety & Security		Emergency services are crucial during flooding for rescue operations and maintaining public order. Flooding can also increase the risk of accidents and infrastructure failures, such as dam or levee breaches.
Transportation		Floods can damage roads, bridges, and rail lines, severely limiting mobility and access. This disruption impacts not just daily commutes but also the delivery of essential goods and services.

Flood Modeling

The flood hazard is a major concern for the Lehigh Valley, and the region continues to be vulnerable to the flood hazard. To assess risk, an exposure estimate was conducted for the 1% and 0.2% annual chance flood events and potential losses were calculated for the Lehigh Valley 1% annual chance flood event using an updated version of FEMA's HAZUS-MH riverine flood module (version 4.0).

Since the 2018 Plan update, new building footprints for both counties were available and used, along with updated tax assessor and the RS Means 2018 building valuations data, to estimate the replacement cost value for the general building stock in the Lehigh Valley. Additionally, an updated critical facility inventory was generated using the 2018 inventory and updated spatial layers provided by the Lehigh and Northampton County GIS Departments and the LVPC. Both updated inventories were integrated into HAZUS-MH v4.0 to estimate losses. This assessment provides more accurate exposure and potential losses for the Lehigh Valley.

A Level 2 HAZUS-MH riverine flood analysis was performed. The default building inventory in HAZUS-MH was updated and replaced at the Census-block level with a custom-building inventory developed for both counties. The updated building inventory was built using detailed structure-specific assessor data, as well as parcel and structure location information. An updated critical facility inventory was also developed and incorporated into HAZUS-MH, replacing the default essential facility such as police, fire & school facilities & utility inventories.

The Lehigh County FEMA DFIRMs dated July 2004 and the Northampton County effective DFIRMs dated July 2014 were used to evaluate exposure and determine potential future losses.

A 3.2-foot resolution depth grid was developed for the 1% annual chance flood event for the Lehigh Valley.

Using Geographic Information System (GIS) tools and the best available data including the DFIRM database for both Counties and the 2008 3.2-foot Light Detection and Ranging (LiDAR) Bare Earth Digital Elevation Model (DEM) available from Pennsylvania Spatial Data Access – the Pennsylvania Geospatial Data Clearinghouse, a flood depth grid was generated and integrated into the HAZUS- MH riverine flood model.

To estimate exposure to the 1% and 0.2% flood events, the DFIRM flood boundaries, updated building and critical facility inventories and 2010 US Census population data were used. The HAZUS-MH 4.0 riverine flood model was run to estimate potential losses for the Lehigh Valley for the 1% annual chance flood event. HAZUS-MH 4.0 calculated the estimated potential losses to the population (default 2010 U.S. Census data) and potential damages to the updated general building stock and critical facility inventories based on the depth grid generated and the default HAZUS-MH damage functions in the flood model. Due to an error in the HAZUS-MH v4.0 software, debris results were not calculated and the model was run in v4.2 to estimate the results.

To estimate the population exposed to the 1% and 0.2% annual chance flood events, the FEMA DFIRM floodplain boundaries were used to estimate the number of structures within the floodplains, which were then factored by the average number of persons per household in the Lehigh Valley. Average household size is 2.54 for Lehigh County and 2.53 for Northampton County.[89] Although this methodology assumes that all structures in the floodplain are residential and single-household, it provides a reasonable estimate of population directly exposed to the flood risk.

Within the Lehigh Valley, more than 12,000 people are exposed to the 1% annual chance flood. The City of Allentown has the greatest number of people exposed in Lehigh County with just over 1,000 people, followed by Lower Mt. Bethel Township in Northampton County with approximately 900 people. About 18,500 people are exposed to the 0.2% annual chance flood, with the City of Allentown and Lower Macungie Township having the greatest number of people exposed, and Lower and Upper Mt. Bethel townships have the highest number of people exposed in Northampton County.

Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the economic impact to their family. The population over the age of 65 is also more vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a flood event, and they may have more difficulty evacuating.

Given the Lehigh Valley's geographic location along major waterways, as well as the population density and development in the floodplain, a flood event may cause residents to be displaced and seek short or long-term sheltering within the region, causing a population evacuation. The impacted population may not be limited to only those who reside in a defined hazard zone, but others who may be impacted by

[89] "DP04: Selected Housing Characteristics - Census Bureau Table." Accessed November 22, 2023. https://data.census.gov/table/ACSDP1Y2022.DP04.

the effects of a hazard event. To address this issue, the Lehigh Valley recognizes the need to identify shelters and potential sites for temporary housing and relocation to ensure displaced residents have a local option.

Potential consequences of population evacuation resulting from a flood event may include the following:

- Economic impact to local communities
- Increased demand for food and shelter
- Impacts to emergency and social services

HAZUS-MH 4.0 uses 2010 US Census data to estimate the potential sheltering needs that resulting from a 1% annual chance flood event. The displacement estimate is provided in number of households. For the purposes of this analysis, the average household size for each County was used to estimate the number of estimated displaced persons. For the 1% annual chance flood event, HAZUS- MH 4.0 estimates 17,816 people will be displaced and 3,930 people will seek short-term sheltering, representing 5.1% and 1.1% of the Lehigh County population, respectively. For the 1% annual chance flood event in Northampton County, HAZUS-MH 4.0 estimates 14,305 people will be displaced and 2,869 people will seek short-term sheltering, representing 4.8% and 1.0% of the County population, respectively.

The total number of injuries and casualties resulting from flooding is generally limited based on advance weather forecasting, blockades and warnings. Therefore, injuries and deaths generally are not anticipated if proper warning and precautions are in place. Ongoing mitigation efforts should help to avoid the most likely cause of injury, which results from persons trying to cross-flooded roadways or channels during a flood.

After considering the population exposed and vulnerable to the flood hazard, the built environment was evaluated. Exposure to the flood hazard includes those buildings located in the flood zone. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content value.

To provide a general estimate of the number of structures, parcels and replacement value exposure, the FEMA DFIRM flood boundaries (1% and 0.2% annual chance flood zones) were overlaid upon Lehigh and Northampton counties' parcel and the updated building stock inventory point shape files. The parcels that intersect the 1% and 0.2% annual chance flood zones were totaled for each municipality. The total number of buildings with their centroid located in the 1% and 0.2% annual chance flood boundaries was also determined, and their estimated building stock replacement value is identified for each municipality.

The depth grid developed for the 1% annual chance flood event for Lehigh and Northampton counties was integrated into the HAZUS-MH riverine flood model. The model was then run to estimate the potential general building stock losses for the 1% annual chance flood event.

Approximately 11,850 parcels are located in the 1% annual chance floodplain and 14,300 are located in the 0.2% annual chance floodplain. For the 1% annual chance flood, the potential damage to structures in Lehigh County is estimated to be $401 million and $440 million in Northampton County. The City of Allentown has by far the largest potential loss estimate for the 1% annual flood at $190 million, or nearly half of all Lehigh County losses. In Northampton County, the City of Easton has the largest potential loss estimate at $92 million, or one-fifth of the total county losses.

In addition to total building stock modeling, individual data available on flood policies, claims, Repetitive Loss (RL) and Severe Repetitive Loss (SRL) properties were analyzed and shown in Table 29 and Table 30. PEMA provided a list of residential properties with NFIP policies, past claims and multiple claims (including RL/SRL). According to the metadata provided: “The NFIP Repetitive Loss File contains losses reported from individuals who have flood insurance through the Federal Government. A property is considered a repetitive loss property when there are two or more losses reported which were paid more than $1,000 for each loss. The two losses must be within 10 years of each other and be as least 10 days apart. Only losses from (sic since) 1/1/1978 that are closed are considered.”

SRL properties were then examined in the Lehigh Valley. According to section 1361A of the National Flood Insurance Act (NFIA), as amended, 42 U.S.C. 4102a, an SRL property is defined as a residential property that is covered under an NFIP flood insurance policy and:

- Has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or

- For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

- For both of the above, at least two of the referenced claims must have occurred within any 10-year period, and must be greater than 10 days apart.

According to PEMA, there are 111 RL and 23 SRL properties in Lehigh County, and 16 RL and 6 SRL properties in Northampton County. This information is current as of September 20, 2023.

The location of the properties with policies, claims and repetitive and severe repetitive flooding were geocoded with the understanding that there are varying tolerances between how closely the longitude and latitude coordinates correspond to the location of the property address, or that the indication of some locations are more accurate than others.

In addition to considering general building stock at risk, the risk of flooding to critical facilities, utilities and user-defined facilities was evaluated. HAZUS-MH was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves, HAZUS estimates the percentage of damage to the building and contents of critical facilities.

In cases where short-term functionality is impacted by a hazard, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce impacts to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

Flood vulnerability maps for each municipality in the Lehigh Valley are in Appendix D. These maps show locations of both the 1% annual chance floodplain and the 0.2% annual chance floodplain with critical facilities.

Direct building losses are the estimated costs to repair or replace the damage caused to the building. The potential damage estimated to the general building stock inventory associated with the 1% annual chance flood event is approximately $842 million. This estimated building damage represents less than 1% of the Lehigh Valley's overall total general building stock inventory exposed to this hazard. These dollar value losses to the Lehigh Valley's total building inventory replacement value, in addition to damages to roadways and infrastructure, would greatly impact the tax base and local economy in both counties.

When a flood occurs, the agricultural industry is at risk in terms of economic impact and crop damage. In 2017, according to the Census of Agriculture, the market value of all Lehigh County agricultural products sold was $79.2 million with 72% in crop sales.[90] The market value of all agricultural products sold from Northampton County was greater than $36 million with 77% in crop sales.[91]

The model breaks down debris into three categories:

- Finished (dry wall, insulation, etc.)
- Structural (wood, brick, etc.) and
- Foundations (concrete slab and block, rebar, etc.)

The distinction is made because of the different types of equipment needed to handle the debris. HAZUS-MH 4.2 estimates approximately 54,837 tons of debris will be generated as a result of the 1% annual chance flood event.

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[90] 2017 Census of Agriculture. "Lehigh County, Pennsylvania." nass.usda.gov, 2017. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Pennsylvania/cp42077.pdf.

[91] 2017 Census of Agriculture. "Northampton County, Pennsylvania." nass.usda.gov, 2017. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Pennsylvania/cp42095.pdf.

Flood Claims as a Measure of Vulnerability

The tables below describe the number of flood insurance claims and policies in Lehigh and Northampton Counties, as well as the amount of claimed losses.

Table 29: NFIP Policies, Claims, and Repetitive Loss Statistics for Lehigh County

Lehigh County[92]	CID	# Policies	# Claims (Losses)	Total Loss Payments	#RL	#SRL
Alburtis Borough	420584	0	2	$1863.35	0	0
Allentown, City of	420585	71	371	$4,580,775.59	42	14
Bethlehem, City of*	420718	78	201	$3,439,556.61	19	7
Catasauqua Borough	420586	19	12	$215,701.98	2	1
Coopersburg Borough	420587	2	7	$25,952.18	1	0
Coplay Borough	421807	0	0	$0	0	0
Emmaus Borough	420588	14	17	$113,917.66	2	0
Fountain Hill Borough	421808	2	1	$3,160.97	0	0
Hanover Township	422261	0	0	$0	0	0
Heidelberg Township	421809	8	8	$37,895.69	1	0
Lower Macungie Township	420589	72	166	$3,183,290.89	27	4
Lower Milford Township	421039	11	3	$18,521.18	0	0
Lowhill Township	421811	5	3	$17,107.77	0	0
Lynn Township	421812	10	5	$20,831.50	0	0
Macungie Borough	420590	3	35	$307,361.54	5	0
North Whitehall Township	421813	11	11	$84,291.90	1	0
Salisbury Township	420591	11	7	$25,049.19	1	0
Slatington Borough	420592	0	3	$7,525.15	0	0
South Whitehall Township	420593	36	67	$915,778.50	11	3
Upper Macungie Township	421044	27	22	$498,548.75	3	0
Upper Milford Township	421815	17	15	$204,912.58	3	0
Upper Saucon Township	420594	23	19	$255,321.65	2	0
Washington Township	421816	9	9	$98,528.09	1	0
Weisenberg Township	421817	4	2	$2,640.19	0	0
Whitehall Township	420595	37	56	$251,711.32	7	0
Lehigh County		470	1042	$14,310,244.23	128	29

Table 30: NFIP Policies, Claims, and Repetitive Loss Statistics Northampton County

[92] Lehigh County Emergency Management provided NFIP data. Current as of 09/20/2023.

Northampton County	CID	# Policies	# Claims (Losses)	Total Loss Payments	#RL	#SRL
Allen Township	421928	5	4	$38,298.79	1	0
Bangor Borough	420716	31	57	$1,422,065.59	12	2
Bath Borough	420717	4	8	$54,838.10	1	0
Bethlehem Township	420980	51	56	$213,3034.02	5	0
Bushkill Township	421929	12	19	$456,557.32	0	0
Chapman Borough	422251	0	0	$0	0	0
East Allen Township	420981	4	9	$47,946.84	1	0
East Bangor Borough	422252	0	0	$0	0	0
Easton, City of	425383	39	268	$11,340,250.86	50	11
Forks Township	421930	48	180	$6,321,631.36	42	13
Freemansburg Borough	420721	17	52	$362,945.17	4	1
Glendon Borough	422254	5	0	$0	0	0
Hanover Township	420722	13	4	$33,793.53	0	0
Hellertown Borough	420723	13	18	$228,742.85	3	0
Lehigh Township	421931	14	13	$125,717.74	3	0
Lower Mt. Bethel Township	420724	64	235	$8,015,909.41	64	16
Lower Nazareth Township	422253	0	0	$00	0	0
Lower Saucon Township	420982	30	30	$427,595.19	4	1
Moore Township	420983	16	15	$220,577.22	2	1
Nazareth Borough	420725	6	6	$30,146.10	0	0
North Catasauqua Borough	420727	1	1	$00	0	0
Northampton Borough	420726	50	25	$257,425.50	3	0
Palmer Township	420728	52	33	$503,852.04	3	0
Pen Argyl Borough	421926	0	0	$0	0	0

Northampton County	CID	# Policies	# Claims (Losses)	Total Loss Payments	#RL	#SRL
Plainfield Township	421147	4	1	$0	0	0
Portland Borough	420729	4	16	$2,475,385.86	3	1
Roseto Borough	422255	0	1	$0	0	0
Stockertown Borough	420730	1	4	$118,957.78	0	0
Tatamy Borough	420731	2	1	$37,605.14	0	0
Upper Mt. Bethel Township	421933	40	141	$4,160,769.04	34	10
Upper Nazareth Township	421934	7	4	$62,320.96	1	0
Walnutport Borough	420732	4	3	$829	0	0
Washington Township	421156	12	10	$71,968.51	2	0
West Easton Borough	420733	2	28	$1,440,879.95	4	0
Williams Township	421036	28	130	$4,570,502.62	34	5
Wilson Borough	421927	0	0	$0	0	0
Wind Gap Borough	420734	3	4	$6,407.28	0	0
Northampton County		685	1,619	$48,619,735.44	301	68

Annualized Loss Estimates

For this estimation, NCEI Flood and Flash Flood data for the Lehigh Valley were used in estimating the expected annual losses from this hazard. Loss estimates were calculated based on the sum of all property damage reported to NCEI for these hazards and dividing by the number of years of reportable data (01/19/1996 – 03/31/2023 = 27 years).

Table 31: Annualized Loss Estimates for Flood and Flash Flood in the Lehigh Valley[93]

Lehigh County

[93] Property damage estimates are based dollar for dollar at the time of the loss and does not include inflation adjusted values. Data Source: NCEI

Property Damage	$1,400,111
Crop Damage	$37,037
Northampton County	
Property Damage	$3,998,148
Crop Damage	$37,037
Lehigh Valley Total	
Property Damage	$5,398,259
Crop Damage	$74,074

According to the USDA Risk Management Agency, between 2010 and 2023 there have been $1,396,578 in reported losses to insured crops due to excess precipitation events. The following table shows these losses annualized.

Table 32: Annualized Crop Loss Estimates for Excess Precipitation Events in the Lehigh Valley[94]

Crop Losses According to USDA RMA 2010 - 2023[95]	
Lehigh County	$26,245
Northampton County	$81,184
Lehigh Valley Total	$107,429

[94] USDA – Risk Management Agency. Cause of Loss Historical Data. 07/19/2023. https://www.rma.usda.gov/Information-Tools/Summary-of-Business/Cause-of-Loss

[95] Sum of reported losses between 2010 – 2023 divided by number of years.

4.3.5 *Hailstorm*

Hailstorms occur when ice crystals form within a low pressure front due to the rapid rise of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight, they fall as precipitation in the form of balls or irregularly shaped masses of ice. Hailstones are formed mostly in thunderstorms with intense updraft, high liquid water content, large vertical extent, large water droplets, and cloud layers below freezing.

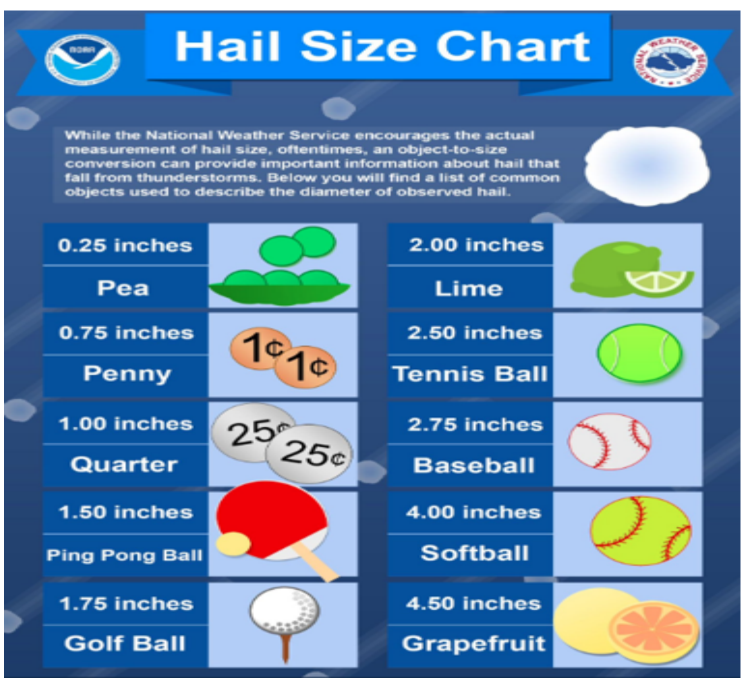
4.3.5.1. Location and Extent

Hailstorm events can occur across the Lehigh Valley region. Hail precipitation is often produced at the front of a severe thunderstorm system or in conjunction with a tornado event.

4.3.5.2. Range of Magnitude

Hail can vary in size from less than 1 inch to several inches in diameter and can cause significant damage to crops and property. Damage depends on the size, duration and intensity of hail precipitation. Individuals who do not seek shelter could face serious injury. Automobiles and aircraft are particularly susceptible to damage. The Lehigh Valley has experienced hail ranging in size from 0.75 inches to 2.5 inches in diameter. According to NCEI, no deaths or injuries due to hail have been recorded in the Lehigh Valley. The figure below depicts the National Weather Service's hail sizing chart.

Figure 17: National Weather Service Hail Size Chart



A potential worst-case scenario would be if a storm carrying hail of over 2 inches was to occur over a prolonged period in the agricultural areas of the Lehigh Valley. Since hail can cause significant crop damage, a storm of this magnitude could potentially destroy agricultural yields and result in significant lost revenue, as well as property damage or injuries.

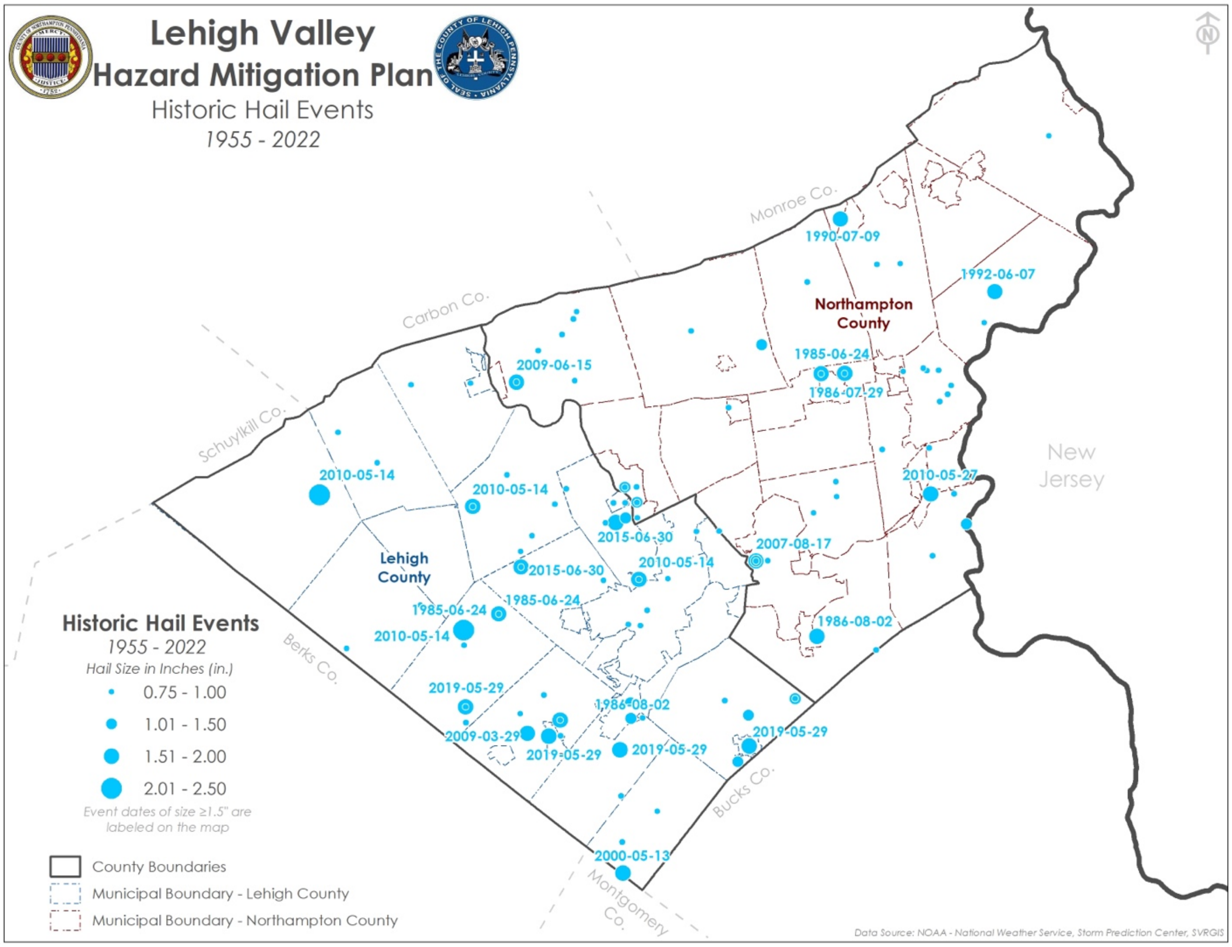
Damage to trees, shrubbery and other vegetation may occur during hailstorm events through defoliation. Unless there are compounding stresses, natural vegetation can typically recover over time following the event. Even tiny hailstones can inflict severe but initially imperceptible damage to fruits, flower and leaf buds, and seedlings in formative stages. Hailstones can cause major damage to crops at a point during growth when the plants are not yet sturdy or strong enough to withstand the falling ice.

4.3.5.3. Past Occurrence

Hailstorms can occur as a routine part of severe weather in the Lehigh Valley. The potential for hail exists throughout the Lehigh Valley, with a few minor incidents recorded each year. According to the 2023 Pennsylvania State Hazard Mitigation Plan *"approximately 96 percent of hailstorm events occurred during the months of April, May, June, July, August, and September. In addition, approximately 87 percent of historic events occurred during the afternoon or evening. Both of these results are consistent with the relationship between hail and thunderstorms, which most often occur during late spring, summer, and early fall months."*[96]

[96] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Figure 18: Map of Hailstorm Events in the Lehigh Valley Region 1955-2022



According to NOAA's National Centers for Environmental Information (NCEI) Storm Events Database, the Lehigh Valley experienced 146 hailstorms between 1962 and 2023, but just four that caused a combined $425,000 in property and crop damage. No deaths or injuries were reported for any of these events. The table below shows hailstorm events recorded since the 2013 Plan.

Table 33: Hailstorm Events in the Lehigh Valley, August 2011 - 2023

Location	Date	Diameter (inches)	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Lehigh County						
Germansville	8/19/2011	0.75 in.	0	0	0	0
Emmaus	5/24/2012	0.75 in.	0	0	0	0
Schnecksville	6/3/2012	0.75 in.	0	0	0	0
Allentown	6/3/2012	0.88 in.	0	0	0	0
Allentown	7/4/2012	0.75 in.	0	0	0	0

Location	Date	Diameter (inches)	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Macungie	7/28/2012	1.00 in.	0	0	0	0
Allentown	4/10/2013	0.75 in.	0	0	0	0
East Penn Junction	5/8/2013	0.75 in.	0	0	0	0
Coplay, Allentown, Bethlehem	5/22/2014	1.00 in.	0	0	0	0
Orefield	6/25/2014	1.00 in.	0	0	0	0
Macungie	9/6/2014	0.75 in.	0	0	0	0
Orefield, Coplay	6/30/2015	1.75 in.	0	0	$25,000	0
Allentown	2/25/2017	0.75 in.	0	0	0	0
Coopersburg	05/29/2019	2.00 in	0	0	0	0
Orefield	08/07/2019	0.75 in.	0	0	0	0
Catasauqua	08/18/2019	1.50 in.	0	0	0	0
Coopersburg	07/06/2020	1.25 in.	0	0	0	0
Fullerton	07/06/2021	0.75 in.	0	0	0	0
Dillinger	07/08/2021	1.00 in.	0	0	0	0
Woodlawn	07/21/2021	0.75 in.	0	0	0	0
Catasauqua	08/22/2022	1.00 in.	0	0	0	0
Lehigh County Total	**N/A**	**N/A**	**0**	**0**	**$25,000**	**0**
Northampton County						
Farmersville, Bethlehem (T)	6/1/2011	1.00	0	0	0	0
Mount Bethel	5/26/2012	0.75 in.	0	0	0	0
Tatamy	7/26/2012	0.75 in.	0	0	0	0
Bethlehem	4/10/2013	0.75 in.	0	0	0	0
Freemansburg	4/10/2013	1.00 in.	0	0	0	0
Bethlehem	5/23/2013	0.88 in.	0	0	0	0
Nazareth	6/24/2013	1.00 in.	0	0	0	0
Uhlers	6/24/2013	0.75 in.	0	0	0	0
Bath	7/9/2014	1.00 in.	0	0	0	0
Moorestown	7/9/2014	1.25 in.	0	0	0	0
North Catasaugua	6/30/2015	1.00 in.	0	0	0	0
Uhlers	7/17/2017	0.75 in.	0	0	0	0
Klecknersville	8/2/2017	0.75 in.	0	0	0	0
Shoenersville	08/18/2019	1.50 in.	0	0	0	0
Copella	07/22/2020	0.75 in.	0	0	0	0
Ulhers	04/21/2021	0.88 in.	0	0	0	0
Danielsville	07/06/2021	1.00 in.	0	0	0	0
Bethlehem	08/22/2022	1.00 in.	0	0	0	0

Location	Date	Diameter (inches)	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Northampton County Total	**N/A**	**N/A**	**0**	**0**	**$0**	**$0**

Based on reports from the NOAA NCEI, the Lehigh Valley's worst hailstorm incident occurred in 2007, when $250,000 in damages was claimed due to hailstorms. Hail as large as two inches in diameter fell across the central and southern parts of Northampton County on August 17th, reaching as far as Williams Township. Half dollar size hail fell in the City of Bethlehem. Penny-size hail fell in Nazareth Borough, and other reports indicated the presence of hail in Lehigh County. The thunderstorms that precipitated the hail moved across Pennsylvania and New Jersey during the afternoon and the evening of August 17.

4.3.5.4. Future Occurrence

It is not possible to predict the formation of a hailstorm with more than a few days' lead-time. The past occurrences described above, however, indicate that hailstorm events in the Lehigh Valley will usually occur every year throughout the months of April and August. Based on this historical data, the east and northeast sections of Northampton County can expect to experience a higher number of hailstorm events compared to other areas in the Lehigh Valley. The Lehigh Valley as a whole has experienced significantly fewer hailstorm events per square mile than areas in the western and southeastern parts of Pennsylvania.

Probability of Future Occurrence

Based on historical occurrences of hailstorm events retrieved from NCEI, the probability of occurrence for hailstorm events in the Lehigh Valley is considered ***Highly Likely,*** greater than 90% annual probability as defined in the Methodology Section.

4.3.5.5. Vulnerability Assessment

Hailstorm events, while often short-lived, can have a significant impact on a range of community lifelines. These events can particularly challenge regions like the Lehigh Valley, where infrastructure and services might not be adapted to such extreme weather conditions. The key community lifelines likely to be affected by hailstorms are shown in the table below.

Table 34: Potential Vulnerabilities of Lifelines to Hailstorm Events

Lifelines	Impact Type	Description
Food, Shelter, & Housing		Hail can cause substantial damage to homes and buildings, leading to displacement and the need for temporary shelter. Agricultural areas might also be affected, impacting food production and leading to potential shortages or increased prices.
Health & Medical		Injuries from hail, such as those caused by falling debris or accidents during the storm, can lead to increased demand for medical services. Healthcare facilities themselves might suffer damage, impacting their ability to provide services.
Communications		Communication networks are essential for issuing warnings and coordinating response efforts. These networks might be affected by hail damage, especially if key infrastructure like cell towers are impacted.
Energy		Hailstorms can damage power lines and renewable energy installations like solar panels, leading to power outages. Fuel supply chains might also be disrupted due to transportation issues.
Transportation		Hail can damage vehicles, roads, and transportation infrastructure, leading to disruptions in travel and transport. This can affect everything from emergency response capabilities to daily commutes and commercial shipping.

For hailstorm events, the entire Lehigh Valley has been identified as the hazard area. Therefore, all people, structures, critical facilities, and lifelines are exposed and potentially vulnerable. Overall, the Lehigh Valley's vulnerability has not changed since the 2018 Plan.

People

People outdoors are considered most vulnerable to the hazard. This is because there is little to no warning and shelter may not be available. Moving to a lower risk location will decrease a person's vulnerability.

Systems & Structures

The entire Lehigh Valley, including all critical infrastructure, continues to be vulnerable to the effects of hail, as the storm cells that produce this hazard can develop over any part of the region. The area of damage due to these storms is relatively small, since a single storm does not cause widespread devastation, but it may cause damage in a focused area. As a hazard, hail can cause serious damage to automobiles, aircraft, skylights, livestock and crops.

Natural, Cultural, & Historical Resources

As discussed in the Past Occurrence subsection, the Lehigh Valley has experienced hailstorm damage ($425,000 in property damage and $50,000 in crop damage according to NCEI). Furthermore, according to the USDA Risk Management Agency (RMA), hailstorm events between 2010 and 2023 resulted in $50,808.50 in crop insurance claims related to hail events.[97] Given the unpredictability of hailstorms, significant property and crop damage is possible during any hailstorm event in the Lehigh Valley.

Community Activities

Hailstorm events are unlikely to cause long-term disruption to community activities beyond the temporary inconvenience of having to seek shelter. It remains possible that some venues may sustain damage during especially large hailstorm events.

Annualized Loss Estimates

For this estimation, NCEI Hailstorm Event data for the Lehigh Valley were used in estimating the expected annual losses from this hazard. Loss estimates were calculated based on the sum of all property damage reported to NCEI for these hazards and dividing by the number of years of reportable data (07/03/1975 – 03/31/2023 = 48 years). According to the USDA Risk Management Agency, there was

[97] USDA – Risk Management Agency. Cause of Loss Historical Data. Retrieved on 07/19/2023. https://www.rma.usda.gov/Information-Tools/Summary-of-Business/Cause-of-Loss

a total of $50,808 in insured crop losses between 2010 and 2023. These figures are shown annualized below.

Table 35: Annualized Loss Estimates for Hailstorm Events in the Lehigh Valley[98]

Lehigh County (NCEI)	
Property Damage	$2,604
Crop Damage	$1,041
Northampton County (NCEI)	
Property Damage	$5,208
Crop Damage	$0
Lehigh Valley Total (NCEI)	
Property Damage	$7,812
Crop Damage	$1,041
Crop Losses According to USDA RMA 2010 - 2023[99]	
Lehigh County	$1,799
Northampton County	$2,109
Lehigh Valley Total	$3,908

[98] Property damage estimates are based dollar for dollar at the time of the loss and does not include inflation adjusted values. Data Source: NCEI

[99] Sum of reported losses between 2010 – 2023 divided by number of years.

4.3.6 *Invasive Species*

4.3.6.1. Location and Extent

An invasive species is a species that is not indigenous to the ecosystem under consideration and whose introduction causes or is likely to cause economic, environmental, or human harm. Such species can have far-reaching consequences, adversely affecting not only the environment but also the economy and public health. Characteristically, invasive species tend to proliferate and spread at an accelerated pace. It's important to note that the term "invasive" isn't exclusive to species from foreign lands; it also encompasses those that migrate from different regions within a country, such as the United States. [100] Pennsylvania, for instance, is home to a diverse array of invasive entities, including pathogens, insects, plants, invertebrates, fish, and mammals. The introduction of these species is predominantly linked to human activities.

Pennsylvania Governor's Invasive Species Council (PGISC), also referenced as the Governor's Invasive Species Council of Pennsylvania (PISC), is the lead organization for invasive species threats. The PISC recognizes two types of invasive species: Aquatic and Terrestrial.

- **Aquatic Invasive Species** are nonnative species that have part or all of their life cycle in water and threaten the diversity or abundance of native species, the ecological stability of the infested waters, human health and safety, or commercial, agriculture, aquaculture, or recreational activities dependent on such waters.

- **Terrestrial Invasive Species** are nonnative species that complete their lifecycle on land instead of in an aquatic environment and whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Furthermore, the Planning Team highlighted ticks and mosquitoes as significant health risks owing to their potential to transmit diseases. For comprehensive information about the illnesses spread by ticks and mosquitoes, please consult the Pandemic and Infectious Disease profile. The geographical distribution and intensity of invasive threats vary based on the species' preferred habitats, as well as their capacity for mobility and colonization. Reports indicate that invasive species have been identified across the Lehigh Valley.

PISC identifies many species threats that are now or could potentially become significant in Pennsylvania.

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[100] National Wildlife Federation. "Invasive Species." National Wildlife Federation. Accessed December 11, 2023. https://www.nwf.org/Home/Educational-Resources/Wildlife-Guide/Threats-to-Wildlife/Invasive-Species.

Table 36: Established & Emerging Invasive Species in the Commonwealth[101]

Aquatic Invasive Species			
Amphibians & Reptiles			
Red-Eared Slider		Yellow-bellied Slider	
Fishes, Diseases, Invertebrates			
Alewife	New Zealand Mudsnail'	Western Mosquitofish	Allegheny Crayfish
Norther Snakehead	Zebra Mussel	Asiatic Clam	Oriental Weatherfish
White Perch	Bloody-Red Shrimp	Quagga Mussel	White River Crayfish
Chinese Mystery Snail	Rainbow Smelt	Gill Lice	Common Carp
Red Swamp Crayfish	Koi Herpesvirus	Fishhook Waterflea	Round Goby
Largemouth Bass Virus	Freshwater Tubenose Goby	Rudd	VHS Disease
Goldfish	Rusty Crayfish	Whirling Disease	Grass Carp
Scud; Amphipod; A Euryhaline	Greensider Darter	Spiny Waterflea	Japanese Mystery Snail
Sea Lamprey	Mud Bithynia	Virile Crayfish	
Mammals & Birds			

[101] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Mute Swan			
Terrestrial Invasive Species			
Plant Pathogens			
Beech Bark Disease	Corn Tar Spot	Strawberry Fruit Rot	Beech Lead Disease
Oak Wilt			
Insects & Other Invertebrates			
Allium Leaf Minder	Emerald Ash Border	Lily Leaf Beetle	Balsam wooly Adelgid
Fall Armyworm	Spongy Moth	Brown Marmorated Stinkbug	Hammerhead worms, Broadhead planarians
Spotted-win drosophila	Cherry curculio	Hemlock Wooly Adelgid	Spotted Lanternfly
Crazy Snake Worm	Introduced Pine Sawfly	Biburnum Lead Beetle	Elm Zigzag Sawfly
Japanese Beetle	Walnut Twig Beetle	Elongated Hemlock Scale	Jumping Worms
Higher Mammals			
Wild Boar	Feral Swine		

The Emerald Ash Borer (EAB) is a metallic green beetle, roughly half an inch in length. Its larvae burrow beneath the bark of various ash tree species, such as green, white, and black ash, disrupting the tree's ability to transport water and nutrients. This infestation eventually results in the death of branches and entire trees. Detected for the first time in Pennsylvania in June 2007, the Emerald Ash Borer has since been confirmed in at least 22 counties. In response, the Pennsylvania Department of Agriculture implemented a quarantine to impede the spread of this invasive species, prohibiting the transportation of all hardwood firewood, ash trees, saw logs, limbs, and related plant parts out of the Commonwealth. By 2016, almost all Pennsylvania counties, including Lehigh and Northampton, reported the presence of the Emerald Ash Borer.

The Hemlock Woolly Adelgid (HWA) poses a significant threat to Eastern hemlock trees in the northeastern United States. First observed in southeastern Pennsylvania in the late 1960s, this small, aphid-like insect feeds on the sap of young branches, causing premature needle drop and branch dieback. While some trees succumb within four years, others linger in a weakened state for an extended period. As of October 2016, the Lehigh Valley was among the regions infested by the Hemlock Woolly Adelgid.

Introduced to Massachusetts from France in 1869, the Gypsy Moth is an invasive insect whose larvae voraciously consume the leaves of a wide variety of trees, including oak, maple, apple, and pine. Its populations fluctuate in cycles, occasionally leading to widespread defoliation. In Pennsylvania, the first sighting occurred in 1932, with a record 4.3 million acres defoliated in 1990. Since 1968, the Pennsylvania Bureau of Forestry has implemented suppression programs to mitigate the Gypsy Moth's impact. In 2017, these efforts extended to Lehigh and Northampton counties, with targeted spraying in high-use public areas to curb the caterpillar population.

The USDA administers a Gypsy Moth program to regulate the movement of potential host materials from infested areas, preventing the spread of this pest. Both Lehigh and Northampton counties fall within a quarantine zone that encompasses all of Pennsylvania and most Northeastern states.

The Asian Tiger Mosquito, introduced to the United States via used tire shipments from northern Asia in the mid-1980s, is a resilient species capable of surviving a range of climates. Since its initial detection in the south-central United States, it has expanded rapidly across the southern and eastern regions. This mosquito is a known vector for several arboviruses, including dengue, chikungunya, yellow fever, and Zika. The CDC identifies the Lehigh Valley as a probable habitat for the Asian Tiger Mosquito, with both counties maintaining active surveillance sites.

Figure 19: Spotted Lanternfly (right)

Lastly, the Spotted Lanternfly, originating from China, India, and Vietnam, threatens to severely impact Pennsylvania's grape, hops, and logging industries. Infested trees, such as the tree of heaven and willow, exhibit weeping wounds and a distinctive greyish or black residue along the trunk, attracting other insects. In late fall, adults lay egg masses on host trees. Quarantines in both Lehigh and Northampton counties aim to prevent the Spotted Lanternfly's spread to new areas and slow its proliferation within quarantined zones.

4.3.6.2. Range of Magnitude

Invasive species pose a spectrum of threats to ecosystems, ranging from minor irritants to catastrophic agents of change, with their impact often exacerbated in ecosystems already under stress, such as during droughts. These weakened ecosystems are more susceptible to the detrimental effects of invasive species. While some invasives are merely nuisances, not harming humans or agriculture, others can radically alter ecosystem compositions. For instance, the Emerald Ash Borer inflicts a staggering 99% mortality rate on infected ash trees. Some invasive species can obstruct waterways, overrun native flora, and disrupt animal habitats.

The DCNR's Bureau of Forestry actively monitors and manages forest pests and diseases through various surveys and initiatives. Annually, the Bureau conducts aerial surveys to identify and map tree dieback, mortality, defoliation, and discoloration. These findings are verified through ground surveys to pinpoint the responsible pests or diseases. The data gathered assists in gauging the extent of damage, predicting future outbreaks, and formulating management strategies. Without intervention, the repercussions of invasive species on trees and plants could be catastrophic.

The environmental toll of invasive species is multifaceted. Their aggressive nature can drastically diminish biodiversity by displacing indigenous species, affecting both the health of individual organisms and the ecosystem's overall integrity. Beyond the direct harm to humans, animals, and plants, invasive species can have secondary impacts, particularly in forested areas. Pennsylvania's forests play a crucial role in preventing soil degradation and erosion, safeguarding watersheds, stabilizing slopes, and sequestering carbon dioxide. Forest loss can exacerbate erosion and flooding. Invasive species also threaten agricultural yields, including honey, potatoes, and stone fruits, posing a risk to the state's agricultural economy.

Invasive species exert significant economic and social repercussions that manifest in various forms. These include direct impacts on real estate values, agricultural output, public infrastructure, native fish populations, tourism, and recreational activities. Additionally, there are substantial expenses related to the control and management of invasive species. A study from 2021 revealed that in North America, the annual cost attributed to invasive species escalated from around $2 billion in the early 1960s to in excess of $26 billion since 2010[102]. On a global scale, the financial burden of invasive species over the

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[102] Crystal-Ornelas, Robert, Emma J. Hudgins, Ross N. Cuthbert, Phillip J. Haubrock, Jean Fantle-Lepczyk, Elena Angulo, Andrew M. Kramer, et al. "Economic Costs of Biological Invasions within North America." *NeoBiota* 67 (July 29, 2021): 485–510. https://doi.org/10.3897/neobiota.67.58038.

last half-century is estimated to be a staggering $1.288 trillion.[103] Forests have been heavily impacted, exemplified by the widespread die-off of eastern hemlock trees infested by the Hemlock Woolly Adelgid.[104]

4.3.6.3. Past Occurrence

Invasive species have been entering the Lehigh Valley for quite some time, though not all occurrences have required government action. Specific occurrences and quantified losses were not identified for these invasive species in the Lehigh Valley. Past occurrences of invasive species as shown in Table 37.

Table 37: Invasive Species in the Lehigh Valley, 2007-2023

Date	Event Type	Losses/Impacts	Source(s)
2007	Emerald Ash Borer	Emerald Ash Borer was first identified in western Pennsylvania during 2007. Since then, Emerald Ash Borer has been detected in a majority of the State, including Lehigh and Northampton	PADCNR
2013	Hemlock	Hemlock Woolly Adelgid was detected in Lehigh and	USDA
2014	Spotted Lanternfly	Spotted Lanternfly was confirmed in Pennsylvania in September 2014. By 2017, 13 counties were quarantined, including Lehigh and Northampton counties.	PA Department of
2014	Gypsy Moth	Gypsy moths were detected in Lehigh and Northampton counties	USDA
2016	Asian Tiger	The Asian tiger mosquito was detected in the Lehigh Valley.	Kennedy

4.3.6.4. Future Occurrence

The PISC warns of an escalating risk of invasive species incursions, largely driven by the intensification of global trade. The surge in goods transported, advanced technologies, and burgeoning international trade agreements have inadvertently facilitated the migration of numerous species to new habitats. In

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[103] Fantle-Lepczyk, Jean E., Phillip J. Haubrock, Andrew M. Kramer, Ross N. Cuthbert, Anna J. Turbelin, Robert Crystal-Ornelas, Christophe Diagne, and Franck Courchamp. "Economic Costs of Biological Invasions in the United States." *Science of The Total Environment* 806 (February 2022): 151318. https://doi.org/10.1016/j.scitotenv.2021.151318.

[104] U.S. National Parks Service. "Hemlock Woolly Adelgid." nps.gov. Accessed December 8, 2023. https://www.nps.gov/grsm/learn/nature/hemlock-woolly-adelgid.htm.

2020, Pennsylvania's imports topped $84 billion, predominantly comprising pharmaceuticals and machinery, but also included agricultural and forestry products, often harboring undetected pests.[105]

Additionally, climate change is reshaping the battleground between native and invasive species, tilting the scales in favor of the latter. Alterations in climate patterns disturb existing ecological balances, rendering native species more vulnerable to invasion and expansion. Temperature fluctuations and extended growing seasons grant invasive pests a temporal advantage, allowing them to thrive in regions once considered hostile. This phenomenon is particularly pronounced in the Northeastern and Midwest regions of the United States.

Rising CO_2 levels, partly attributed to the decimation of tree populations by invasive pests, can disproportionately benefit invasive flora already outcompeting indigenous plants. Moreover, climate-induced droughts can increase water salinity, creating hospitable conditions for Harmful Algal Blooms (HAB). Algae, which flourish with higher CO_2 concentrations, are poised for proliferation. The effects of climate change, such as augmented agricultural runoff and warmer waters, are already catalyzing more frequent and intense algae blooms.

Furthermore, the interplay between invasive species and natural disasters like wildfires and droughts can exacerbate ecological shifts. Invasive species, by displacing native vegetation, can increase the fuel available for wildfires, and drought conditions can leave barren land ripe for invasion.[106] These dynamics could gradually tip the balance of ecosystems in favor of non-native species. However, predicting the exact trajectory of these shifts remains challenging, given the myriad factors influencing each species and their specific environmental contexts. [107]

Probability of Future Occurrences

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for invasive species impacting the Lehigh Valley is considered **'highly likely'** (higher than 90% probability) as defined in the Methodology Section.

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[105] Department of Commerce. "Pennsylvania USMCA State Fact Sheet." trade.gov, 2020. https://www.trade.gov/sites/default/files/2020-12/Pennsylvania%20USMCA%20State%20Fact%20Sheet.pdf.

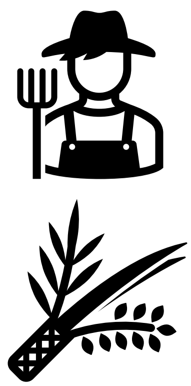
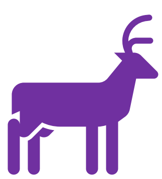
[106] Poland, Therese M., Toral Patel-Weynand, Deborah M. Finch, Chelcy Ford Miniat, Deborah C. Hayes, and Vanessa M. Lopez, eds. Invasive Species in Forests and Rangelands of the United States: A Comprehensive Science Synthesis for the United States Forest Sector. Cham: Springer International Publishing, 2021. https://doi.org/10.1007/978-3-030-45367-1.

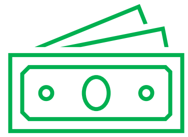
[107] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

4.3.6.5. Vulnerability Assessment

Invasive species, whether plant, animal, or microbial, can significantly impact various community lifelines. These species can disrupt ecosystems and the economy, especially in areas like the Lehigh Valley, which might not be adapted to these non-native intruders. The primary community lifelines likely to be affected by invasive species are shown in the table below.

Table 38: Potential Vulnerabilities of Lifelines to Invasive Species

Lifelines	Impact Type	Description
Agriculture & Food Supply		Invasive species can damage crops and compete with native agriculture, leading to reduced yields and increased costs for pest control. This can impact food supply chains and local economies dependent on agriculture.
Water & Wastewater Systems		Certain invasive species, particularly those in aquatic environments, can clog waterways and drainage systems, affecting water quality and the operation of water treatment facilities.
Health & Medical		Some invasive species, such as certain mosquitoes, can be vectors for diseases not previously common in the area, leading to new public health challenges and increased demand for medical services.
Natural & Cultural Resources		Invasive species can threaten native wildlife and habitats, leading to a loss of biodiversity. This not only affects ecosystems but can also impact cultural practices and tourism that rely on native flora and fauna.

Lifelines	Impact Type	Description
Economic Stability		The economic impact of invasive species can be profound, affecting industries like agriculture, forestry, fishing, and tourism. The cost of managing these species can strain local and regional budgets.

People

The Lehigh Valley is designated as a hazard zone for invasive species, exposing the population, infrastructure, and natural resources to potential threats. Invasive species pose a significant challenge, particularly affecting public health, the environment, and agriculture. While quantifying losses is complex, the repercussions on the local populace and economy are evident. Vulnerable groups, such as the elderly and immunocompromised, are at heightened risk from diseases transmitted by pests like the Asian Tiger Mosquito.

The presence of invasive species, such as the Hemlock Woolly Adelgid, Emerald Ash Borer, Spotted Lanternfly, and Gypsy Moth, leads to a domino effect of consequences. Infestations weaken and kill vegetation, increasing the risk and intensity of wildfires due to the abundance of dead plant matter. These shifts in species composition can alter entire fire ecosystems. Additionally, the health of urban trees is compromised, affecting their resilience to other natural calamities like hurricanes, droughts, and severe winter conditions.

Systems & Structures

While invasive species don't directly damage structures, the loss of trees due to pests can destabilize stream banks, exacerbate erosion, and heighten sedimentation. Fallen dead tree limbs can obstruct roads, damage power lines, and increase wildfire risks during storms.

Natural, Cultural, & Historical Resources

Economic losses from invasive species in the Lehigh Valley are multifaceted, stemming from reduced revenue in agriculture and forestry, eradication costs, and human health impacts. However, precise cost assessments are challenging. The eradication and surveillance efforts' expenses are currently indeterminate. Beyond environmental damage, invasive species threaten sectors like fishing, boating, and tourism.

Table 39: Estimated Losses Relating to Agricultural Production[108]

County	Impacted Farmland Acreage	Market Value of All Agricultural Products
Lehigh County	74,511	$79,216,000
Northampton County	59,195	$36,058,000
Lehigh Valley Total	133,706	$115,274,000

[108] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

4.3.7 Landslide

4.3.7.1. Location and Extent

A landslide is the movement of rock, earth, or debris down a slope. Landslides can result from a combination of both natural events and human interventions in the environment. They can be activated by factors like intense rainfall, swift snowmelt, construction that alters natural slope angles, erosion, seismic activities, and shifts in groundwater dynamics. Locations especially susceptible to landslide hazards encompass previously affected landslide zones, foots of steep inclines, drainage channel bases, developed hilly terrains, and territories freshly ravaged by wildfires. Human-induced factors exacerbating slope destabilization encompass altering natural terrain inclinations, augmenting soil moisture, and vegetation depletion. As urban and recreational expansions encroach upon hilly regions, more individuals become vulnerable to landslide risks each year.[109]

While landslides are sporadic events across the state, they predominantly occur in the western and north-central regions. In the Lehigh Valley, areas characterized by moderate to steep inclines can be susceptible to rock falls and other related slope failures. However, based on the USGS assessment, both Lehigh and Northampton counties possess a relatively low potential for landslides.

4.3.7.2. Range of Magnitude

Landslides can wreak havoc on transportation networks, utilities, and structures, often leading to travel disruptions. While fatalities and injuries from landslides are uncommon in Pennsylvania, most incidents tend to be moderate to slow in progression. Historically, most reported fatalities stemmed from rock falls or slides that affected vehicles on highways. Debris flows triggered by storms are the only other landslide category with a significant likelihood of causing harm. As housing and recreational infrastructures expand onto or near precipitous mountain terrains, the risks associated with landslides escalate.

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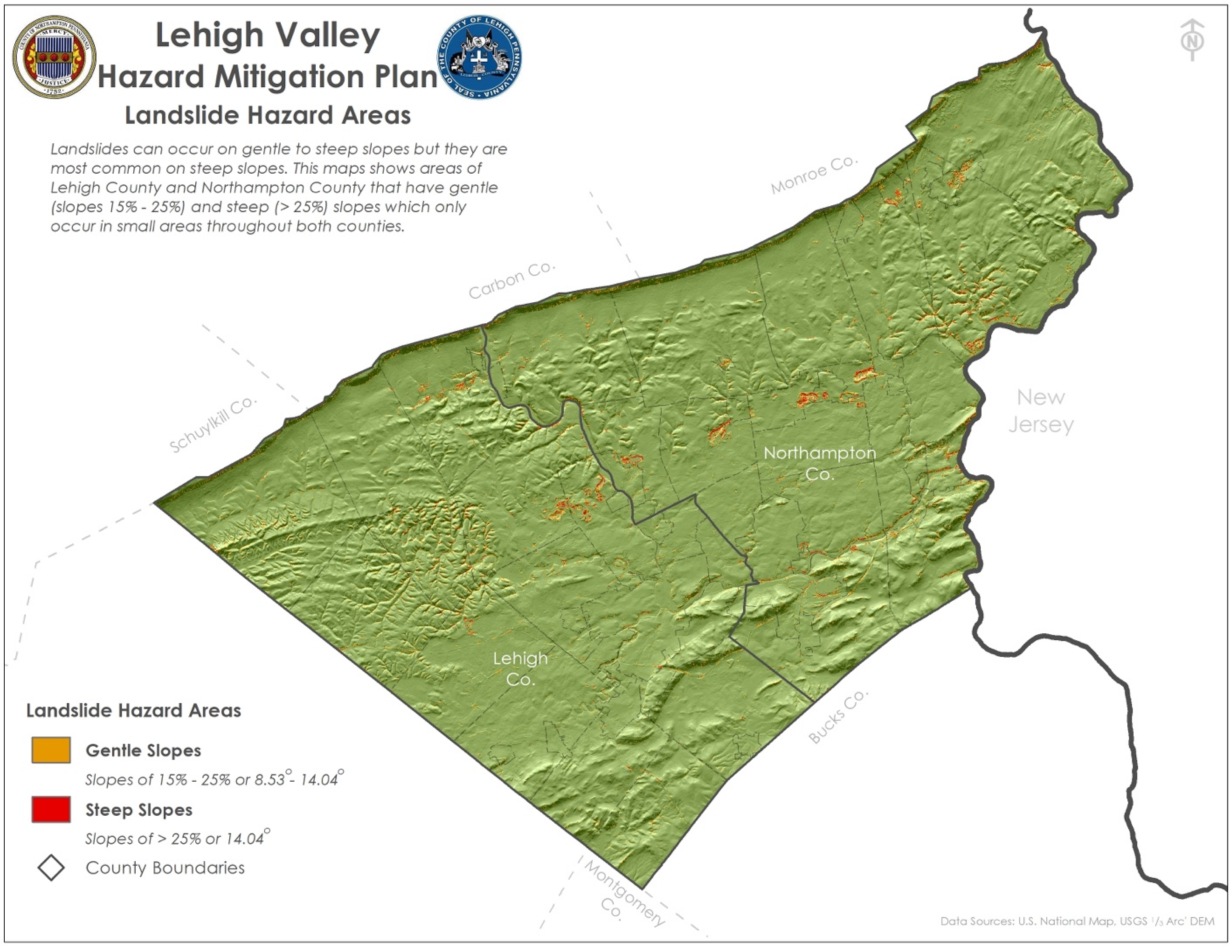
[109] Delano, Helen L. *Landslides in Pennsylvania / by Helen L. Delano and J. Peter Wilshusen. 2nd Ed.* Pennsylvania Geological Survey. Accessed December 8, 2023. http://archive.org/details/landslidesinpenn00dela.

Figure 20: Landslide Hazard Areas in the Lehigh Valley



A major concern for the Lehigh Valley is the potential for landslides to affect critical regions, such as the Lehigh Gap or bustling thoroughfares, including the junction of Routes 145, 248, and 873. This apprehension arises from a preliminary overlay of the Valley's steep terrains with its major roads and populated zones. The focus on this specific location stems from its unique topographical and land utilization characteristics. A landslide spilling into the Lehigh River from neighboring inclines might obstruct or redirect water currents, prompting upstream flooding. Furthermore, a landslide striking a busy riverside roadway in areas like the Lehigh Gap or Slatington Borough during peak traffic could result in a catastrophic vehicular collision with potential fatalities.

Landslides can have varying environmental impacts, determined by their magnitude and exact location. These can range from:

- Alterations in land contours.
- Vegetation damage or eradication.
- Potential redirection or obstruction of water channels, impacting streams and rivers.

- Elevated sediment runoff during and post-event.

4.3.7.3. Past Occurrence

Pennsylvania has frequently been a hotspot for significant landslide occurrences due to its unique blend of a humid climate, locally intense topography, and the varied erosion and weathering characteristics of its sedimentary rocks. Additionally, human endeavors, including commercial, residential, and industrial development, along with transportation and mining projects, often intensify the susceptibility to landslides.

However, the documentation of landslides, compared to other hazards, is relatively incomplete. This discrepancy arises mainly because many landslides go unnoticed, rendering historical records of such events in the Lehigh Valley sparse and inconsistent.

A few notable events include:

- In March 2007, after substantial rainfall, a mudslide in Hanover Township (Lehigh County) led to precarious road conditions, resulting in the temporary closure of Dauphin Drive. Thankfully, no casualties were reported.

- On March 30, 2014, a rockslide occurred in Lower Saucon Township (Northampton County).

- A mudslide was reported on April 30, 2014, in Upper Mt. Bethel Township (Northampton County).

- Another rockslide took place on July 11, 2017, along Route 611 in Lower Mt. Bethel Township (Northampton County).

Moreover, from 1954 to 2023, FEMA designated one geological hazard-related disaster (DR) or emergency (EM) declaration for Pennsylvania, due to severe storms, flooding, and a mudslide. This declaration (DR-1649) was announced on June 30, 2006, encompassing Northampton County, and assistance was rendered to those affected by the calamity.

4.3.7.4. Future Occurrence

Given the region's history and various risk factors, it's reasonable to anticipate future landslides in the Lehigh Valley. However, the magnitude of these landslides can differ based on their type and exact location. The acceleration of aggressive development, particularly in areas with steep slopes, can exacerbate the likelihood of landslides in the region. Activities such as building and road construction play a significant role in this, as they may compromise or tilt otherwise stable terrains, making them more susceptible to landslides.

From the perspective of the Lehigh and Northampton County Emergency Management Agencies, the probability of landslides occurring in the Lehigh Valley is categorized as 'unlikely'.

4.3.7.5. Vulnerability Assessment

Landslides, often triggered by factors like heavy rainfall, earthquakes, or human activities, can have a profound impact on various community lifelines. These natural events can pose significant challenges, especially in vulnerable areas like the Lehigh Valley. The primary community lifelines likely to be affected by landslides are shown in the table below.

Table 40: Potential Vulnerabilities of Lifelines to Landslide

Lifelines	Impact Type	Description
Food, Shelter, & Housing		Landslides can destroy or damage homes and buildings, leading to displacement of residents and the need for temporary housing solutions. The rebuilding process can be extensive and resource-intensive.
Health & Medical		The immediate threat of injury during a landslide and potential for public health concerns afterward (due to disrupted water and sanitation systems) can increase the demand for medical services and strain healthcare facilities.
Utilities		Landslides can damage utility lines and infrastructure, leading to power outages, water supply disruptions, and communication breakdowns. Restoring these services is crucial for recovery and normalcy.
Transportation		Landslides can block roads and railways, disrupting transportation and access, including emergency response routes. Repairing these routes can be time-consuming and costly.

Overall, the Lehigh Valley's vulnerability to the landslide hazard has not changed since the 2018 Plan. The categorization and overall hazard extent remain the same; however, the USGS layer provides a more detailed hazard extent.

Vulnerability to ground failure hazards is a function of location, soil type and geology, type of human activity, use and frequency of events. The effects of landslides can be lessened by avoidance of 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 past hazard history of the site, and by making inquiries to planning and engineering departments of local governments.[110] In general, the built environment located in the high susceptibility zones and the population, structures and infrastructure located downslope are vulnerable to this hazard. Approximately 6.1% of Lehigh County and 5.6% of Northampton County are located in the high susceptibility/moderate incidence landslide hazard area. In Lehigh County, Washington Township has the highest percentage of its area (38.4%) in this zone, while in Northampton County; Lehigh Township has the highest percentage (36.9%).

To estimate the population located within the landslide hazard areas, the approximate hazard area boundaries were overlaid on the 2010 Census population data. The Census blocks with their center within the boundary of the high susceptibility/moderate incidence landslide hazard area were used to calculate the estimated population considered exposed to this hazard. The population located in the low susceptibility area was also estimated and reported. Approximately 0.8% of the population in Lehigh County and 1.6% in Northampton County are located in high susceptibility/moderate incidence landslide hazard area.

The landslide hazard's impact on the economy and estimated dollar losses are difficult to measure. Direct costs include the actual damage sustained by buildings, property and infrastructure. Indirect costs include clean-up costs, business interruption, loss of tax revenues, reduced property values and loss of productivity. Additionally, ground failure threatens transportation corridors, fuel and energy conduits and communication lines.[111]

To estimate the general building stock vulnerable to this hazard, the associated building replacement values (buildings and contents) were determined for the identified buildings within the approximate hazard area. In summary, the estimated replacement value of general building stock located in high susceptibility/moderate incidence landslide hazard areas is nearly $3 billion. This estimate represents approximately 1% of the total building stock value inventory in the Lehigh Valley. These dollar value losses to the region's total building inventory replacement value would impact the local tax base and economy.

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[110] U.S. Department of the Interior and U.S. Geological Survey. "Landslide Types and Processes," July 2004. https://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html.

[111] U.S. Geological Survey. "National Strategy for Landslide Loss Reduction." Open-File Report. 2022. https://pubs.usgs.gov/of/2022/1075/ofr20221075.pdf.

4.3.8 Lightning Strike

4.3.8.1. Location and Extent

Lightning is a giant spark of electricity resulting from the build-up of positive and negative charges within a thunderstorm. The clap of thunder is the result of a shock wave created by the rapid heating and cooling of the air in the lightning channel. All thunderstorms produce lightning and are very dangerous. On average, 28 people in the United States die each year from lightning strikes, according to all U.S. lightning deaths reported from 2006 through 2021.[112]

Every year in the United States, over 100,000 thunderstorms unfold, resulting in more than 25 million lightning strikes that touch the ground. These strikes are responsible for numerous injuries and fatalities. While lightning is a common feature of all thunderstorms, its frequency and impact can vary by region. The Lehigh Valley is particularly susceptible, much like the rest of the country, especially during the peak summer months.

Data from the Cooperative for Applied Meteorological Studies, spanning 2000-2009, indicates that the Lehigh Valley and southwestern Pennsylvania experience a notably higher lightning flash density. Although the direct impacts of a lightning strike are typically localized, potent storms can induce a series of strikes across a vast area. The repercussions can escalate significantly if a strike targets critical infrastructure like a power station or a populous public venue.

4.3.8.2. Range of Magnitude

The number of lightning-caused U.S. homeowners insurance claims increased in 2022 over 2021 but is still less than the annual number of claims between 2017-2020.

In 2022, U.S. lightning–caused claims increased by 2.2 percent to 62,189 (from 60,851 in 2021), with numbers from the top ten claim states contributing to about half of the total. National claim value decreased 27.6 percent (from $1.3 billion) to $950 million. While the national average cost per claim was $15,280, the average was $36,319 in California. According to the Insurance Information Institute, in 2022, Pennsylvania ranked 10th for the number and value of homeowner insurance claims due to lightning damage with $23.8 million in total claims. The average cost per claim was $12,155.[113]

Many case histories show observed heart damage, inflated lungs and brain damage in lightning fatalities. Many who have survived have reported a loss of consciousness, amnesia, paralysis and burns. Deaths and injuries to livestock and other animals, thousands of forest and brush fires, as well as

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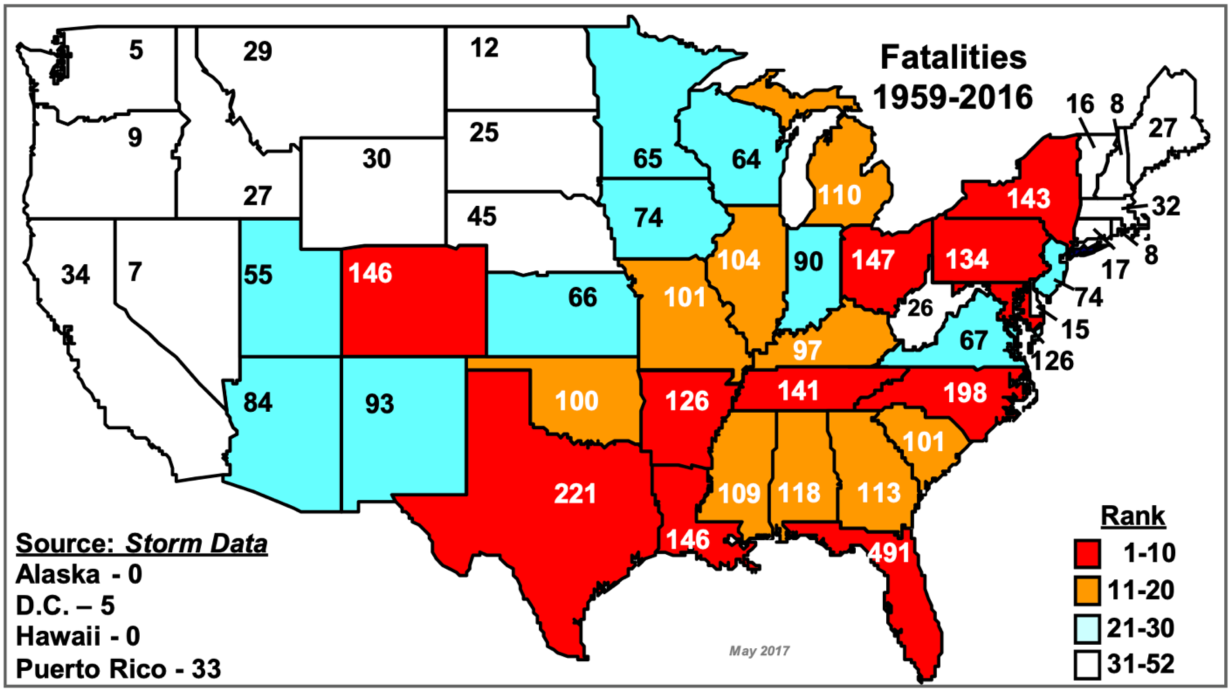
[112] Centers for Disease Control and Prevention. "U.S. Lightning Strike Deaths | Lightning | CDC," September 16, 2022. https://www.cdc.gov/disasters/lightning/victimdata/infographic.html.

[113] Insurance Information Institute. "Facts + Statistics: Lightning." iii.org, 2022. https://www.iii.org/fact-statistic/facts-statistics-lightning.

millions of dollars in damage to buildings, communications systems, power lines, and electrical systems are also the result of lightning.

Between 1959 and 2016, Pennsylvania ranked ninth among all states for the number of lightning deaths with 134 deaths. This represents approximately 3% of all fatalities that occurred throughout the United States over this period.

Figure 21: Lightning Fatalities by State 1959 – 2016 [114]



The environmental impacts most often associated with lightning strikes include damage or destruction of trees and ignition of wildfires.

4.3.8.3. Past Occurrence

Defined as a lightning strike resulting in death, injury, or damage to property or crops, a lightning "event" has specific consequences. From 1993 to 2023, the Lehigh Valley registered 86 such events, with Northampton County accounting for 60 and Lehigh County for 26, as documented by NOAA-NCEI.

The most financially devastating lightning event in the Lehigh Valley occurred on August 25, 2007. A church in Plainfield Township was struck by lightning, which sparked a fire and led to $250,000 in

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[114] Vaisala. "Lightning Fatalities by State." weather.gov, May 2017. https://www.weather.gov/media/safety/59-16_State_Ltg_Fatality%2BFatality_Rate_Maps.pdf.

damages. Shortly after, another strike incinerated a sawmill in Upper Mount Bethel Township, causing an estimated $1 million in damages. Fortunately, no injuries were reported from these events.

In terms of human casualties, data indicates a fatality resulting from a lightning strike in Bethlehem Township in August 2009. A chilling incident on July 19, 2011, saw a father and daughter hit by lightning under a tree at the Moore Township Recreation Fields in Northampton County. The father sustained burns across various parts of his body and experienced numbness, while his daughter suffered a flash burn to her right eye.

From 1993 onwards, lightning has claimed one life, caused 12 injuries, and inflicted over $4.15 million in damages to the Lehigh Valley. The subsequent table outlines lightning events documented since the 2018 Plan.

Table 41: Lightning Events in Lehigh Valley 2018 - 2023[115]

County	Location	Date	Deaths	Injuries	Property Damage ($)
Lehigh County					
Lehigh	Mechanicsville	06/26/2023	0	0	$5,000
Lehigh	Wescosville	06/26/2023	0	0	$5,000
Northampton County					
Northampton	Shoenersville	08/18/2020	0	0	-
Northampton	Bath	08/05/2022	0	0	-
Lehigh Valley Total			**0**	**0**	**$10,000**

4.3.8.4. Future Occurrence

Lightning strikes in the Lehigh Valley that resulted in multiple injuries or extensive property damage have occurred 86 times over 30 years of record (1993 to 2023). The future occurrence of lightning

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[115] National Centers for Environmental Information. "Storm Events Database." ncdc.noaa.gov. Accessed November 22, 2023. https://www.ncdc.noaa.gov/stormevents/.

activity in the Lehigh Valley is anticipated, and the susceptibility to damage from these events will remain unchanged.

Climate change is expected to significantly influence future lightning events, potentially leading to an increase in both frequency and intensity. As global temperatures rise, the atmosphere becomes warmer and more unstable, creating conditions that are more conducive to thunderstorm activity, which in turn can lead to more lightning. Additionally, increased evaporation rates and more abundant atmospheric moisture resulting from higher temperatures can fuel more powerful storms. This heightened storm activity is likely to result in more frequent and intense lightning events. Moreover, changing weather patterns may alter the geographical distribution of lightning storms, potentially bringing them to regions previously less affected. This increased lightning activity not only raises the risk of direct strikes but also heightens the likelihood of secondary effects such as wildfires, power outages, and damage to infrastructure. The overall impact of climate change on lightning events underscores the need for adaptive strategies in hazard mitigation planning to address these evolving risks.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for lightning strike events is considered ***'highly likely'*** as defined in the Methodology Section.

4.3.8.5. Vulnerability Assessment

Lightning strikes, while often brief, can have significant and sometimes far-reaching impacts on community lifelines. These natural events can pose unique challenges, especially in areas like the Lehigh Valley. The primary community lifelines likely to be affected by lightning strikes are shown in the table below.

Table 42: Potential Vulnerabilities of Lifelines to Lightning Strikes

Lifelines	Impact Type	Description
Energy		Lightning strikes can cause power outages by damaging electrical infrastructure, including power lines and transformers. This disruption affects not just residential areas but also critical services and businesses.
Communications		Lightning can damage communication infrastructure, such as cell towers and broadcasting equipment, leading to disruptions in both personal and emergency communications.

Lifelines	Impact Type	Description
Housing		Direct strikes can cause structural damage to buildings, necessitating repairs and, in severe cases, temporary relocation of residents.
Health & Medical		Direct lightning strikes or secondary effects like fires can result in injuries requiring medical attention. Additionally, power outages and communication disruptions can affect healthcare facilities' operations.

The Lehigh Valley, as a whole, is designated a high-risk area for lightning events, making all components within - including individuals, buildings, vital facilities, and essential services - susceptible and potentially at risk. Analysis of NOAA-NCEI lightning data for this region, coupled with information from both current and past iterations of the Pennsylvania Hazard Mitigation Plan, reveals a relatively stable pattern of vulnerability throughout the Lehigh Valley, despite variations in the number of lightning incidents among different municipalities. These lightning events are linked to a range of direct and indirect impacts, such as personal injuries, fatalities, structural and infrastructural damage, agricultural losses, power disruptions, and added strain on community resources.

There's a noticeable link between the density of population and buildings and the extent of hazard vulnerability and associated losses. Urban zones in the Lehigh Valley, characterized by higher concentrations of people and buildings, face a heightened risk of lightning strikes. Skyscrapers, acting as lightning attractors, have historically borne the brunt of these incidents. The specific risk posed by lightning to a building is influenced by its relative height in the area and whether it is equipped with lightning rods or similar protective technologies.

It should be assumed that all structures and critical facilities are susceptible to lightning strikes. Additionally, livestock operations are more prone to lightning risks, as animals often seek shelter under trees during storms, which are common lightning targets. It's crucial to acknowledge that many food and agriculture-related critical facilities, predominantly privately-owned farms with significant livestock holdings, are not specifically catalogued for their vulnerability in the Commonwealth's list of critical facilities.

Lightning strikes can also trigger electrical disturbances, forest or wildfires, and damage vital infrastructure, including power lines and communication towers. The agricultural sector is particularly vulnerable to devastating losses from lightning and subsequent fires.

4.3.9 *Pandemic & Infectious Disease*

4.3.9.1. Location and Extent

Pandemics refer to widespread disease outbreaks, determined by the extent of spread rather than fatalities. These often stem from infectious diseases caused by pathogens like bacteria, viruses, fungi, or parasites. These pathogens are transmitted between individuals through direct or indirect contact. In the Pennsylvania 2023 State Hazard Mitigation Plan, PEMA Defines pandemic as a "disease outbreak affecting or attacking a large number of people across an extensive region, including several countries, and/or continent(s)." Pandemic and infectious disease events cover a wide geographical area and can affect large populations, potentially including the entire population of the Lehigh Valley.

The magnitude of an outbreak, particularly its geographical spread and affected population, hinges on the ease of transmission, contact between infected and healthy individuals, and the mode of disease transmission. The transmission rates of pandemic illnesses are often higher in denser areas where there are large concentrations of people.[116] Additionally, natural disasters – particularly flooding – can further exacerbate the situation by enabling widespread bacteria growth in water. Disease vectors such as mosquitoes may also temporarily increase in population following a natural disaster.

In late 2019 and early 2020, a novel coronavirus spread into a worldwide pandemic. Named COVID-19, this type of coronavirus is a new virus that causes respiratory illness and is extremely contagious even prior to exhibiting symptoms or if the infected person is asymptomatic and can be fatal. The virus is believed to have originated in the Wuhan of China, quickly spreading to nearby countries in late 2019 and the whole world by March 2020.[117]

Another concern in the Lehigh Valley is arthropod-borne viruses (arboviruses) transmitted by blood-feeding arthropods like mosquitoes and ticks. Given the high populations of these vectors, the Lehigh Valley is particularly vulnerable. Residents of all areas of the Lehigh Valley are equally vulnerable to the impacts of a pandemic.

The following diseases are specifically discussed below.

- **Influenza**: Beyond seasonal outbreaks, pandemic strains like H5N1, H7N9, and the 2009 H1N1 can severely impact public health infrastructure.

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[116] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[117] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

- **West Nile Virus**: Spread to people through the bite of an infected mosquito. Originating from regions like Africa and West Asia, this virus causes brain inflammation. It made its North American debut in New York City in 1999 and has since seen continent-wide epidemics.

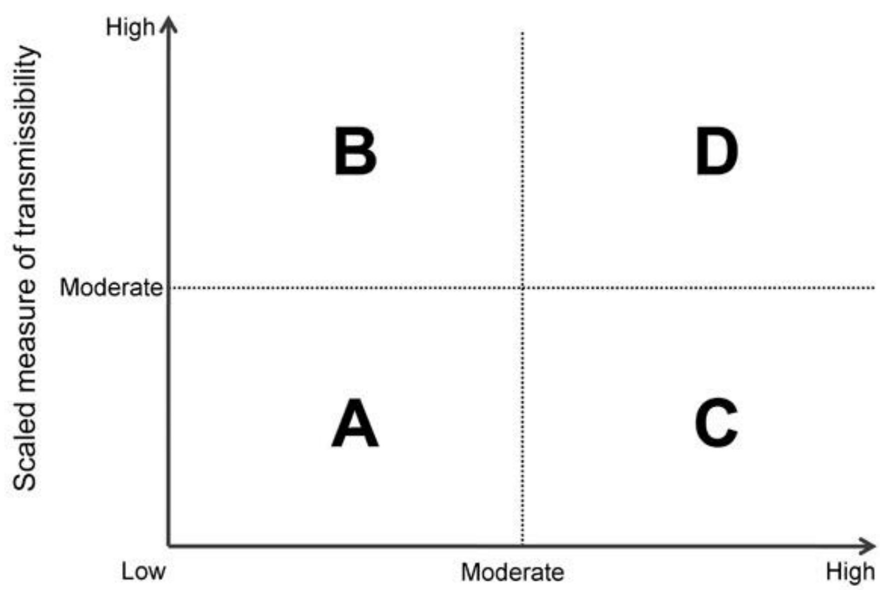
- **Lyme disease**: Transmitted by infected ticks. Pennsylvania has consistently recorded high Lyme disease cases, with infected deer ticks found in all its counties.

- **COVID-19**: Identified first in Wuhan, China, this virus led to a global pandemic. Its impact varies, with older individuals and those with underlying health conditions at higher risk.

4.3.9.2. Range of Magnitude

As mentioned already, the severity of any disease outbreak is determined by a multitude of variables. Examples of variables which will shape the severity of such events include the mode of transmission (e.g., airborne or skin-to-skin contact), how contagious the disease is, how long it can survive on surfaces, and how long an individual is contagious before showing symptoms. The CDC uses the Pandemic Severity Assessment Framework (PSAF) to determine the impact of a pandemic, or how "bad" the pandemic will be.[118] The PSAF includes two main factors to determine impact: clinical severity (how serious the illness is associated with infection) and transmissibility (how easily the pandemic virus spreads from person-to-person).

Figure 22: Scaled Measure of Clinical Severity



[118] CDC. "Pandemic Severity Assessment Framework (PSAF) | Pandemic Influenza (Flu) | CDC," November 3, 2016. https://www.cdc.gov/flu/pandemic-resources/national-strategy/severity-assessment-framework.html.

Guidance from the CDC states that health officials should perform at least two assessments when using the PSAF. The first assessment is appropriately called an "initial assessment," and health officials should complete this assessment early on during a pandemic. At this point, activity may be detected in pockets or certain communities across the country so information and understanding about the pandemic virus may be limited. The initial assessment is intended to help health officials develop a preliminary understanding of the potential impact of the pandemic. Once quality data becomes available, health officials can perform a "refined assessment" which provides a more detailed and accurate picture of pandemic impact, including assessments of the impact by age group. The following table describes scaled measures of transmissibility and clinical severity for refined assessments of pandemic influenza effects.

Table 43: Scaled Measures of Transmissibility and Clinical Severity

Parameter No. and Description[119]	Scale						
	1	2	3	4	5	6	7
Transmissibility							
Symptomatic attack rate, community, %	<10	11-15	16-20	21-24	>25	-	-
Symptomatic attack rate, school, %	<20	21-25	26-30	31-35	>36	-	-
Symptomatic attack rate, workplace, %	<10	11-15	16-20	21-24	>25	-	-
Household secondary attack rate, symptomatic, %	<5	6-10	11-15	16-20	>21	-	-

[119] Reed, Carrie, Matthew Biggerstaff, Lyn Finelli, Lisa M. Koonin, Denise Beauvais, Amra Uzicanin, Andrew Plummer, Joe Bresee, Stephen C. Redd, and Daniel B. Jernigan. "Novel Framework for Assessing Epidemiologic Effects of Influenza Epidemics and Pandemics - Volume 19, Number 1—January 2013 - Emerging Infectious Diseases Journal - CDC." Accessed August 28, 2023. https://doi.org/10.3201/eid1901.120124.

Parameter No. and Description[119]	Scale						
	1	2	3	4	5	6	7
R0: basic reproductive number	<1.1	1.2-1.3	1.4-1.5	1.6-1.7	>1.8	-	-
Peak % outpatient visits for influenza-like illness	1-3	1-3	1-3	1-3	1-3	-	-
Clinical Severity							
Case-fatality ratio, %	<0.02	0.02-0.05	0.05-0.1	0.1-0.25	0.25-0.5	0.5-1	>1
Case-hospitalization ratio, %	<0.5	0.5-0.8	0.8-1.5	1.5-3	3-5	5-7	>7
Ratio, deaths: hospitalization, %	<3	4-6	7-9	10-12	13-15	16-18	>18

Federal, state, and local public health agencies provide instructions to all organizations and individuals based on the severity of a pandemic and the infectious diseases' transmission methods. The worst-case scenario for Lehigh Valley would be a disease with high transmissibility (5) and high clinical severity (7) per the CDC's PSAF.

Influenza

According to the Pennsylvania Department of Health, the severity of influenza varies widely from one season to the next. The number of flu-associated deaths in the United States usually ranges from 3,000 to 49,000 deaths per year but can be much higher if a new strain develops to which no one is immune. Common symptoms of influenza include:

- Fever
- Headache
- Tiredness
- Dry cough
- Sore throat

- Nasal congestion
- Body aches

Certain people are at greater risk for serious complications if they get the flu. This includes older people, young children, pregnant people and people with common health conditions such as asthma, diabetes or heart disease. Complications of flu can include pneumonia, ear infections, sinus infections, dehydration and worsening of chronic medical conditions, such as congestive heart failure, asthma or diabetes.[120]

West Nile Virus

Severe illness can occur in people of any age; however, people over 60 years of age are at greater risk. People with certain medical conditions, such as cancer, diabetes, hypertension, kidney disease, and people who have received organ transplants, are also at greater risk. Approximately 80% of people who are infected will not show any symptoms. Approximately 20% of infected people with West Nile will have symptoms such as fever, head and body aches, nausea, vomiting, and sometimes swollen lymph glands or skin rash on the chest, stomach and back; these symptoms can last from a few days to several weeks. About one in 150 people infected with West Nile will develop severe illness. Associated symptoms can include blindness, disorientation, coma, convulsions, headache, high fever, muscle weakness, neck stiffness, numbness, paralysis, stupor, and tremors. These symptoms may last for several weeks, and the neurological effects may be permanent. About one out of ten people who develop severe illness affecting the central nervous system die.[121]

Lyme Disease

According to the Pennsylvania Department of Health, Lyme disease has three stages, and each state has distinct signs and symptoms.

Early Stage

- Erythema migrans (EM) – red, oval or round rash. The rash may be round or oval with no clearing, it may have a red ring with clearing in the center, it may appear blueish in color. The first EM rash usually appears at the site of the tick bite, but may progress to multiple EM rashes anywhere on the body.
- May feel warm to the touch but is rarely itchy or painful.

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[120] Pennsylvania Department of Health. "Flu." Department of Health. Accessed November 8, 2023. https://www.health.pa.gov/topics/disease/Flu/Pages/Flu.aspx.

[121] Pennsylvania Department of Health. "West Nile Virus Fact Sheet." health.pa.gov, August 9, 2023. https://www.health.pa.gov/topics/Documents/Diseases%20and%20Conditions/Vectorborne/West%20Nile%20Virus.pdf.

- Fever, chills, headache, muscle and joint pain, swollen lymph nodes. Most Lyme cases in Pennsylvania occur in the late spring and summer months when flu is rare. Lyme and other tickborne diseases should be considered when you have a flu-like illness in the summer.

Mid Stage

- Fever
- Numbness, tingling, shooting pain, or weakness in the arms or legs. Neurologic symptoms can occur in approximately 10% of untreated people.
- Severe headache or neck stiffness
- Sensitivity to light
- Facial paralysis

Late Stage

- Additional EM rashes on other areas of the body
- Arthritis with severe joint pain and swelling, particularly the knees and other large joints
- Intermittent pain in tendons, muscles, joints, and bones
- Heart palpitations or an irregular heartbeat
- Episodes of dizziness or shortness of breath
- Inflammation of the brain and spinal cord
- Problems with short term memory
- Nerve pain, shooting pains, numbness or tingling in the hands or feet
- Facial paralysis

The exact timing of the onset of symptoms of Lyme disease will vary by case. Lyme disease can be treated with antibiotics, but there is currently no human vaccine. Most people treated with antibiotics, especially those treated early, fully recover from Lyme diseases. About 20% of people may develop Post Treatment Lyme Disease Syndrome (PTLDS) which is a persistence of some Lyme symptoms even after antibiotic treatment. Most symptoms resolve within months. Repeated treatments with antibiotics have not been shown to be effective in treating PTLDS.[122]

COVID-19

People with COVID-19 have had a wide range of symptoms reported – ranging from mild symptoms to severe illness. Symptoms may appear 2-14 days after exposure to the virus. Anyone can have mild to severe symptoms. Possible symptoms include:

- Fever or chills

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[122] Pennsylvania Department of Health. "Lyme Disease." Department of Health. Accessed November 8, 2023. https://www.health.pa.gov:443/topics/disease/Vectorborne%20Diseases/Pages/Lyme.aspx.

- Cough
- Shortness of breath of difficulty breathing
- Fatigue
- Muscle or body aches
- Headache
- New loss of taste or smell
- Sore throat
- Congestion or runny nose
- Nausea or vomiting
- Diarrhea

Some people who have COVID-19 can experience long-term effects from their infection, known as Long COVID or Post-COVID Conditions (PCC). Long COVID is broadly defined as signs, symptoms, and conditions that continue or develop after acute COVID-19 infection. People with Long COVID may develop or continue to have symptoms that are hard to explain and manage. Clinical evaluations and results of routine blood tests, chest X-rays, and electrocardiograms may be normal. The symptoms are similar to those reported by people with myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) and other poorly understood chronic illnesses that may occur after other infections. People with these unexplained symptoms may be misunderstood by their healthcare providers, which can result in a delay in diagnosis and receiving the appropriate care or treatment.[123]

A team of Brazilian researchers performed a preliminary assessment of the severity of the COVID-19 pandemic using the PSAF in April 2020. In their preliminary assessment, they rate COVID-19's scaled transmissibility at 5 and its scaled clinical severity at 4 to 7, placing the COVID-19 pandemic in the "very high severity" quadrant.[124] This preliminary assessment ranks the COVID-19 pandemic as the most severe pandemic since the 1918 influenza pandemic. As of mid-2023, the CDC has not published a PSAF rating from the COVID-19 Pandemic.

4.3.9.3. Past Occurrence

Influenza

Influenza is among the most common and recognizable diseases within the Lehigh Valley, the Commonwealth of Pennsylvania, and the U.S. as a whole. Influenza virus infections are detected year-round in the U.S., although cases typically increase during "flu season" in the fall and winter months.

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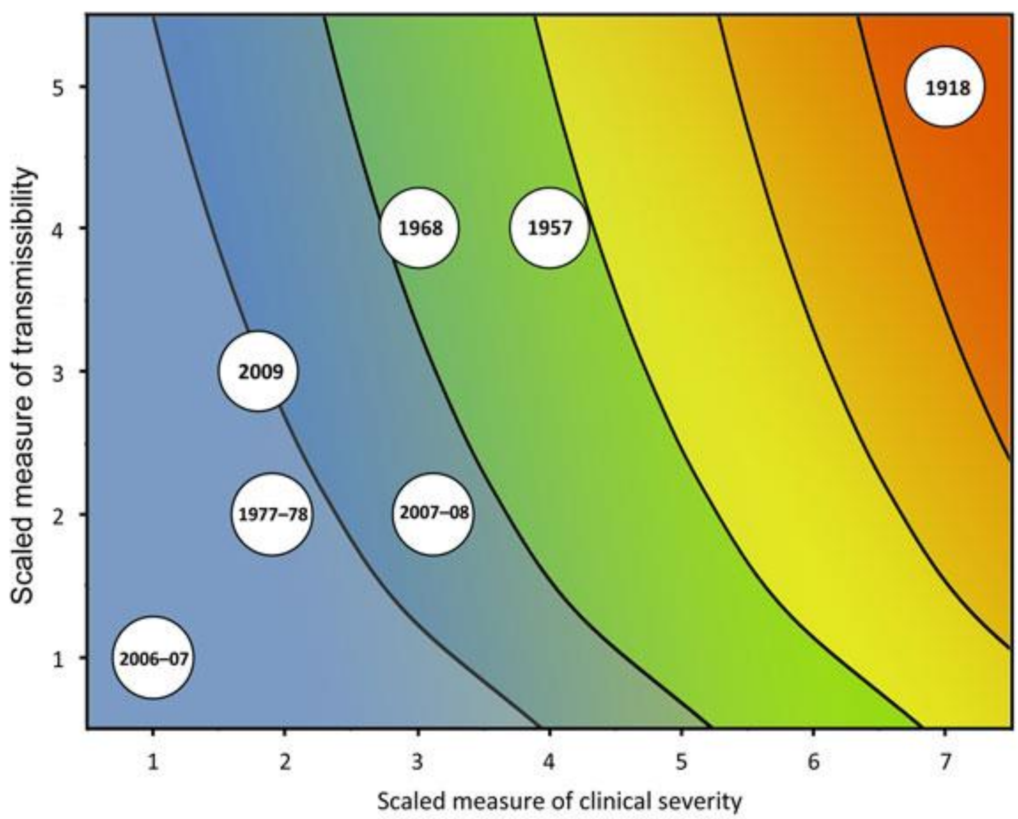
[123] Centers for Disease Control and Prevention. "Post-COVID Conditions." Centers for Disease Control and Prevention, July 20, 2023. https://www.cdc.gov/coronavirus/2019-ncov/long-term-effects/index.html.

[124] Carvalho, Mariane Cardoso, Rosana Alves de Melo, Flávia Emília Cavalcante Valença Fernandes, Amanda Regina da Silva Góis, Rachel Mola de Mattos, and Roxana Braga de Andrade Teles. "Prevalence and factors associated with deaths caused by COVID-19: cross-sectional study." *Online Brazilian Journal of Nursing* 22 (August 16, 2023). https://doi.org/10.17665/1676-4285.20236645.

Nationally, the highest number of influenza cases are reported during the month of February.[125] The United States Department of Health and Human Services estimates that influenza pandemics have occurred for at least 300 years at unpredictable intervals. The Pennsylvania Department of Health maintains an influenza surveillance data archive that provides summaries for each influenza season, dating back to 2005.

While influenza is a relatively routine virus, there are occasional instances of particularly severe influenza seasons. The Spanish Flu claimed 500,000 lives in the United States and there were 350,000 cases in Pennsylvania—150,000 in Philadelphia alone. Most deaths resulting from the Asian Flu occurred between September 1957 and March 1958, when there were about 70,000 deaths in the United States and approximately 15% of the population of Pennsylvania was affected. Prior to the CDC adopting the PSAF as its official pandemic severity assessment tool in 2014, the PSAF was used to model several past diseases and influenza seasons. Per the CDC's PSAF, the following figure and table show some of the notable past influenza seasons and pandemics.

Table 44: PSAF Chart for Select Influenza Seasons and Pandemics



[125] Centers for Disease Control and Prevention. "Learn More about the Flu Season." Centers for Disease Control and Prevention, September 20, 2022. https://t.cdc.gov/C03.

Table 45: Previous Pandemics Transmission & Clinic Severity Scores

Disease/Flu Season	Transmissibility Score	Clinical Severity Score
1918 Spanish Flu Pandemic	5	7
1957-1958 Flu Pandemic	4	4
1968 Flu Pandemic	4	3
1977-1978 Flu Epidemic	2	2
2006-2007 Flu Season	1	1
2007-2008 Flu Season	2	3
2009-2010 Swine Flu Pandemic	3	2

Table 46: Previous Significant Outbreaks of Influenza over the Past Century

Date	Pandemic Name / Subtype	Worldwide Deaths (Approximate)
1918 – 1920	Spanish Flu / H1N1	50 million
1957 – 1958	Asian Flu / H2N2	1.5 – 2 million
1968 – 1969	Hong Kong Flu / H3N2	1 million
2009 – 2010	Swine Flu / A/H1N1	12,000

West Nile Virus

The West Nile virus was first detected in the Lehigh Valley in 2001 when mosquito pools, dead birds and/or horses tested positive for the virus. In the Lehigh Valley, there have been birds, mosquitoes and humans that have tested positive for the virus. When reviewing the statistics for West Nile Virus within the Lehigh Valley since 2001, there has been small but noticeable increase in the number of positive cases among non-human carriers, although this trend is not detectable when viewing human cases, which remain very rare. At this time, it is not clear whether the increase in West Nile detections among non-humans is due to increasing infections or more aggressive monitoring and detection efforts. West Nile occurrences in the Lehigh Valley are listed in the table below.

Table 47: West Nile Cases Reported in the Lehigh Valley

Year	Lehigh County		Northampton County	
	Number of Positive Cases	Positive Human Cases	Number of Positive Cases	Positive Human Cases
2001	8	0	0	0
2002	56	0	27	0
2003	59	2	16	3
2004	4	0	4	0
2005	76	0	2	0
2006	6	0	4	0
2007	10	0	7	0
2008	4	0	3	0
2009	1	0	0	0
2010	17	0	9	0
2011	94	0	19	0

Year	Lehigh County		Northampton County	
	Number of Positive Cases	Positive Human Cases	Number of Positive Cases	Positive Human Cases
2012	150	2	59	1
2013	53	0	29	0
2014	74	0	13	0
2015	72	0	40	0
2016	61	0	18	1
2017	91	1	18	1
2018	177	4	106	0
2019	23	0	20	0
2020	7	0	1	0
2021	131	1	39	0
2022	63	0	41	1

Lyme Disease

Tick-borne diseases are transmitted by ticks infected with bacteria, viruses or parasites and are a concern for the Lehigh Valley. One of the most common in the northeast is Lyme disease. Pennsylvania has led the nation in yearly confirmed cases of Lyme disease several times since 2000, and it remains an ongoing concern in the Lehigh Valley. Since 2001, the yearly cases of Lyme disease have remained relatively constant. However, there were fewer reported cases of Lyme disease in 2021 than in any year since 2001. The number of reported cases of Lyme disease in the Lehigh Valley from 2001 to 2021 are identified in the following table.

Table 48: Reported Lyme Disease Cases in the Lehigh Valley

Year	Reported Cases Lehigh County	Reported Cases Northampton County
2001	84	85
2002	62	172
2003	215	241
2004	201	197
2005	179	164
2006	105	99
2007	134	123
2008	147	109
2009	197	197
2010	102	132
2011	193	170
2012	153	129
2013	137	140

Year	Reported Cases Lehigh County	Reported Cases Northampton County
2014	140	84
2015	170	171
2016	242	139
2017	296	178
2018	209	88
2019	211	141
2020	121	71
2021	71	75

COVID-19

The first case of COVID-19 was detected in Pennsylvania during the first week of March, 2020. Between March 1st, 2020, and June 15th, 2023, there were 213,713 reported COVID-19 cases in the Lehigh Valley with a total of 2,693 deaths. The following table lists COVID-19 case and death data for each county during this time period.

Table 49: Reported COVID-19 Infections and Deaths

Location	Cumulative Reported Cases	Total Deaths
Lehigh County	112,637	1,422
Northampton County	101,076	1,271

4.3.9.4. Future Occurrence

Predicting the future occurrences of pandemics is difficult. Although any infectious disease can reach pandemic levels, influenza has the greatest likelihood of causing the next pandemic. It is likely that certain diseases will impact both Lehigh Valley counties in the future. Additionally, an increase in population and population density in the Lehigh Valley may increase resident exposure and susceptibility to outbreaks. Infected mosquitos and ticks will continue to inhabit and impact the Lehigh Valley.

The precise timing of pandemic influenza is uncertain. The precise timing of pandemic influenza is uncertain, but occurrences are most likely when the Influenza Type A virus makes a dramatic change, or antigenic shift, that results in a new or "novel" virus to which the population has no immunity. This emergence of a novel virus is the first step toward a pandemic.

As with influenza, future occurrences of West Nile virus are unclear. Instances of the virus have been generally decreasing due to aggressive eradication efforts, but some studies show that warmer temperatures associated with climate change can accelerate mosquito development, biting rates, and the incubation of the West Nile virus within mosquitoes.[126]

Tick-borne diseases including Lyme disease will continue to impact the Lehigh Valley due to its natural environment. Each year, the number of cases increases. Research continues to address concerns of the disease. Climate has been linked to one of the factors that influences the transmission, distribution and incidence of Lyme disease. Studies have provided evidence that climate change has also contributed to the expanded range of ticks, increasing the potential risk of Lyme disease.

The future of COVID-19 is uncertain at this time. CDC data shows that weekly visits to emergency departments are decreasing. However, there are still more than 1,000 COVID-19 deaths reported per week as of October 28th, 2023.[127]

Based on previous occurrences of the various diseases, pandemics and outbreaks of the different diseases will continue to occur. However, it is uncertain as to the future of these diseases and their impacts on the Lehigh Valley. Future pandemics may also emerge from other diseases, especially invasive pathogens that residents from both Lehigh and Northampton counties do not have natural immunity to.

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[126] US EPA, OAR. "Climate Change Indicators: West Nile Virus." Reports and Assessments, July 1, 2016. https://www.epa.gov/climate-indicators/climate-change-indicators-west-nile-virus.

[127] Centers for Disease Control and Prevention. "COVID Data Tracker." Centers for Disease Control and Prevention, March 28, 2020. https://covid.cdc.gov/covid-data-tracker.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for pandemic and infectious disease events in the Lehigh Valley is considered 'likely' as defined in the Methodology Section.

4.3.9.5. Vulnerability Assessment

A pandemic, characterized by the widespread outbreak of a disease, can significantly impact a wide range of community lifelines, disrupting normal societal functions. In areas like the Lehigh Valley, the following community lifelines are particularly vulnerable to the effects of a pandemic are shown in the table below.

Table 50: Potential Vulnerabilities to Lifelines from a Pandemic

Lifelines	Impact Type	Description
Health & Medical		The most direct impact of a pandemic is on health services. Hospitals and healthcare facilities can become overwhelmed with patients, leading to a strain on resources, personnel, and infrastructure. The need for medical supplies, ventilators, and personal protective equipment can surge beyond normal levels.
Food, Water, & Shelter	 	Supply chains for essential goods, including food and water, can be disrupted due to illness-related workforce shortages or quarantine measures. Ensuring access to these basic necessities becomes a critical challenge, particularly for vulnerable populations.
Transportation		Pandemics can lead to reduced transportation services due to decreased demand, illness among transportation workers, or quarantine measures. This can affect the movement of goods and people, including the delivery of essential supplies and access to healthcare.

Lifelines	Impact Type	Description
Communications		Reliable communication is crucial for disseminating public health information, guidelines, and updates during a pandemic. The increased demand for internet and telecommunication services can strain existing communication networks, especially with more people working from home.
Energy		While energy infrastructure may be less directly impacted, workforce shortages due to illness can affect the maintenance and operation of power plants and the energy grid.
Safety & Security		The need for public safety and security services can increase, as pandemics can lead to heightened public anxiety, the enforcement of quarantine measures, and the potential for civil unrest.
Economic Stability		Pandemics can have a profound impact on the economy, affecting businesses, employment rates, and financial stability. Sectors such as tourism, hospitality, and retail can be particularly hard hit.

For the pandemic hazard, the entire Lehigh Valley has been identified as the hazard area; therefore, the entire population of the Lehigh Valley is vulnerable to a pandemic event. Pandemic events are a significant concern, mainly due to their impact on public health. The elderly population and individuals with suppressed immune systems may be more susceptible to effects of diseases such as influenza. Additionally, some occupation-specific risks may make some employees more vulnerable. Those working in direct contact with patients are more likely to be exposed to a pandemic disease, just as employees working outdoors during warmer months may be more vulnerable to West Nile virus, Zika, Dengue fever and Lyme disease.

Areas with a higher population density will have a higher exposure to diseases, especially those populations living in areas prone to mosquitoes and ticks. Additionally, vulnerable populations such as the young and elderly are considered at higher risk. In the event of a disease pandemic, such as influenza, people will not likely evacuate the impacted areas unless ordered by government officials.

Most people would likely choose to shelter in place and avoid highly populated public places. Overall, the Lehigh Valley may experience an increase in population after a natural disaster that may impact the health of Lehigh and Northampton County residents. In the event of a pandemic, such as influenza, residents may choose to temporarily leave the area to avoid becoming ill. If a pandemic were to occur outside of the Lehigh Valley, the region may see an increase in population of people moving away from the impacted areas.

4.3.10 Radon Exposure

4.3.10.1. Location and Extent

Radon is a naturally occurring radioactive element which forms through the normal decay of other elements in the ground like uranium and thorium. With a half-life of only 3.8 days, radon would not exist in significant amounts were it not for the fact that it is constantly being produced through the decay of other elements. While natural, radon is different than other radioactive materials because it exists in a gaseous state under normal conditions, and this makes it easy to inhale. Furthermore, radon is colorless, odorless, and tasteless, which makes it very difficult to detect without specialized equipment. Inhalation of radon can lead to significant health concerns as a result of the biological effects of ionizing radiation. Due to these conditions, radon exposure is an ongoing concern for many communities across the Lehigh Valley, Pennsylvania, and the country.

Radon can be detected in nearly all U.S. counties, but the concentrations of it vary. In 1993, the Environmental Protection Agency (EPA) established the Map of Radon Zones to assist national, state, and local entities target their resources and implement radon-resident building codes.[128] The map utilizes three different tiers of radon concentration to assess the risk of radon at the county level. However, these concentrations are not uniform across a given county, and radon levels can vary from home to home. The Pennsylvania Department of Environmental Protection acknowledges the variability of radon concentrations at a local level and discourages individuals from using a neighbor's radon test as an indicator of exposure levels in their own home.[129]

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[128] US EPA, Office of Air and Radiation. "EPA Map of Radon Zones." Data and Tools, August 18, 2014. https://www.epa.gov/radon/epa-map-radon-zones.

[129] Pennsylvania Department of Environmental Protection. "Pennsylvania's Home Buyer's and Seller's Guide to Radon." depgreenport.state.pa.us/elibrary, May 9, 2023. https://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=3983&DocName=PENNSYLVANIA%20CITIZEN%26%2339%3bS%20GUIDE%20TO%20RADON.PDF%20%20%3cspan%20style%3D%22color:green%3b%22%3e%3c/span%3e%20%3cspan%20style%3D%22color:blue%3b%22%3e%28NEW%29%3c/span%3e%2010/9/2021.

Figure 23: Environmental Protection Agency Map of Radon Zones

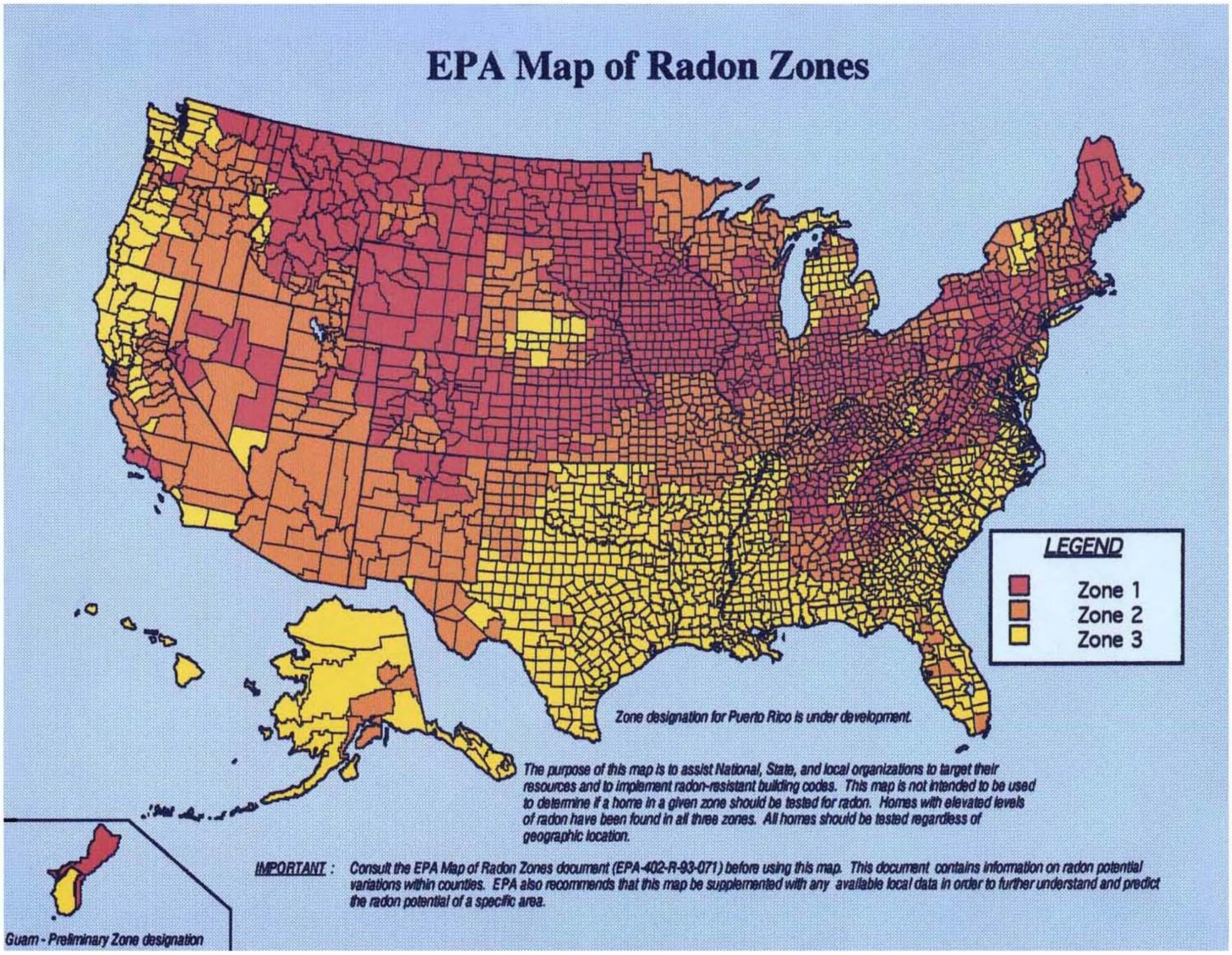

Table 51 – Description of Radon Zones

Zones	Description
Zone 1 (red)	Highest potential; average indoor radon levels may be greater than 4 pCi/L (picocuries per liter)
Zone 2 (orange)	Moderate potential; average indoor radon levels may be between 2 and 4 pCi/L
Zone 3 (yellow)	Low potential; average indoor radon levels may be less than 2 pCi/L

Both Northampton and Lehigh are considered to be Zone 1 counties, which means that the average indoor radon levels are likely to exceed 4 pCi/L (picocuries per liter). The EPA recommends that all homeowners who have radon concentrations of 4 pCi/L or greater take remedial actions to reduce the presence of radon. High radon levels were initially thought to be exacerbated in tightly sealed houses, although it is now recognized that rates of air flow into and out of houses, plus the location of air inflow and the radon content of air in the surrounding soil, are key factors affecting radon concentrations. Air must be drawn into a house to compensate for outflows of air caused by a furnace, fan, thermal "chimney" effect, or wind effects. When new air is pulled into the structure, a portion of it can be pulled from the soil through various openings such as cracks in the foundation or around fittings for pipes. Some of the air pulled from the ground can contain radon, and the radon will tend to settle in low points of the structure as it is 7.5 times heavier than air. Soil gas typically contains between a few hundred to a few thousand pCi/L of radon; therefore, even a small rate of soil gas inflow can lead to elevated radon concentrations in a house.

The radon concentration of soil gas depends upon a number of soil properties, the importance of which is still being evaluated. In general, ten to fifty percent of newly formed radon atoms escape the host mineral of their parent radium and gain access to the air-filled pore space. 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 from which the radon can easily escape. The amount of pore space in the soil and its permeability for air flow, including cracks and channels, are important factors determining radon concentration in soil gas and its rate of flow into a house. Soil depth and moisture content, mineral host and form for radium, and other soil properties may also be important. For houses built on bedrock, fractured zones may supply air having radon concentrations similar to those in deep soil.[130]

Areas where houses have high levels of radon can be divided into three groups in terms of uranium content in rock and soil:

- Areas of very elevated uranium content (>50 parts per million [ppm]) around uranium deposits and prospects: Although very high levels of radon can occur in such areas, the hazard normally is restricted to within a few hundred feet of the deposit.

- Areas of common rocks having higher than average uranium content (5 to 50 ppm). In Pennsylvania, such rock types include granitic and felsic alkali igneous rocks and black shales. In the Reading Prong – which extends through the Lehigh Valley – high uranium values in rock or soil and high radon levels in houses are associated with Precambrian granitic gneisses commonly containing 10 to 20 ppm uranium, but locally containing more than 500 ppm uranium.

[130] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

- Areas of soil or bedrock that have normal uranium content but properties that promote high radon levels in houses. This group is incompletely understood at present. Relatively high soil permeability can lead to high radon, the clearest example being houses built on glacial eskers. Limestone-dolomite (carbonate) soils also appear to be predisposed for high radon levels in houses, perhaps because of the deep clay-rich residuum in which radium is concentrated by weathering on iron oxide or clay surfaces, coupled with moderate porosity and permeability. Of the 62 municipalities in the Lehigh Valley, 46 are underlain entirely or in part by carbonate rock.[131]

4.3.10.2. Range of Magnitude

The primary concern of radon is the impact of radiation, which can broadly be thought of as the transfer of energy via particles or waves, on people, pets, and other biology. The biological impacts of radiation vary depending on the characteristics of the radiation – in many instances, radiation is a useful component of life in the 21st century. Television, Wi-Fi, and cellular services all rely on radiation to function; even visible light is a basic form of electromagnetic radiation, and human eyesight uses minor differences in the wavelengths of light to interpret different colors in the world. These forms of radiation are not normally concerning for humans because they have relatively low amounts of energy.

Lower energy radiation is unable to ionize atoms or molecules, which is the process of stripping away electrons. However, higher energy radiation *is* ionizing, and this is the type of radiation which can lead to significant health problems. Ionizing radiation can be produced through the decay of radon and other radioactive elements. Virtually everyone on Earth is exposed to a small amount of ionizing radiation each day (often referred to as background radiation), and certain actions such as flying or receiving an X-ray can temporarily increase an individual's exposure to ionizing radiation. While a small dose of ionizing radiation is unavoidable, it is critical to minimize long-term exposure to reduce overall cell damage and the subsequent health effects.

Ionizing radiation contains enough energy to damage DNA, and this can significantly impair normal and healthy cellular reproduction. Prolonged exposure to ionizing radiation increases the overall likelihood of cancers and other health ailments. Unlike other radioactive materials, radon can be easily inhaled because it exists as a gas at room temperatures. As a result, people exposed to higher-than-normal radon concentrations for extended periods are at an increased risk of developing lung cancer.[132]

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[131] Lehigh Valley Planning Commission. “Natural Resources.” lvpc.org. Accessed October 26, 2023. https://www.lvpc.org/natural-resources.html.

[132] National Cancer Institute. “Radon and Cancer - NCI.” cgvArticle. cancer.gov, December 6, 2011. Nciglobal, Ncienterprise. https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/radon/radon-fact-sheet.

According to estimates from the EPA, radon is the leading cause of lung cancer among non-smokers and the second leading cause of lung cancer overall.[133]

Table 52: Comparative Risk of Radon Exposure for Non-Smokers[134]

Radon Level	If 1,000 people who never smoked were exposed to this level over a lifetime*	The risk of cancer from radon exposure compared to**...
20 pCi/L	Approximately 36 people could get lung cancer	35 times the risk of drowning
10 pCi/L	Approximately 18 people could get lung cancer	20 times the risk of dying in a home fire
8 pCi/L	Approximately 15 people could get lung cancer	4 times the risk of dying in a fall
4 pCi/L	Approximately 7 people could get lung cancer	The risk of dying in a car crash
2 pCi/L	Approximately 4 people could get lung cancer	The risk of dying from poison
1.3 pCi/L	About 2 people could get lung cancer	(average indoor radon level)
0.4 pCi/L	-	(average outdoor radon level)
NOTE: If you are a former smoker, your risk may be higher.		

[133] US EPA, Office of Air and Radiation. "Health Risk of Radon." Overviews and Factsheets. epa.gov, August 14, 2014. https://www.epa.gov/radon/health-risk-radon.

[134] Pennsylvania Department of Environmental Protection. "Pennsylvania Resident's Guide to Radon." dep.pa.gov, May 9, 2023. https://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=3983&DocName=PENNSYLVANIA%20CITIZEN%26%2339%3bS%20GUIDE%20TO%20RADON.PDF%20%20%3cspan%20style%3D%22color:green%3b%22%3e%3c/span%3e%20%3cspan%20style%3D%22color:blue%3b%22%3e%28NEW%29%3c/span%3e%2010/9/2021.

*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.

There is no known safe level of radon exposure, and minimizing exposure is the key to reducing the likelihood of negative health consequences. According to the CDC, children exposed to radon receive higher estimated radiation doses than adults, and the risk of children developing lung cancer as a result of radon may be twice as high as adults. The increased risk of lung cancer among children may be due in part to differences in lung structure and children having faster average breathing rates than adults.[135] Additionally, a study of 53,146 children born between 1979 and 1992 found evidence that children born in and continuously living in areas classified as "high" and "normal" risk for background radiation from radon have higher incidence of acute lymphatic leukemia.[136]

4.3.10.3. Past Occurrence

In 1984, routine monitoring of employees leaving the Limerick nuclear power plant near Reading, PA, showed that readings on Mr. Stanley Watras frequently exceeded expected radiation levels, yet only natural, non-fission-product radioactivity was detected on him. Radon levels in his home were detected around 2,500 pCi/L, much higher than the 4 pCi/L guideline of the EPA or even the 67 pCi/L limit for uranium miners. As a result of this event, the Reading Prong section of Pennsylvania where Watras lived became the focus of the first large-scale radon scare in the world.[137]

Radon is a constant threat throughout the Lehigh Valley. As a naturally occurring element, radon has been present in the ground across the Lehigh Valley since long before the area was settled. Overall, Pennsylvania is an area with historically high radon levels due to shear fault zones in the state that contain large amounts of uranium which eventually decays into radon.[138] Current data on abundance

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[135] Agency for Toxic Substances and Disease Registry. "Radon Toxicity: Who Is at Risk of Radon Exposure?" atsdr.cdc.gov, May 26, 2023. https://www.atsdr.cdc.gov/csem/radon/who_risk.html.

[136] Kohli, S., H. Noorlind Brage, and O. Löfman. "Childhood Leukaemia in Areas with Different Radon Levels: A Spatial and Temporal Analysis Using GIS." *Journal of Epidemiology & Community Health* 54, no. 11 (November 1, 2000): 822–26. https://doi.org/10.1136/jech.54.11.822.

[137] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[138] Casey, Joan A., Elizabeth L. Ogburn, Sara G. Rasmussen, Jennifer K. Irving, Jonathan Pollak, Paul A. Locke, and Brian S. Schwartz. "Predictors of Indoor Radon Concentrations in Pennsylvania, 1989–2013." *Environmental Health Perspectives* 123, no. 11 (November 2015): 1130–37. https://doi.org/10.1289/ehp.1409014.

and distribution of radon in Pennsylvania houses is considered incomplete and potentially biased.[139] However, a study published in 2015 reviewed 1,983,705 indoor radon tests conducting in over 800,000 buildings between 1987 and 2013 from all 67 counties in Pennsylvania. Through this work, the researchers concluded that:

1. Nearly 300,000 homes had radon concentrations which exceeded the EPA's action level (4 pCi/L)

2. Buildings located in cities had nearly 27% lower radon levels than those located in more rural townships.

3. Buildings using well water had 21% higher indoor radon concentrations than those using municipal water.[140]

The 2015 study also determined that the region of Pennsylvania with the highest detected levels of radon was along the Reading Prong. This is particularly relevant for Northampton and Lehigh because the Reading Prong runs through both counties. The geology of the Reading Prong is characterized by elevated levels of uranium, and the radioactive decay of the uranium results in higher-than-normal concentrations of radon in the region.

Another study conducted by the United State Geological Survey alongside the Pennsylvania Department of Health and Environmental Protection aimed to examine radon levels in wells throughout the state. The data for the study was collected from 1986 to 2015 and accounts for approximately 31 percent of the land area of Pennsylvania. The study concluded that more than 14 percent of the tested wells had radon levels at or above 4,000 pCi/L.[141]

4.3.10.4. Future Occurrence

Radon exposure is inevitable given present soil, geologic, and geomorphic factors across Pennsylvania. In the future, the overall likelihood of radon exposure in the Lehigh Valley will remain high Development in areas where previous radon levels have been significantly high will continue to be more susceptible to exposure. New incidents of concentrated exposure may occur with future development or deterioration

[139] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf..

[140] Casey, Joan A., Elizabeth L. Ogburn, Sara G. Rasmussen, Jennifer K. Irving, Jonathan Pollak, Paul A. Locke, and Brian S. Schwartz. "Predictors of Indoor Radon Concentrations in Pennsylvania, 1989–2013." *Environmental Health Perspectives* 123, no. 11 (November 2015): 1130–37. https://doi.org/10.1289/ehp.1409014.

[141] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

of older structures. Exposure can be limited with proper testing for both past and future development and appropriate mitigation measures.[142]

4.3.10.5. Vulnerability Assessment

Radon, a naturally occurring radioactive gas, can have various impacts on community lifelines when its levels become elevated, particularly in enclosed spaces like homes and buildings. In areas like the Lehigh Valley, where geological conditions can facilitate higher radon levels, the following community lifelines are particularly susceptible to the effects of radon exposure are shown in the table below.

Table 53: Potential Vulnerabilities to Lifelines from Radon

Lifelines	Impact Type	Description
Health & Medical		Radon is a leading cause of lung cancer among non-smokers. Prolonged exposure to high radon levels increases health risks, potentially leading to a greater burden on healthcare services due to increased cancer rates.
Housing		Managing radon levels involves testing and mitigation efforts in homes, schools, and workplaces. This might require modifications to building designs and ventilation systems to reduce indoor radon concentrations..
Community Services		Public awareness and education are crucial in managing radon risks. Community services may be involved in disseminating information about radon testing and mitigation, and in providing assistance or resources for radon mitigation efforts.

As part of the latest Pennsylvania State Hazard Mitigation Plan, jurisdictional and state critical facility vulnerability assessments were completed by spatially overlaying hazards with census tracts and state critical facility layers in GIS. For radon exposure, the assessment relied on EPA surveys showing that 1 in 5 homes had elevated radon levels. Using this statistic, the radon loss estimates assumed that 20% of

[142] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

the buildings within zip codes with elevated test results have elevated radon values and each would require installation of a radon mitigation system. The assessment also relies on the EPA's estimate that installation of an adequate radon mitigation system costs an average of $1,200.00. Using this methodology, it was concluded that in 2023 there were 47,511 buildings across both Northampton and Lehigh which would require installation of a radon mitigation system. The cost of installing radon mitigation systems in all of these structures was estimated to be $57,013,440.00.[143]

[143] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

4.3.11 Subsidence / Sinkhole

4.3.11.1. Location and Extent

Land subsidence refers to the sudden or gradual downward movement of the Earth's surface, predominantly in a vertical direction, due to movements of sub-surface earth materials. This phenomenon, as described by the US Geological Survey in 2007, is particularly notable in Pennsylvania, where the primary causes are mining activities and the dissolution of carbonate rocks such as limestone or dolomite. These carbonate rocks, susceptible to erosion by water passing through natural fractures and bedding planes, often lead to the formation of voids below the surface. Over time, the weight of the overlying materials can cause these voids to collapse, forming surface depressions and contributing to a karst landscape, characterized by sinkholes, linear depressions, and caves. While these karst features can vary in density from 0 to 600 per square mile, they are less frequently mapped in urban areas, not due to their absence but likely because of urban development masking these features.

Sinkholes, a common geological feature in regions with soluble carbonate rock, form over thousands of years as acidic rainwater dissolves the bedrock, creating larger openings and eventually leading to soil collapse due to insufficient support. While some sinkholes occur naturally, others result from human activities such as water pipe leaks, mining, groundwater over-extraction, surface water diversion, creating artificial water bodies, or drilling new wells. These activities can expedite the natural bedrock degradation process, thus contributing to sinkhole formation.

Sinkholes can appear suddenly and without warning, with indicators including slumping fences, trees, foundations, formation of small ponds, wilting vegetation, discolored well water, and structural cracks. They vary in shape, from steep-walled holes to bowl-like depressions.

In Lehigh and Northampton counties, 47 of the 62 municipalities are either entirely or partially situated over carbonate bedrock, as outlined in the Community Profile section. This bedrock has given rise to karst landforms. The limestone and dolomite formations underpin the central urban area of the Lehigh Valley and provide fertile farmland. Additionally, bedrock is a crucial resource for the cement industry.

Table 54: Municipalities with Identified Surface Limestone Vulnerable to Sinkholes

Lehigh County	Northampton County
Alburtis Borough	Allen Township
City of Allentown	Bath Borough
City of Bethlehem	City of Bethlehem
Catasauqua Borough	Bethlehem Township
Coplay Borough	Bushkill Township
Emmaus Borough	East Allen Township
Fountain Hill Borough	City of Easton
Hanover Township	Forks Township
Lower Macungie Township	Freemansburg Borough
Lower Milford Township	Glendon Borough
Macungie Borough	Hanover Township

Lehigh County	Northampton County
North Whitehall Township Salisbury Township South Whitehall Township Upper Macungie Township Upper Milford Township Upper Saucon Township Weisenberg Township Whitehall Township	Hellertown Borough Lower Mount Bethel Township Lower Nazareth Township Lower Saucon Township Moore Township Nazareth Borough Northampton Borough North Catasauqua Borough Palmer Township Plainfield Township Portland Borough Stockertown Borough Tatamy Borough Upper Mount Bethel Township Upper Nazareth Township West Easton Borough Williams Township Wilson Borough

4.3.11.2. Range of Magnitude

Subsidence areas and sinkholes exhibit unique characteristics in terms of size, shape, timing, and location relative to human development, all of which influence the extent of the damage they cause. These geological occurrences can range from subtle shifts in elevation to dramatic, wide openings on the Earth's surface. In urban settings, subsidence and sinkhole events pose a significant risk, potentially causing extensive damage. Key issues include disruptions to utilities and damage to both private and public assets, such as buildings, roads, and underground facilities. Without early detection and proactive mitigation, prolonged subsidence or sinkhole development can lead to severe outcomes, including fractured or collapsed building foundations and roadways.

The Lehigh Valley faces a particularly severe threat in its urban areas, notably Allentown, Bethlehem, and Easton. The formation of a sinkhole in densely populated or high-traffic areas could result in substantial property damage and even loss of life. For a detailed analysis of the populations, buildings, and critical infrastructure at risk, the Vulnerability Assessment provides in-depth information.

Sinkholes also pose environmental risks, particularly to local groundwater systems in carbonate rock formations. These areas are prone to pollution as water can easily permeate from the surface into the subsurface through cavities and fractures, bypassing natural filtration processes. Sinkholes near chemical infrastructure, such as pipelines and hazardous material storage facilities, heighten the risk of environmental contamination due to potential breaches and hazardous material releases. Contaminants of concern include sewage, fertilizers, herbicides, pesticides, and industrial chemicals. While abrupt subsidence events can initially damage vegetation, natural regrowth typically occurs over time[144].

4.3.11.3. Past Occurrence

The Pennsylvania Department of Conservation and Natural Resources' Sinkhole Inventory Online Database, along with the 2023 Pennsylvania State Hazard Mitigation Plan, recorded 470 sinkholes in Lehigh County and 677 in Northampton County between 2010 and 2013. Additionally, local data from the Lehigh and Northampton County Knowledge Center databases for 2012 and 2017 indicate 101 sinkhole incidents across 23 municipalities. Bethlehem Township experienced the highest number of sinkholes (28), followed by Palmer Township (19), Easton (12), Hanover Township in Northampton County (6), and Lower Saucon Township (5). However, details on damages or injuries are not readily available, and it's important to note that many sinkholes remain unreported, especially those occurring on private lands like farms and woodlands, which typically don't pose immediate threats to structures.

Significant sinkhole events have been documented in the region. One notable incident in Allentown in February 1994 resulted in a massive sinkhole measuring 100 feet in length, 50 feet in width, and 20 feet in depth. This event led to the collapse of a portion of 7th Street and the adjoining Corporate Plaza Building, necessitating the building's eventual demolition and its replacement with a parking lot, although the exact cost of damages remains unknown.

Another major event involved sinkholes along Bushkill Creek in 2000, resulting in the closure of a bridge connecting Tatamy Borough and Stockertown Borough. During repair efforts, another large sinkhole emerged near a residence south and west of the bridge, causing a section of the creek bank to collapse and extending the damage to the initial sinkhole repair site.

Many sinkholes have occurred on the property of George Wolf Elementary School in Bath borough between 2002 and 2019.

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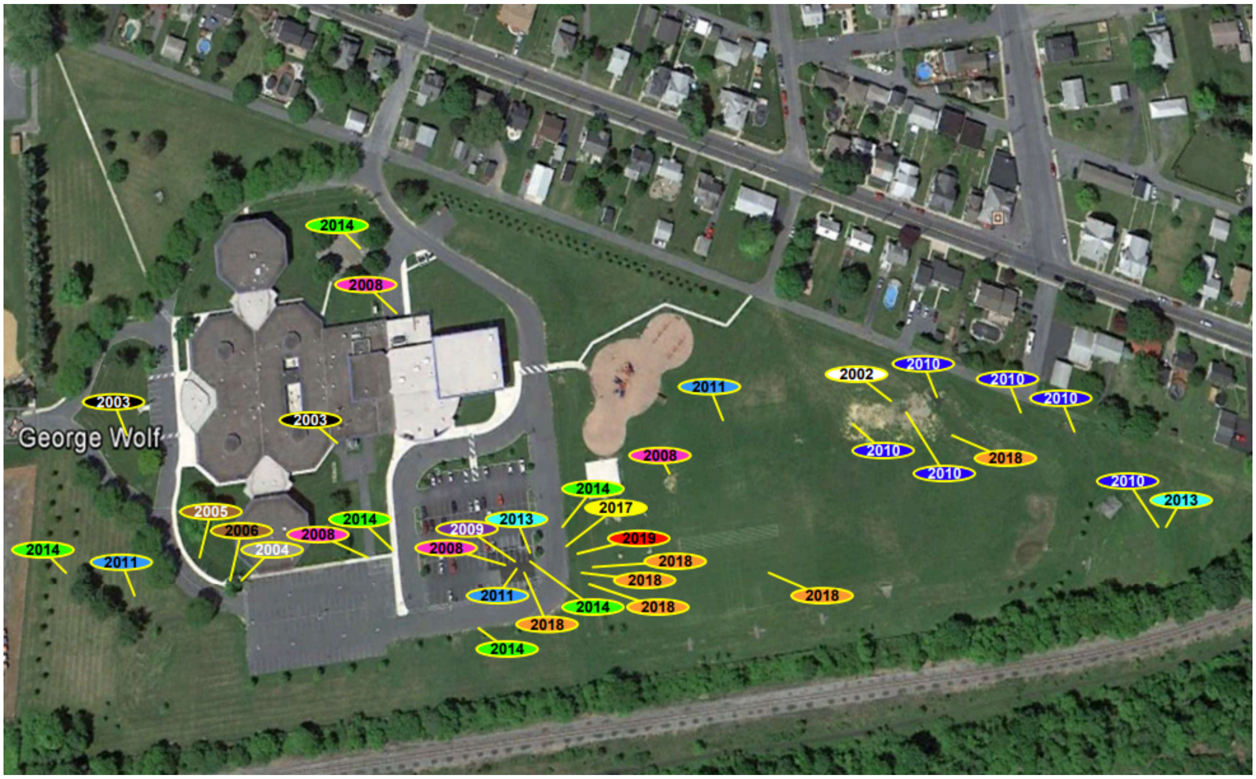
[144] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Figure 24 – Sinkholes at George Wolf Elementary School



The costliest sinkhole event to date occurred in January 2004. A sinkhole inflicted structural damage on the northbound Route 33 Bridge over Bushkill Creek. The Pennsylvania Department of Transportation had to close and eventually demolish and replace both the northbound and southbound bridges, incurring a total cost of about $6 million. This incident led to an official disaster declaration by the Governor of Pennsylvania.

4.3.11.4. Future Occurrence

Sinkholes regularly occur in the Lehigh Valley, particularly in its carbonate-rich regions. With ongoing development in these areas, the likelihood of sinkhole events is expected to rise. From the perspective of the Emergency Management Agencies of Lehigh and Northampton Counties, the likelihood of subsidence and sinkhole incidents in the Lehigh Valley is categorized as 'likely,' in accordance with the definition provided in the Methodology Section.

4.3.11.5. Vulnerability Assessment

The Lehigh Valley's susceptibility to subsidence and sinkholes remains a constant concern. Municipal guidelines for construction in high-risk areas play a crucial role in mitigating this hazard. Communities can lessen their vulnerability through various measures, including land use regulations, insurance programs, designs resistant to subsidence, and, in cases of mine-related subsidence, selective support or mine filling.

Private property sinkholes typically fall under the responsibility of the property owner for repairs. Homeowners' insurance often excludes sinkhole damage, but since 1987, Pennsylvania offers specific sinkhole insurance to alleviate financial burdens on homeowners.

Strategic planning is the most cost-effective and efficient approach to reducing subsidence risks. Municipalities can decrease sinkhole occurrences by properly maintaining and updating water utility lines and implementing zoning laws to control development in areas with high karst activity. The Surface Mining Control and Reclamation Act of 1977 mandates land use controls for active mines, requiring assessments for potential subsidence and plans for prevention or mitigation if necessary.

The Pennsylvania 2023 State Hazard Mitigation Plan outlines a methodology for evaluating each county's relative vulnerability to subsidence or sinkholes, focusing on census blocks in areas with or prone to karst formation. These blocks, considered at moderate to high risk, are evaluated based on population, building counts, and values at the county level.

Table 55: Vulnerability of People and Buildings to Subsidence or Sinkhole Development

County	Vulnerable Population	Vulnerable Buildings	Exposed Building Value[145]	% of Total Building Value
Lehigh	289,887	94,197	$58,131,128	77%
Northampton	226,131	76,063	$43,460,895	74%

In Lehigh County, carbonate bedrock underlies significant portions, affecting 19 of 25 municipalities. Northampton County shows a similar pattern, with 29 of its 38 municipalities situated on carbonate bedrock. The proportion of carbonate area in these municipalities is directly correlated with their sinkhole formation risk.

Population exposure to this hazard is calculated using 2010 Census data, overlaying the hazard area to estimate the number of people at risk. In the Lehigh Valley, approximately 478,958 individuals are potentially exposed to sinkhole hazards.

Evacuations due to these geological events are usually localized and small-scale, affecting residences and businesses in the immediate vicinity of the sinkhole. The severity of an event can range from temporary displacement to complete destruction of homes.

The built environment in carbonate areas is inherently vulnerable. Subsidence and sinkholes pose significant threats to infrastructure, including major roadways and bridges in the Lehigh Valley. The

[145] In Thousands of Dollars

economic impact of potential future subsidence or sinkhole events cannot be precisely estimated at this time.

4.3.12 *Wildfire*

4.3.12.1. Location and Extent

Wildfire is an uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures. Open fields, grass, dense brush, and forest-covered areas are typical sites for wildfire events. Wildfires often begin unnoticed and can spread quickly, creating dense smoke that can be seen for miles. A wildland fire is a wildfire in an area in which development is essentially nonexistent, except for roads, railroads, power lines and similar facilities. A wildland- urban interface (WUI) fire is a wildfire in a geographical area where structures and other human development meet or intermingle with wildland.

Wildfires can occur at any time of the year but are most likely in the Lehigh Valley during a drought, and can occur in forests, fields, grass and brush. Under dry conditions or drought, croplands may also be prone to wildfires. Any small fire in a wooded area, if not quickly detected and suppressed, has the potential to grow out of control. About 98% of wildfires in Pennsylvania are caused by human carelessness, negligence and ignorance. However, some are caused by lightning strikes, and in rare instances, spontaneous combustion.[146]

The greatest potential for wildfires is in March, April and May, and to a lesser extent October and November. In the spring, bare trees allow sunlight to reach the forest floor, drying fallen leaves and other ground debris. In the fall, dried leaves are also fuel for fires.

According to 2011-land use and land cover data, which is the most recent available, nearly 30% of the land in the Lehigh Valley is developed, nearly 40% is farmland and 30% is forested as shown below.

Urban areas are located adjacent to forests and farmlands. Both vegetation and structures serve as fuel for wildfire events.[147]

Table 56: Land Use Categories in the Lehigh Valley

Land Use Category	Total Area (Square Miles)	Percent of Total
Barren (Quarry)	1.8	0.2
Developed	202.4	27.9
Farmland	288.2	39.7

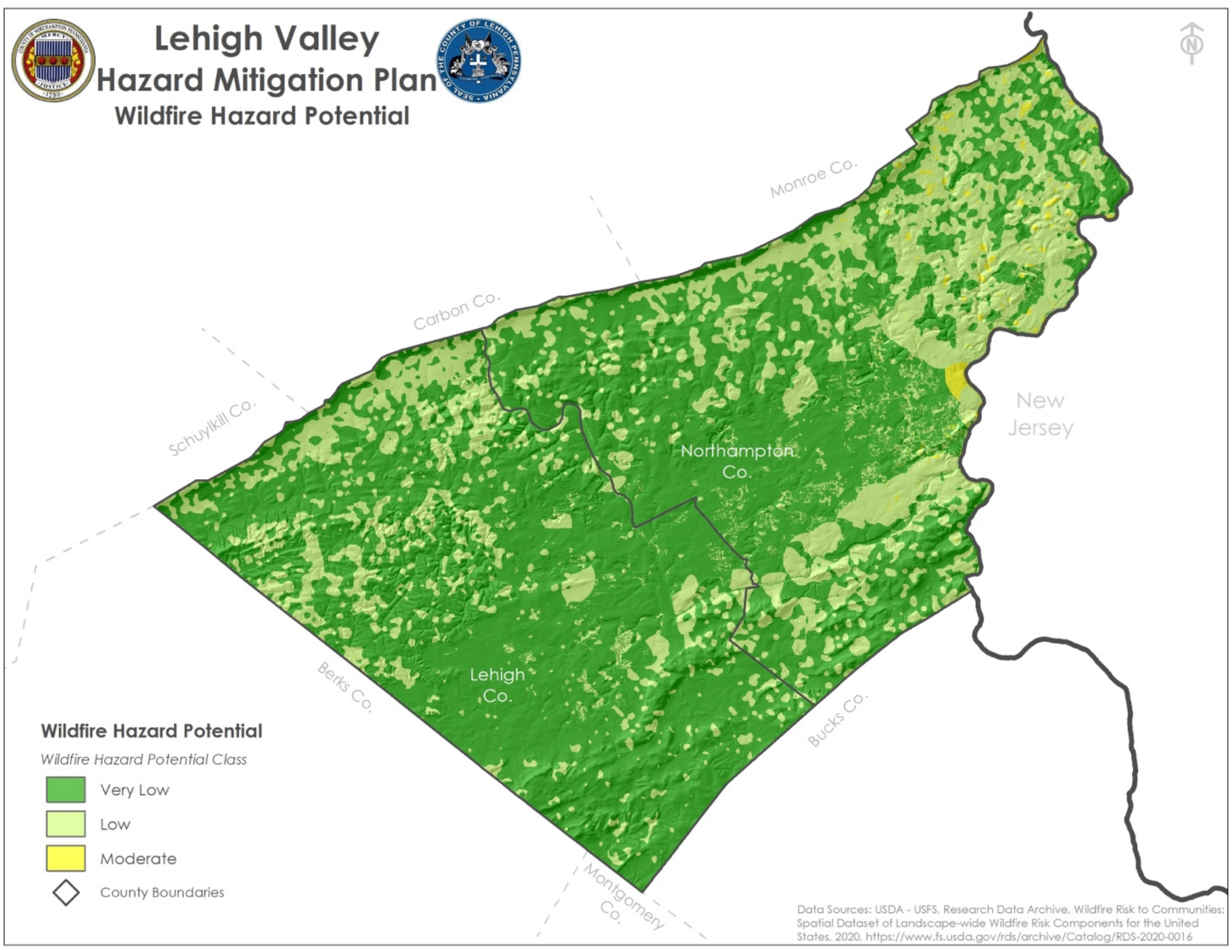
[146] Pennsylvania Bureau of Forestry. “2022 Annual Report Wildland Fire Program.” elibrary.dcnr.pa.gov, 2022. https://elibrary.dcnr.pa.gov/PDFProvider.ashx?action=PDFStream&docID=4156241&chksum=&revision=1&docName=2021+PA+PAS+Wildland+Fire+Program+Annual+Report&nativeExt=pdf&PromptToSave=False&Size=735660&ViewerMode=2&overlay=0.

[147] U.S. Department of Agriculture and U.S. Forest Service. “Influence of Forest Structure on Wildfire Behavior and the Severity of Its Effects,” May 2003. https://www.fs.usda.gov/projects-policies/hfi/docs/forest_structure_wildfire.pdf.

Land Use Category	Total Area (Square Miles)	Percent of Total
Forested	217.6	30.0
Water	6.8	0.9
Wetlands	8.7	1.2
TOTAL	**725.5**	**100**

The WUI is considered the area where houses and wildland vegetation coincide. According to the Spatial Analysis for Conservation and Sustainability (SILVIS) Lab, Department of Forest Ecology and Management, University of Wisconsin-Madison, the WUI is divided into two categories: intermix and interface. Intermix WUI areas are where housing and vegetation "intermingle." Intermix areas have more than one house per 40 acres and have more than 50% vegetation. Interface WUI areas contain housing in the vicinity of contiguous wildland vegetation.

Figure 25: Wildfire Hazard Potential in the Lehigh Valley



Interface areas have more than one house per 40 acres, have less than 50% vegetation, and are within 1.5 miles of an area larger than 1,235 acres that is more than 75% vegetated.[148]

The California Fire Alliance determined that areas within 1.5 miles of wildland vegetation are the approximate distance that firebrands can be carried from a wildland fire to the roof of a house. Therefore, even structures not located within the forest are at risk from wildfire. This buffer distance, along with housing density and vegetation type, was used to define the WUI in the Lehigh Valley. Across the Lehigh Valley, approximately 31% is classified as WUI. A majority of the Lehigh Valley is located in the WUI intermix areas. There are bands of the WUI interface along the northern and southern borders of the counties.

Most high priority areas are found along the northern tier of the Lehigh Valley, along the Blue Mountain, bordering Schuylkill, Carbon and Monroe counties. In addition, large high priority areas are found in Alburtis Borough, Emmaus Borough, Fountain Hill Borough, Macungie Borough, Salisbury Township and Upper Milford Township. Please note that other high priority areas are also found scattered throughout the Lehigh Valley. These areas have favorable fuels, intermixed areas of vegetation and development, and are "hotspots" of past wildland fire occurrences.

Areas that have been categorized as 'medium' priority areas exhibit favorable fuels, but do not have a history of wildland fire occurrence or do not have intermixed areas of vegetation and development. In the Lehigh Valley, the medium priority areas tend to be concentrated along the northern and southern tier. The low priority areas, located in the central portion of the Lehigh Valley, have unfavorable fuels, a lack of wildland fire occurrence, and less agriculture or other non-forest land uses.

4.3.12.2. Range of Magnitude

Wildfires in the Lehigh Valley present a spectrum of challenges, ranging from manageable small-scale blazes to extensive infernos engulfing vast tracts of land. While minor fires are often within the capabilities of local fire departments, major wildfires may necessitate evacuation of communities and demand support from regional or national firefighting units. The consequences of a major wildfire can be catastrophic, affecting both natural environments and human settlements.

The safety of firefighters is paramount, and while fatalities among them are rare in Pennsylvania, the risk is ever-present. Common injuries include falls, sprains, abrasions, and heat-related issues like

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[148] Radeloff, Volker C., David P. Helmers, H. Anu Kramer, Miranda H. Mockrin, Patricia M. Alexandre, Avi Bar-Massada, Van Butsic, et al. "Rapid Growth of the US Wildland-Urban Interface Raises Wildfire Risk." *Proceedings of the National Academy of Sciences* 115, no. 13 (March 27, 2018): 3314–19. https://doi.org/10.1073/pnas.1718850115.

dehydration. Responding to wildfires also increases the risk of vehicular accidents and often requires emergency responders to operate in remote areas, away from their primary service communities.[149]

Wildfires, whether naturally occurring or human-induced, pose significant threats to life, property, and the environment. They can result in the loss of human and animal lives, destruction of property, and damage to ecosystems. Wildfires often lead to severe erosion, silting of water bodies, and increased flood risks due to the loss of ground cover. However, they also play a role in ecological balance by clearing dead vegetation, opening space for new growth, and stimulating the regeneration of certain plant species.

Historically, the Lehigh Valley has experienced mostly small and containable wildfires. Since 2000, incidents have ranged from minor brushfires to fires covering up to 100 acres. A major concern is a large-scale wildfire during a drought, which could spread rapidly, especially in areas where wildland meets urban development, posing a significant threat to properties.

Furthermore, large wildfires can set the stage for secondary natural disasters like floods and mudslides. They alter the landscape and reduce the ground's ability to absorb rainwater, leading to increased runoff, flash flooding, and mudflows. The risk of flooding in these areas remains elevated for years post-wildfire, until vegetation regenerates, a process that can take up to five years.[150]

The Fire Regime Group map of the Lehigh Valley serves as a crucial tool in understanding the region's wildfire patterns and management strategies. This detailed map categorizes the valley into different fire regime groups, each characterized by specific fire frequencies and severities that naturally occur in those areas. The visual representation helps in identifying zones with varying fire behaviors, ranging from frequent, low-intensity fires to less frequent but high-intensity fires. This classification is vital for effective fire management, as it guides local authorities in tailoring their prevention and mitigation strategies to the unique ecological and topographical features of each area. By providing a clear overview of the diverse fire regimes across the Lehigh Valley, the map is an indispensable resource for ecologists, land managers, and emergency services in planning and executing region-specific fire management policies.

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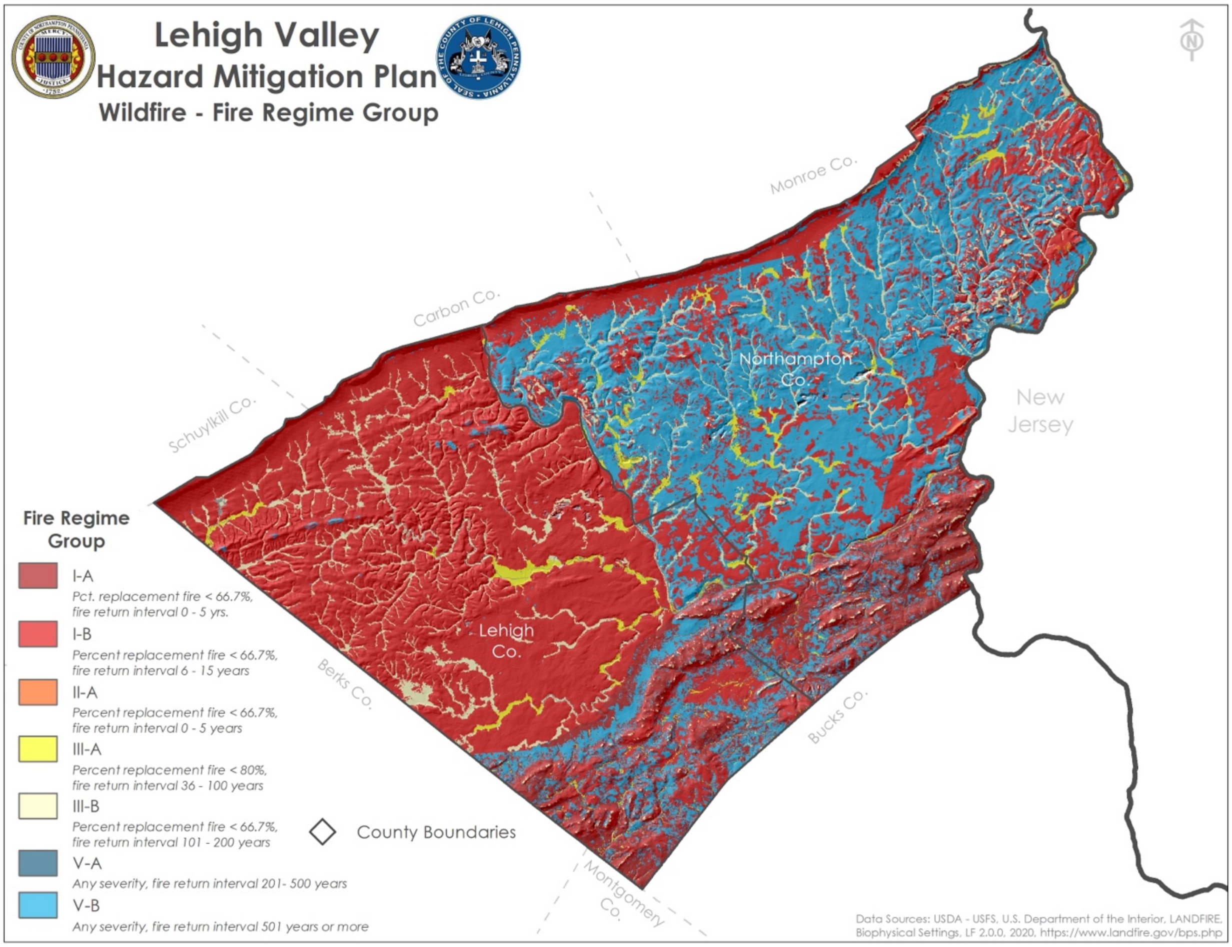
[149] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[150] Federal Emergency Management Agency. "FEMA Fact Sheet Flood After Fire." fema.gov, December 16, 2020. https://www.fema.gov/sites/default/files/documents/fema_flood-after-fire_factsheet_nov20.pdf.

Figure 26: Fire Regime Group Map of the Lehigh Valley



4.3.12.3. Past Occurrence

The Pennsylvania 2023 State Hazard Mitigation Plan notes reported wildfires and acres burned in the Lehigh Valley between 1992 and 2015. 122 wildfires in Lehigh County burned over 313 acres, while 87 wildfires in Northampton County burned more than 168 acres.[151] Wildfire events that were recorded in the National Centers for Environmental Information (NCEI) Storm Events are shown in Table 57 below, with one death reported. In addition, Lehigh and Northampton County Knowledge Center databases identified 67 brushfires from 2012 to 2017. Information regarding damages, injuries or deaths was not available.

[151] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Table 57: Historical Occurrences of Wildfires in the Lehigh Valley

Date	County	Location	Acres Burned	Deaths	Injuries	Property Damage ($)
3/26/2012	Northampton	Lower Nazareth Township	Unknown	0	0	0
4/9/2012	Northampton	Upper Mount Bethel	7	0	0	0
11/24/2013	Lehigh	South Whitehall Township	Unknown	0	0	0
11/24/2013	Northampton	Forks Township	Unknown	0	0	0
4/6/2015	Lehigh	Washington Township	27	0	0	0
4/6/2015	Northampton	Lower Saucon Township	2	1	0	$1,000
4/18/2015	Lehigh	Blue Mountain	300	0	0	0
4/18/2015	Northampton	Unknown	5	0	0	0
6/15/2017	Northampton	Lehigh Township	10	0	0	0

4.3.12.4. Future Occurrence

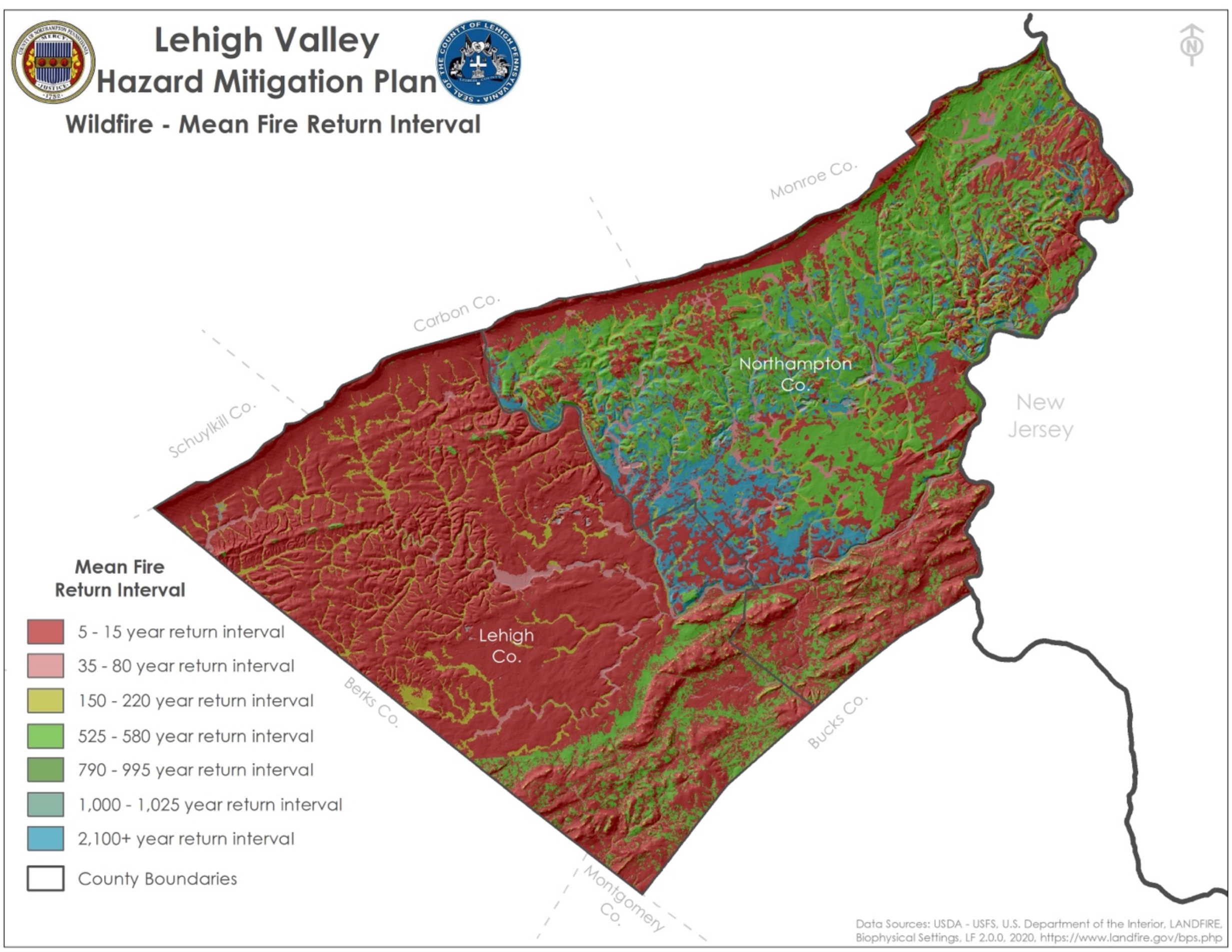
Predicting the frequency of wildfires in the Lehigh Valley is a complex task, influenced by a myriad of fluctuating factors. The likelihood of fire occurrences is affected by a range of variables, including development patterns, geographical location, available fuel sources, and the presence of construction activities, particularly in the Wildland-Urban Interface (WUI) zone. These factors create a dynamic and challenging environment for fire prediction and management.

The potential for a fire to escalate in size and intensity hinges on several environmental conditions, including the rapidity and effectiveness of firefighting efforts. Periods of drought, for instance, create drier conditions that significantly elevate the risk of wildfires. Moreover, the presence of invasive forest insects exacerbates this risk. These insects, by attacking and killing trees, inadvertently increase the amount of combustible material in the forest, thereby fueling potential wildfires.

The accompanying map, illustrating the Mean Fire Return Interval in the Lehigh Valley, serves as a valuable tool for understanding and visualizing wildfire patterns in the region. The map uses a color-coded system, where warmer tones indicate areas with shorter fire return intervals, suggesting a higher frequency of fires, and cooler tones depict longer intervals, implying less frequent fire occurrences. This visualization helps identify critical zones where fire management and preventive measures are most urgently required.

Additionally, the map integrates various data layers, including types of vegetation, human settlements, and natural barriers, offering a holistic view of the factors that influence fire frequencies. This comprehensive approach aids stakeholders, such as environmental managers and policy makers, in making informed decisions. By studying this map, they can strategically direct resources towards fire prevention and control efforts, thereby enhancing the safety of the Lehigh Valley's natural and residential communities.

Figure 27: Wildfire Mean Fire Return Interval



Based on the Lehigh and Northampton County Emergency Management Agencies operational viewpoint, the probability of occurrence for wildfire events in the Lehigh Valley is considered 'possible' as defined in the Methodology Section.

4.3.12.5. Vulnerability Assessment

Wildfires, often driven by a combination of dry conditions, high winds, and sometimes human activities, can have a profound impact on various community lifelines. These events can pose significant challenges, especially in vulnerable areas like the Lehigh Valley. The primary community lifelines likely to be affected by wildfires are shown in the table below.

Table 58: Potential Vulnerabilities of Lifelines to Wildfire

Lifelines	Impact Type	Description
Safety & Security		Wildfires pose immediate threats to life and property, requiring significant emergency response efforts. Evacuations, rescue operations, and law enforcement to maintain order and prevent looting in evacuated areas are critical.
Health & Medical		Smoke and air quality issues from wildfires can lead to respiratory problems and exacerbate chronic health conditions. There's also a risk of burns and other injuries directly caused by fires. Healthcare facilities must be prepared for an influx of patients and potential relocation if in the path of a fire.
Housing & Building Infrastructure		Wildfires can destroy homes and buildings, leading to displacement and the need for temporary housing. The rebuilding process can be extensive and resource-intensive.

Wildfires in the Lehigh Valley pose a range of significant challenges and potential losses, with the foremost concern being the health and safety of residents and emergency responders. Vulnerable populations, including those living in close proximity to the interface between urban development and wildland areas, are particularly at risk. In the event of a wildfire evacuation order, it becomes imperative to ensure that residents receive adequate shelter and necessary medical care. While evacuations are typically temporary, a seamless transition back to the Lehigh Valley is essential once safety is restored.

Moreover, wildfires can exert substantial economic repercussions on the community. Initial structural losses and subsequent reductions in revenue from impacted businesses, along with declines in tourism, can be devastating. The effects extend to infrastructure, including vital roadways such as Interstates I-78 and I-476, which traverse wildland-urban interface (WUI) areas. These considerations are pivotal for planning evacuation routes effectively.

Structures within the WUI are particularly susceptible to wildfire events, with wooden or vinyl siding constructions being more prone to fire hazards compared to brick or concrete buildings. A thorough analysis reveals municipalities in Lehigh County, such as Alburtis, Coopersburg, Macungie, and Slatington boroughs, with over 90% of their general building stock exposed to this hazard. Similarly, in Northampton County, Hellertown, Pen Argyl, Roseto, Walnutport, and Wind Gap boroughs face a high level of vulnerability in terms of building stock.

Furthermore, it's important to acknowledge that critical facilities are often situated within wildfire-prone areas, adding another layer of vulnerability. Many of these facilities house vulnerable populations, such as schools and senior facilities, as well as the first responders responsible for managing wildfire events, including fire and police facilities. Comprehensive planning and preparedness are essential to safeguard both lives and infrastructure in the face of potential wildfire threats in the Lehigh Valley.

4.3.13 *Windstorm / Tornado*

4.3.13.1. Location and Extent

Straight-line winds, a meteorological phenomenon, are characterized by air moving from high-pressure to low-pressure areas, with the wind's intensity directly proportional to the pressure difference. These winds, when reaching sustained speeds of 40 mph or more for at least an hour, or gusts of 58 mph or more regardless of duration, are classified as windstorms. Known for their widespread impact, straight-line winds are distinct from tornadoes in both their formation and the nature of damage they cause.

In contrast, tornadoes are among the most violent of nature's storms, notorious for causing fatalities and extensive damage in a matter of seconds. These violent, rotating funnel-shaped clouds emerge from thunderstorms, making land contact with wind speeds that can exceed 250 mph. Tornadoes often have a wide path of destruction, over a mile wide and up to 50 miles long. They typically form during severe thunderstorms or hurricanes when cool air rapidly overtakes a layer of warm air. These intense storms can travel at speeds between 30 and 125 mph and produce internal winds surpassing 300 mph. However, a tornado's lifespan is generally short, seldom exceeding 30 minutes.

In the Lehigh Valley, both tornadoes and windstorms are climatic realities. While tornadoes are more localized and result from specific meteorological conditions, they can still be a part of larger severe thunderstorm systems. These systems sometimes create environments conducive to multiple or long-lasting tornadoes. Tornadoes are more likely to occur during the late afternoon to early evening—the warmest part of the day—and are most common in the spring and early summer months, from March through June. This understanding is crucial for preparedness and response strategies in the region, ensuring that communities are equipped to handle both tornadoes and windstorms.

4.3.13.2. Range of Magnitude

The United States experiences more tornadoes than any other country, approximately 1,000 in a typical year.[152] While the extent of tornado damage is usually localized, extreme winds of this vortex can be among the most destructive on Earth when they move through populated, developed areas.

Windstorms and tornadoes can occur throughout the Lehigh Valley, though events are usually localized. The Lehigh Valley is also located within the Hurricane Susceptibility Region, which extends along the northeastern coastline of the United States.

The Enhanced Fujita Scale (EF-Scale), depicted in Figure 28, is a crucial tool for categorizing the intensity of tornadoes. Introduced in 2007 as an update to the original Fujita Scale, the EF-Scale provides a more

[152] Weather.com meteorologists. "Here's How Many Tornadoes Your State Sees In A Typical Year." The Weather Channel, April 4, 2023. https://weather.com/safety/tornado/news/2020-03-26-average-number-of-tornadoes-by-state-each-year-united-states.

refined assessment of tornado strength. It achieves this by assigning ratings based on estimated wind speeds and the corresponding extent of damage.

In assessing the impact of a tornado, experts conduct thorough damage surveys. These surveys involve a detailed comparison of the observed damage with a predefined set of Damage Indicators (DI) and Degrees of Damage (DOD). This methodology allows for a more accurate estimation of the wind speeds generated by the tornado. Based on these evaluations, a tornado is assigned a rating on the EF-Scale, which ranges from EF0 to EF5. Each category on the scale signifies an escalating level of destruction.

The transition to the EF-Scale from the original F-Scale was driven by the need for a more accurate and realistic assessment of tornado damage. This revised scale takes into account the latest understanding of tornado impacts and aligns more closely with the design and construction standards of modern structures. The EF-Scale, therefore, serves as a more precise gauge of tornado severity, aiding in better understanding the potential impacts and guiding effective response strategies.

Figure 28: Enhanced Fujita Scale

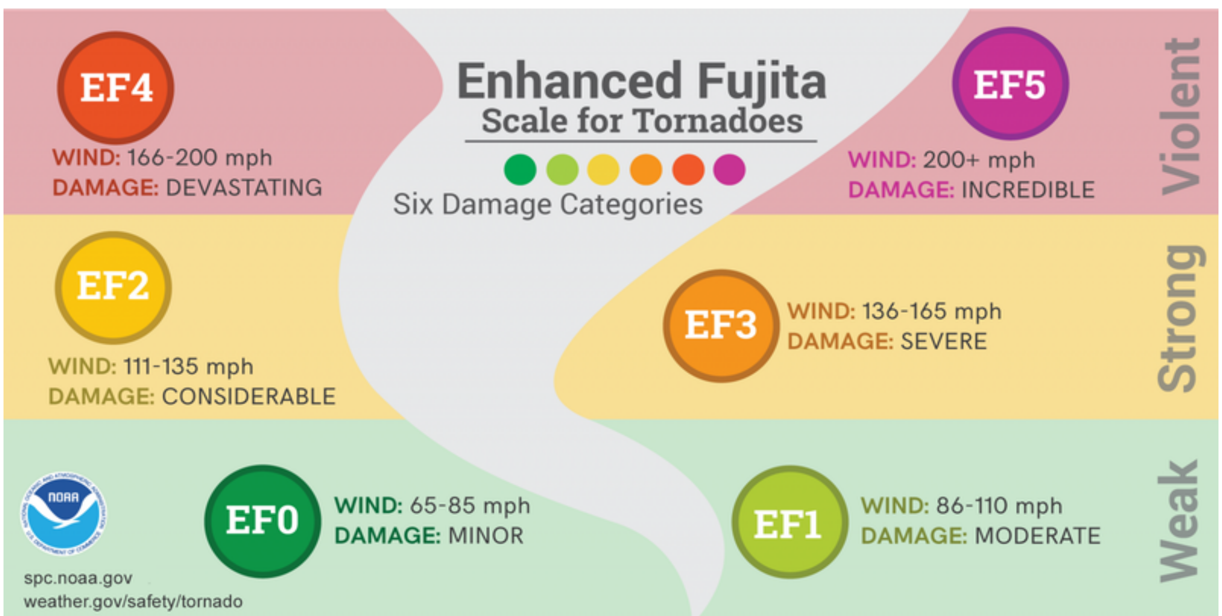


Table 59: Enhance Fujita Scale and Damage Description

EF - Scale Number	F - Scale Number	Wind Speed (mph)	Type of Damage Done
EF0	F0-F1	65-85	Light damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.

EF - Scale Number	F - Scale Number	Wind Speed (mph)	Type of Damage Done
EF1	F1	86-110	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	F1-F2	111-135	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground
EF3	F2-F3	136-165	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	F3	166-200	Devastating damage. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	F3-F5	>200	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 yards; high-rise buildings have significant structural deformation

4.3.13.3. Past Occurrence

Data from the NCEI Storm Events Database reveals a notable increase in tornado occurrences over recent decades. Comparing two periods, from 1950 to 1995, a span of 46 years, there were 493 tornadoes recorded. In contrast, a shorter period from 1996 to 2021, lasting only 26 years, saw a similar number of tornadoes at 497. This trend appears to be more pronounced regionally and might partly be attributed to advancements in reporting techniques. According to a 2018 report by the National Weather Service, part of NOAA, the overall frequency of tornadoes across the United States has been relatively steady since 1950, suggesting that the observed increase could be linked to more sophisticated and thorough reporting methods.[153]

The year 2021 stood out in recent tornado activity, recording the highest number since 1998. Two different sources, the SPC and NCEI, reported 44 and 50 tornadoes, respectively, in 2021. This year was marked by several significant tornado events, including the first EF-3 tornado in the state since 2004, which occurred in the Philadelphia suburbs. Additionally, Hurricane Ida was responsible for spawning several tornadoes in the southeast, resulting in one fatality. Another notable incident was an EF-2 tornado in late October that caused considerable damage in Buffalo Township. This event was part of a larger outbreak that included 18 tornadoes across eastern Ohio and western Pennsylvania, highlighting a year of particularly high tornado activity in the region.

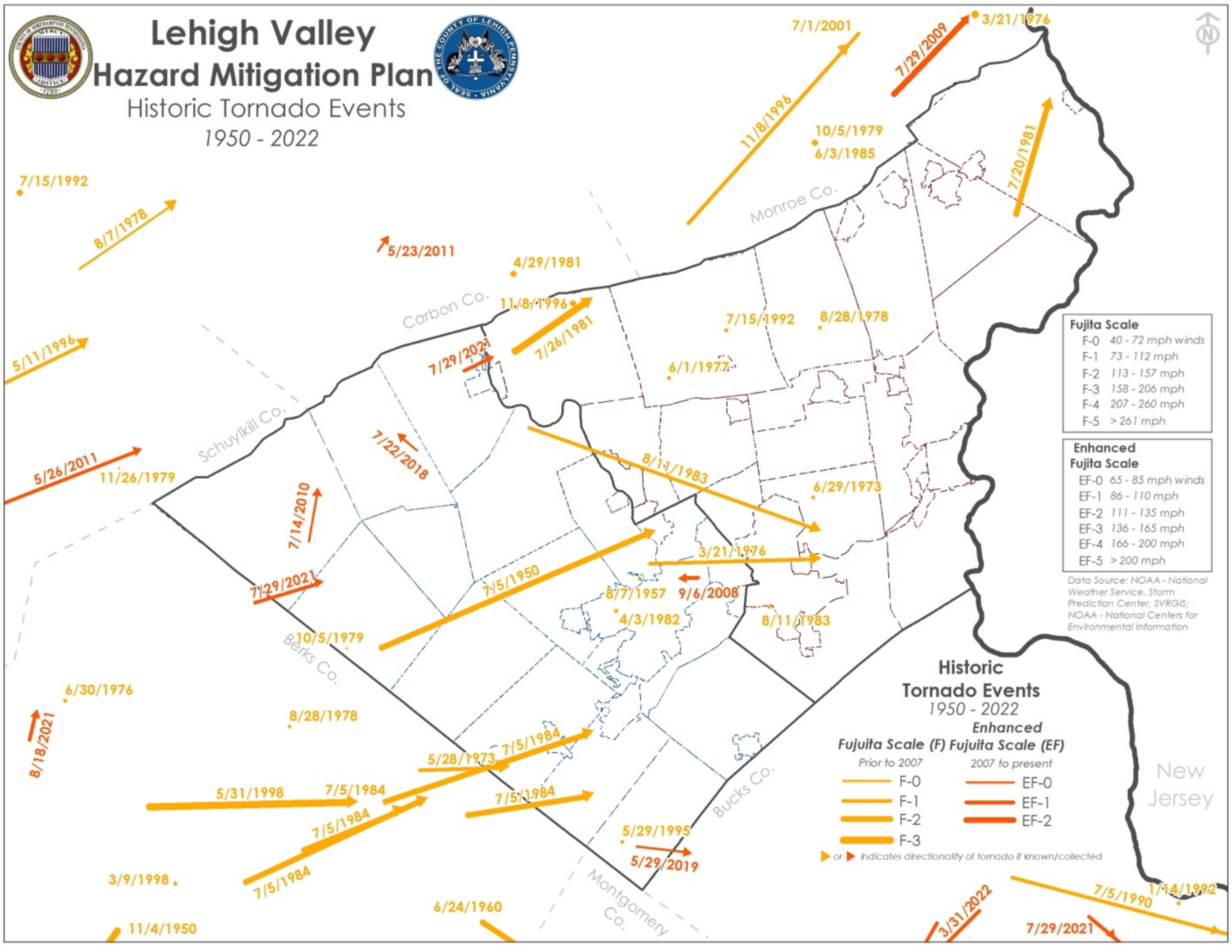
Past occurrences and losses associated with historic tornado events prior to February 2007 are based on the former Fujita Scale. Events after February 2007 are based on the Enhanced Fujita Scale.

According to the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Events Database, between 1950 and 2023, Lehigh County had 12 tornadic events and 491 windstorm events; Northampton County experienced 12 tornadic events and 498 windstorm events. These events include funnel clouds, high winds, strong winds, thunderstorm winds. Total property damages, because of these windstorm and tornado events, were estimated at $38.957 million in Lehigh County and $33.098 million in Northampton County. The intensity of these tornadic events ranged from F0 to F3.

The most severe tornado to hit Lehigh County since 2006 was an EF1 that touched down in east Allentown in 2008. This was the only confirmed tornado in the United States associated with Tropical Storm Hanna, producing widespread damages exceeding $1.5 million, but no deaths or injuries. Of the 12 tornadoes recorded in Northampton County, three were categorized as F0, six as F1, two as F2, and one was categorized as an F3.

[153] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," pg. 420. October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Figure 29: Map of Tornado Events in the Lehigh Valley 1950-2022



The most recent recorded tornado in the Lehigh Valley occurred on August 7, 2023, in Allentown, when an unexpected and brief tornado struck the Midway Manor neighborhood, bordering Bethlehem, without a specific tornado warning. The National Weather Service reported that due to the tornado's swift formation and short duration, from 7:21 to 7:23 p.m., there was no time to issue a specific warning. However, the area was under a severe thunderstorm warning, and a tornado watch had been issued earlier, signaling favorable conditions for a tornado.

Sarah Johnson, a meteorologist with the National Weather Service, emphasized the importance of treating severe thunderstorm warnings with the same urgency as tornado warnings, as they can be equally damaging. The service plans to review the event to improve warning lead times.

The tornado, confirmed by the weather service after surveying the damage, was the second in the Lehigh Valley in 2023 and at least the 33rd since 1950. With peak wind speeds estimated at 100 mph, it was categorized as an EF1 tornado on the Enhanced Fujita Scale. Its path was 0.30 miles long and 160 yards wide, extending into Bethlehem.

The tornado's trail began near East Pennsylvania Street, causing significant damage, including a church roof, a shed, and uprooted trees. It intensified near Club Avenue, resulting in substantial damage to homes, with some losing 30-50% of their roof covering. The tornado eventually weakened and dissipated near Pennsylvania Avenue, fortunately without causing any injuries or fatalities.

Since 2012, there have been 8 high wind events, 233 thunderstorm winds events, and five tornadic events reported within the Lehigh Valley. No property damage has been reported since the 2018 Plan. No deaths were reported from any of these events; however, one injury was reported.

Table 60: Annualized Loss Estimates from Windstorm & Tornadic Events in the Lehigh Valley

County	Property Damage
Lehigh County (NCEI)	$599,338
Northampton County (NCEI)	$509,200
Lehigh Valley Total (NCEI)	**$1,108,538**

4.3.13.4. Future Occurrence

The Lehigh Valley is no stranger to the ravages of strong winds, which not infrequently wreak havoc through significant property damage, uprooting trees, and causing widespread utility disruptions. Looking ahead, it's reasonable to anticipate that future tornadoes will mirror the patterns and impacts of those previously experienced in this region. Annually, the Lehigh Valley is expected to confront both direct and indirect consequences of windstorms and tornadoes. These events are likely to trigger a cascade of secondary hazards, including the deterioration or failure of infrastructure, interruptions in utility services, power outages, and challenges related to water quality and supply. Furthermore, they may lead to transportation-related issues, including delays, accidents, and general inconveniences.

Data from the National Weather Service indicates that Pennsylvania averages around 10 tornadoes per year, resulting in approximately two fatalities. While the likelihood of a tornado strike may be low, the potential for catastrophic damage is high. An F4 tornado, with wind speeds reaching up to 200 mph, can exert a wind load exceeding 100 pounds per square foot, overwhelming the structural integrity of most buildings.

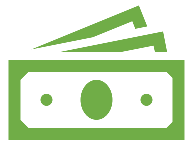
From the perspective of the Lehigh and Northampton County Emergency Management Agencies, the probability of windstorm and tornado events occurring in the Lehigh Valley is categorized as 'possible,' as outlined in the Methodology Section. This classification underscores the need for continued vigilance and preparedness in the face of these natural phenomena.

4.3.13.5. Vulnerability Assessment

Tornadoes, characterized by their intense and destructive wind patterns, can severely impact community lifelines, especially in tornado-prone areas like the Lehigh Valley. The following community lifelines are particularly vulnerable to the effects of tornadoes as shown in the table below.

Table 61: Potential Vulnerabilities of Lifelines to Tornadic Events

Lifelines	Impact Type	Description
Safety & Security		Immediate threats to life and property necessitate rapid emergency response, including search and rescue operations, medical assistance, and maintaining public order to prevent looting or other crimes in affected areas.
Health & Medical		Tornadoes can cause injuries ranging from minor to severe, placing a sudden demand on healthcare facilities. Hospitals and clinics must be prepared for an influx of patients and possible damages to their own infrastructure.
Housing & Building Infrastructure		Tornadoes can cause significant damage to homes, businesses, and public buildings, leading to displacement of residents and the need for temporary shelters and long-term rebuilding efforts.
Utilities		Tornadoes can disrupt essential services by damaging power lines, water mains, and communication networks. Restoring these services is crucial for recovery and supporting other lifeline sectors.
Transportation		Damage to roads, bridges, and transportation infrastructure can hinder emergency response efforts and the movement of goods and people. Clearing debris and repairing infrastructure are critical post-tornado activities.

Lifelines	Impact Type	Description
Economic Stability		The economic impacts of tornadoes include the costs of emergency response, rebuilding, and the broader effects of property destruction and business interruptions. Insurance claims and financial assistance play significant roles in economic recovery.

The overall susceptibility of the Lehigh Valley to wind and tornado hazards remains consistent with the findings of the 2018 Plan, indicating that all areas within the region continue to face vulnerability. The latest 2023 update to the Pennsylvania State Hazard Mitigation Plan included a detailed assessment of each county's relative risk to tornadoes. This evaluation specifically pinpointed census tracts that either experienced a minimum of three tornado events from 1986 to 2019 or witnessed over 200 strong wind events between 1986 and 2017. Following this identification, a comprehensive analysis was conducted, aggregating data on population, the number of buildings, and the overall value of buildings in these at-risk census tracts at the county level. The results of this aggregation, providing a clearer picture of the potential impact at the county scale, are presented below.

Table 62: Estimated Jurisdictional Losses due to Tornadoes & Windstorms[154]

County	Vulnerable Population	Vulnerable Buildings	Exposed Building Value[155]	% of Total Building Value
Lehigh	300,360	98,712	$54,201,431	72%
Northampton	166,030	56,438	$31,208,481	53%

[154] Pennsylvania Emergency Management Agency and Michael Baker International. “Pennsylvania 2023 Standard State All-Hazard Mitigation Plan,” pg. 425. October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[155] In Thousands of Dollars

4.3.14 *Winter Storm*

4.3.14.1. Location and Extent

Winter storms consist of cold temperatures, heavy snow or ice and sometimes strong winds. Annually, Pennsylvania faces a series of winter storms that have a widespread impact across the state. This includes all counties within the Commonwealth, with the Lehigh Valley being no exception. As highlighted in the 2023 Pennsylvania Hazard Mitigation Plan, the Lehigh Valley generally experiences a significant snowfall each winter, with accumulations ranging from 21 to 50 inches. This data underscores the region's vulnerability to severe winter weather conditions and the importance of preparedness for these events.

4.3.14.2. Range of Magnitude

The intensity of a winter storm is influenced by a multitude of factors, such as the propensity of a region to experience snowstorms, the amount and intensity of snowfall, wind velocities, temperature levels, visibility conditions, the duration of the storm, the area's topography, and the specific timing of the storm within the day and season. These storms, often marked by freezing temperatures, significant snow or ice accumulation, and occasionally strong winds, are typically generated by low-pressure systems moving across Pennsylvania, frequently in alignment with the jet stream's trajectory. The regular occurrence of these storms turns them into hazards when they cause infrastructural damage, disrupt transportation and utilities, impede business activities, or lead to adverse outcomes like fatalities, frostbite, or extreme cold conditions. The impact of these storms can be particularly severe, leading to closures of secondary roads, especially in rural regions, loss of utility services, and increased demand for heating fuel. Winter storms can be classified into various types, each with distinct characteristics and impacts:

- Heavy Snow: According to the National Weather Service (NWS), heavy snow is generally snowfall accumulating to four inches or more within 12 hours, or snowfall accumulating to six inches or more in 24 hours or less.
- Blizzard: Blizzards have sustained wind or frequent gusts to 35 miles per hour (mph) or greater and falling or blowing snow that reduces visibility to a quarter-mile or less for three or more hours.[156] A severe blizzard is defined as having a wind velocity of 45 mph, temperatures of 10°F or lower, a high density of blowing snow with visibility frequently measured in feet over an extended period.
- Sleet or Freezing Rain: Sleet is defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes. These pellets of ice usually bounce after hitting the ground or other hard surfaces. Heavy sleet is a relatively rare event, defined as ice

[156] National Oceanic and Atmospheric Administration and National Weather Service. "Glossary - NOAA's National Weather Service." w1.weather.gov, 2023. https://w1.weather.gov/glossary/index.php?word=blizzard.

pellets covering the ground to a depth of a one- half inch or more. Freezing rain falls as a liquid, but freezes into glaze upon contact with the ground.

- Ice storm: An ice storm is used to describe damaging accumulations of ice during freezing rain situations. Significant accumulations of ice pull down trees and utility lines resulting in loss of power and communication. These accumulations of ice make walking and driving extremely dangerous. Significant ice accumulations are usually a quarter-inch or greater.
- Nor' Easter: A Nor'easter is a storm along the East Coast of North America, so called because the winds over the coastal area are typically from the northeast. These storms may occur at any time of year but are most frequent and most violent between September and April.

In 1996, the Lehigh Valley was struck by its most extreme winter event to date: the Blizzard of 1996. During January 7-8, the region witnessed a historic snowstorm, with the Lehigh Valley International Airport recording over two feet of snowfall, leading to a declared state of emergency. Compounding the situation, an additional 4-6 inches of snow fell on January 12. This severe weather event tragically resulted in the loss of three lives and caused several buildings to collapse under the heavy snow. The aftermath of the blizzard was marked by rapid snowmelt, which led to significant flooding and property damage, exceeding $42 million in the Lehigh Valley.

Beyond their impact on infrastructure and human safety, winter storms also pose environmental threats. They can inflict damage on shrubs and trees through heavy snowfall, ice accumulation, or strong winds, leading to broken branches or even uprooted trees. Additionally, common responses to winter storms, such as salting roads and other de-icing methods, can adversely affect surface and groundwater quality. On the brighter side, gradual thawing of snow and ice can contribute positively to replenishing groundwater reserves. However, a rapid temperature increase following substantial snowfall can result in swift runoff, heightening the risk of flooding.

4.3.14.3. Past Occurrence

Data from the National Oceanic and Atmospheric Administration and the National Centers for Environmental Information reveal that between 1993 and 2023, Lehigh County encountered 256 winter storm events, while Northampton County faced 257. These events led to property damages of approximately $3.8 million in Lehigh County and $2.25 million in Northampton County. A detailed account of winter storm events is provided in Table 63 below.

Furthermore, between 1954 and 2023, FEMA records indicate that Pennsylvania was issued seven winter storm-related disaster (DR) or emergency (EM) declarations. These declarations were associated with various inclement weather types, such as severe winter storms, snowstorms, blizzards, and heavy snowfall. Typically, these severe weather conditions affected a broad portion of the state and impacted multiple counties. Notably, out of these events, both Lehigh and Northampton counties were part of five of the official declarations.

Table 63: Winter Storm Events in the Lehigh Valley

Date	Event Type	FEMA Declaration?	Losses/Impacts (source: NOAA NCEI)
February 3, 2014	Heavy Snow	No	Snow fell across eastern Pennsylvania, with the greatest amounts falling in the Lehigh and Delaware Valleys. At LVIA, 9.3 inches of snow was recorded. LANTA suspended all commuter bus service. Tractor- trailers became stuck
February 12-14, 2014	Winter Storm	No	A major winter storm affected all eastern Pennsylvania with heavy snow and sleet. A state of emergency was in effect in Pennsylvania. Commuter bus service from the Lehigh Valley to New York City was cancelled. 19.2 inches
January 22-24, 2016	Winter Storm	Yes (DR-4267)	A major Nor'easter produced record snowfall in eastern Pennsylvania, with a 2-day total snowfall of 31.9 inches at the Lehigh Valley International Airport. The normal seasonal snowfall of 32.9 inches at the airport was almost exceeded by this one event. Pennsylvania Governor Tom Wolf declared a State of Emergency. Both Lehigh and Northampton counties were declared federal disaster areas. An Allentown man collapsed from a heart attack
March 14, 2017	Blizzard / Winter Storm	No	Heavy snow fell across the region in the morning with a mix of sleet and freezing rain later in the day. 13.7 inches of snow was recorded at LVIA. No injuries or damages
February 1, 2021	Winter Storm	No	Snow began in the county on January 31. It became heavy on February 1 as intense banding developed over the Lehigh Valley. Lighter snow continued into February 2 before the storm finally departed. By the end of the event, a report was received from Coopersburg of 31.0 inches of snow. Numerous other reports of 24 to 30 inches of snow were received in the major winter storm. The Lehigh Valley International Airport recorded a storm total of 27.3 inches of snow. A 67-year-old woman with Alzheimer's died of
March 12, 2022	Winter Storm	No	A complex weather system brought precipitation to the mid-Atlantic on March 12. Strengthening low pressure tracked from the Southeast US to just off the mid-Atlantic coast and began to rapidly intensify as it departed towards New England

4.3.14.4. Future Occurrence

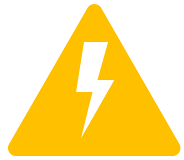
Historical winter storm events in the Lehigh Valley suggest that the region is likely to continue experiencing such events of varying intensities. The pattern of significant past occurrences indicates that many people and properties in the area remain at risk from potential future winter storms. Based on assessments by the Emergency Management Agencies of both Lehigh and Northampton counties, the probability of winter storm events occurring in the Lehigh Valley is classified as 'likely'. This assessment is further detailed in the Methodology Section.

4.3.14.5. Vulnerability Assessment

Winter storms, characterized by severe cold, snow, ice, and sometimes strong winds, can have a significant impact on community lifelines, particularly in regions like the Lehigh Valley that experience harsh winter conditions. The primary community lifelines likely to be affected by winter storms are shown in the table below.

Table 64: Potential Vulnerabilities of Lifelines to Winter Storms

Lifelines	Impact Type	Description
Safety & Security		The immediate threat to life due to extreme cold, icy conditions, and potential for accidents necessitates a robust emergency response, including rescue operations and law enforcement to manage traffic accidents and ensure public safety.
Health & Medical		Exposure to extreme cold can lead to hypothermia and frostbite, while slippery conditions increase the risk of falls and accidents. Healthcare facilities must be prepared for an influx of patients and potential challenges in maintaining operations during severe weather.
Housing & Building Infrastructure		Heavy snowfall and ice can cause damage to roofs and structures. Ensuring that buildings are adequately insulated and heated is critical to prevent pipe freezing and to maintain safe living conditions.

Lifelines	Impact Type	Description
Utilities		Winter storms can disrupt power, heating, and water services, as well as communication networks. Restoring these services is crucial for survival and comfort during extended cold periods.
Transportation		Snow and ice can severely impact road, air, and rail travel, leading to delays, accidents, and the need for extensive snow and ice removal efforts.

Winter storms are a concern to the Lehigh Valley because of the region's location and geographic propensity to experience winter weather more frequently and with greater severity than many other parts of the State. Additionally, winter storms are of significant concern due to delays caused by the storms and impacts on the people and facilities of the region.

Overall, the Lehigh Valley's vulnerability has not changed since the 2018 Plan, and the entire region continues to be exposed and vulnerable to the winter storm hazard.

In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. Given professional knowledge and the currently available information, the potential losses for this hazard are considered to be overestimated and represent conservative estimates for losses associated with severe winter storm events. Potential loss estimates range from $1.6 to $16.9 billion for the Lehigh Valley.

Winter storms are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. People can die in traffic accidents on icy roads, from heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold. The elderly are considered most susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion or hypothermia. In addition, winter storm events 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.

Heavy snow can immobilize a region, shutting down air and rail transportation, stopping the flow of supplies and disrupting medical and emergency services. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost.[157]

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. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.[158]

In the event of a power outage, residents of the Lehigh Valley may choose to voluntary evacuate their homes to an area with electricity until power is restored. However, choosing to leave during a snowstorm can put motorists at risk of car crashes if roadways are not plowed. Additionally, the Lehigh Valley may experience an increase in population for a short period of time if areas surrounding Lehigh and Northampton counties experience power outages during a winter storm.

Infrastructure at risk for this hazard includes roadways that could be damaged due to the application of salt and intermittent freezing and warming conditions that can damage roads over time. The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. The potential secondary impacts from winter storms also impact the local economy including loss of utilities, interruption of transportation corridors and loss of business function.

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[157] US Department of Commerce and National Oceanic and Atmospheric Administration. "Snow Storm Safety." NOAA's National Weather Service. Accessed November 22, 2023. https://w2.weather.gov/safety/winter-snow.

[158] US Department of Commerce and National Oceanic and Atmospheric Administration. "Snow Storm Safety." NOAA's National Weather Service. Accessed November 22, 2023. https://w2.weather.gov/safety/winter-snow.

Human-Caused Hazards

4.3.15 Civil Disturbance / Mass Gathering

4.3.15.1. Location and Extent

A civil disturbance is defined by FEMA as a civil unrest activity - such as a demonstration, riot, or strike – that disrupts a community and requires intervention to maintain public safety.[159] Within the Lehigh Valley, pre-planned events such as sports gatherings, college ceremonies and public festivals draw large numbers of individuals that are considered mass gathering events. Additionally, the location of government facilities, landmarks, prisons, colleges and universities within the region may draw the attention of protest organizations. These facilities are generally located within the larger, more urban environments within the cities of Allentown, Bethlehem and Easton.

4.3.15.2. Range of Magnitude

Civil disturbance or mass gatherings can range from small groups of individuals joined together with a common message or purpose to large groups' intent on disrupting operations. Mass gatherings generally range from planned events such as festivals, sporting events, and college graduations to peaceful or violent assemblies of large groups. At the most extreme, a full-scale riot can involve mobs who burn or otherwise destroy property, terrorize individuals, and disrupt both routine and emergency services. Even in its more passive forms, a group that blocks roadways, sidewalks, or buildings interferes with public order. Often that which was intended to be a peaceful demonstration can escalate into general chaos.

In the Pennsylvania 2023 State Hazard Mitigation Plan, PEMA distinguishes a crowd from a mob. A crowd may be a casual, temporary collection of people without a strong, cohesive relationship, whereas a mob is usually emotional, loud, tumultuous, violent, and lawless.[160] Crowds and mobs can be further separated into the following categories:

Casual crowd: A casual crowd is merely a group of people who happen to be in the same place at the same time. Violent conduct does not occur.

Cohesive or Conventional Crowd: A cohesive or conventional crowd consists of members who are involved in some type of unified behavior. Members of this group are involved in some type of common

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[159] FEMA glossary. Retrieved on 07/06/2023 from: https://training.fema.gov/programs/emischool/el361toolkit/glossary.htm

[160] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

activity, such as worshipping, dancing, or watching a sporting event. Although they may have intense internal discipline, they require substantial provocation to arouse to action.

Expressive Crowd: An expressive crowd is one held together by a common commitment or purpose. Although they may not be formally organized, they are assembled as an expression of common sentiment such as excitement or frustration. Members wish to be seen as a formidable influence. One of the best examples of this type is a group assembled to protest. Note that a conventional crowd may sometimes become an expressive crowd; because excitement and emotional expression are defining features of expressive crowds, individuals in such crowds are engaging in collective behavior as described above.

Aggressive or Acting Crowd: An aggressive or acting crowd goes one step beyond an expressive crowd by behaving in violent or other destructive behavior, such as looting. A mob, an intensely emotional crowd that commits or is ready to commit violence is a primary example of an acting crowd. Panic is another example, a sudden reaction by a crowd that involves self-destructive behavior, such as accidental trampling when fleeing an emergency. Crowds that become aggressive are usually assembled for a specific purpose. This crowd often has leaders who attempt to arouse the members or motivate them to action. The crowd may be more impulsive and emotional and require only minimal stimulation to arouse violence.

Aggressive Mob: An aggressive mob is one that attacks, riots, and terrorizes. The object of violence may be a person, property, or both. An aggressive mob is distinguished from an aggressive crowd only be lawless activity. Examples of aggressive mobs are the inmate mobs in prisons and jails, mobs that act out their frustrations after political defeat, or violent mobs at political protests or rallies.

Escape Mob: An escape mob is attempting to flee from something such as a fire, bomb, flood, or other catastrophe. Members of escape mobs are generally difficult to control and can be characterized by unreasonable terror.

Acquisitive Mob: An acquisitive mob is one motivated by the desire to acquire something. Riots caused by other factors often turn into looting sprees. This mob exploits a lack of control by authorities in safeguarding property.

Expressive Mob: An expressive mob is one that expresses fervor or revelry following some sporting event, religious activity, or celebration. Members experience a release of pent-up emotions in highly charged situations.

The effects of civil unrest are influenced by various elements such as underlying causes, political context, and the approach to managing them. Typically, the repercussions of these events are limited and temporary, except when sabotage occurs. Such disturbances might result in minor injuries to emergency personnel or participants due to clashes, and acts of vandalism can damage properties, facilities, infrastructure, and the environment. Proper policing at anticipated sites of civil unrest and key potential targets like state agency offices can reduce the likelihood of a minor gathering escalating into a major disturbance.

4.3.15.3. Past Occurrence

The Lehigh Valley is home to annual events classified as mass gatherings by the Pennsylvania Department of Health. The list in Table 65 is a partial compilation of annual events that draw large groups together with peaceful intent. Due to the number of events being hosted by each municipality in the Lehigh Valley, a full listing of events is unable to be maintained. The information identified below was provided by the County emergency management agencies and was noted to be events that require assistance from county and municipal agencies due to location and number of attendees.

Table 65: Select, Reoccurring Planned Gatherings in the Lehigh Valley

Event	Estimated Daily Attendance	Location
Allentown Fair	5,000	Allentown
Lights in the Parkway	6,000	Allentown
Cinco De Mayo	25,000	Allentown
St. Patrick's Day Parade	5,000	Allentown
Blues, Brews & BBQ	5,000	Allentown
Run the Valley Running Festival	20,000	Allentown
NLF National Championship – Big 4 Lacrosse	600	Upper Macungie
4th of July Fireworks	10,000	Allentown, Bethlehem, others
Chriskindlmarkt	N/A	Bethlehem
Truck Show	2,000	Macungie
Wheels of Time	N/A	Macungie
Schnecksville Fair	1,500	Schnecksville

Community Day	600	Coopersburg

Most past occurrences of non-planned gatherings within the Lehigh Valley have been peaceful, with only one incident being associated with any type of violence: a large group of juveniles (30-40) were reported fighting in North Whitehall Township.

In 2011 when Lehigh University rented their facilities out to a company that hosted a Rave party for the college students. During the event, a student became ill, followed by numerous others. Local responders quickly arrived and determined the event to be a Mass Casualty Incident. In total, 44 students were transported from the event and taken to local hospitals for a variety of injuries and illnesses.

In May and June 2020, protests proliferated across the U.S. following the death of George Floyd in Minneapolis, Minnesota. Many of these protests drew significant crowds, and a few protests in Pennsylvania ultimately became violent. In Philadelphia, police deployed tear gas and rubber bullets in response to looting, and 104 officers were injured or assaulted. In Pittsburg, police also deployed tear gas, and a curfew was enforced on May 30th.[161] Protests in the Lehigh Valley also occurred – primarily in Allentown and Bethlehem – but there were no reports of significant violence against people and/or property. These protests are an example of how incidents with seemingly no connection to the Lehigh Valley can still have an impact on the region.

In late 2023, a wave of protests erupted across the country in response to events occurring in the Middle East. These protests largely focused on aspects of Israel-Palestine relations, and as of the development of this plan, these protests are still occurring. Several protests have taken place in the Lehigh Valley, although these have been peaceful demonstrations of First Amendment rights. Like the George Floyd protests, these protests show how events which occur outside of the Lehigh Valley can still have an effect on the region.

Table 66: Previous Un-Planned Mass Gatherings in the Lehigh Valley

County	Jurisdiction(s)	Event	Date	Estimated Population
Lehigh	Salisbury	Protest against housing immigrant minors at	7/20/14	Unknown
Northampton	Lower Nazareth	Union protest	11/19/15	Unknown
Northampton	Easton City	Anti- and pro-Trump rallies	11/12/16	Unknown

[161] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Northampton	Bethlehem City	Pantsuit rally: silent rally to promote unity	11/12/16	Unknown
Northampton	Bethlehem Township	Northampton Community College students protest against	5/3/17	Unknown
Northampton/ Lehigh	Bethlehem City, Allentown, Reading	George Floyd Protests	5/29/20 – 5/30/20	Unknown

4.3.15.4. Future Occurrence

Many civil disturbances are reflections of human behavior and responses to current events. This reality makes it virtually impossible to predict future occurrences of civil disturbance. However, it is highly likely that future instances will occur, as the First Amendment of the Constitution protects freedom of speech, freedom of assembly, and the right to petition. At the same time, the possibility of a gathering of people becoming disruptive and/or violent cannot be eliminated, and law enforcement may be put in the difficult position of having to uphold the Constitution while maintaining law and order and protecting the public. Major national and global events are often catalysts for civil disturbances, and the Lehigh Valley should be particularly vigilant in the wake of such events. The likelihood of civil disturbance/mass gathering is considered 'highly likely' as defined in the Methodology Section.

4.3.15.5. Vulnerability Assessment

Civil disturbances, such as protests, riots, or other forms of public unrest, can significantly impact community lifelines, particularly in urban areas like the Lehigh Valley. These disturbances, depending on their scale and nature, can disrupt normal community functions in various ways as shown in the following table.

Table 67: Potential Vulnerabilities to Lifelines from Civil Disturbances

Lifelines	Impact Type	Description
Safety & Security		Civil disturbances often require a heightened law enforcement presence to maintain public order, protect lives and property, and manage crowd control. In severe cases, there can be risks of injury to both participants and law enforcement personnel.

Lifelines	Impact Type	Description
Health & Medical		Injuries resulting from confrontations or accidents during disturbances can lead to increased demand for emergency medical services. Healthcare facilities must be prepared for potential surges in patients and ensure the safety of their staff and premises.
Housing & Building Infrastructure		Public unrest can lead to property damage, including vandalism and arson, affecting homes, businesses, and public buildings. This damage may result in displacement of residents and costly repairs.
Utilities		Civil disturbances can disrupt utility services either directly through damage to infrastructure or indirectly due to access restrictions. Ensuring continuity of essential services like electricity, water, and telecommunications is critical.
Transportation		Public unrest can lead to road closures and disruptions in public transportation services, impacting the movement of people and goods. This can also hinder emergency response and law enforcement efforts.
Economic Stability		Civil disturbances can have a significant economic impact, from the immediate costs of emergency response and infrastructure repairs to longer-term effects on local businesses, tourism, and investor confidence.
Community Services & Cohesion		Public unrest can disrupt community services such as schools, libraries, and social services. Additionally, such events can strain social cohesion, especially if they reflect underlying community tensions or lead to polarized responses.

Civil disturbance/mass gathering is of particular concern in the Lehigh Valley due to numerous regularly scheduled and unscheduled gatherings of large numbers of individuals. Overall, the Lehigh Valley's vulnerability has not changed since the 2018 Plan, and the entire region continues to be exposed and vulnerable to the civil disturbance/mass gathering hazard.

The vulnerability of a jurisdiction and its residents to a non-planned mass gathering is difficult to measure due to the unknown target or topic that is causing the group to gather. Mass gatherings may stretch health systems beyond their capacity. However, these events also present opportunities for long-lasting positive effects such as a stronger public health system after the event, or residents and visitors that are better informed about how they can protect themselves from certain disease.[162] Additionally, the health consequences of mass gathering-related events may include injuries resulting from crowd density and inadequate infrastructure, such as a bridge collapse, exposure to extreme weather events, and escalation of violence as a result of crowd behavior.[163]

In 2020, a company called Property Claim Services (PCS), which has tracked insurance claims related to civil disobedience since 1950, assessed the cost of civil disturbance following the death of George Floyd. PCS concluded that civil disturbances across the country between May 26, 2020 – June 8, 2020 resulted in more than $1 billion of paid insurance claims.[164] While this figure is lower than those associated with other disasters such as hurricanes and wildfires, it significantly exceeds insurance claims stemming from previous civil disturbances since PCS began tracking this data 1950.

Past civil disturbance/mass gathering occurrences in the Lehigh Valley have not had loss measured by financial or property damage. Pre-planned events are generally coordinated with local municipalities, response agencies and county agencies to ensure safety. Costs associated with loss due to damage or other adverse incidents during or related to the event are generally covered by the organization hosting the event. Pre-planned or non-planned events may result in road closures, which in turn may delay the provision of emergency services.

The impacts of civil disturbance/mass gathering events are contingent upon numerous factors, including issues, politics and method of response. There may be injuries to first responders or participants from physical confrontations, and vandalism may cause damage to property, facilities, and infrastructure.

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[162] Center for Disease Control and Prevention. "COVID-19 and Your Health." Centers for Disease Control and Prevention, July 6, 2023. Retrieved on 07/14/2023 from: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html.

[163] Sharma, Avinash, Brian McCloskey, David S. Hui, Aayushi Rambia, Adam Zumla, Tieble Traore, Shuja Shafi, et al. "Global Mass Gathering Events and Deaths Due to Crowd Surge, Stampedes, Crush and Physical Injuries – Lessons from the Seoul Halloween and Other Disasters." Travel Medicine and Infectious Disease 52 (March 1, 2023): 102524. Retrieved on 07/14/2023 from: https://doi.org/10.1016/j.tmaid.2022.102524.

[164] Kingson, Jennifer A. 2020. "Exclusive: $1 Billion-plus Riot Damage Is Most Expensive in Insurance History." Axios. September 16, 2020. Retrieved on 07/12/2023 from: https://www.axios.com/2020/09/16/riots-cost-property-damage.

Adequate law enforcement at planned mass gathering events and around likely target locations like the offices of state agencies minimizes the chances of a small assembly of individuals turning into a significant disturbance.

4.3.16 Dam Failure

This section provides a profile and vulnerability assessment of the dam failure hazard in Lehigh and Northampton Counties. 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). Many dams fulfill a combination of these stated functions.[165] Dams are an important resource in the United States.

4.3.16.1. Location and Extent

A dam failure is a sudden, rapid, and uncontrolled release of impounded water. Dam failures can result from one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam
- Deliberate acts of sabotage
- Structural failure of materials used in dam construction
- Movement or failure of the foundation supporting the dam
- Settling and cracking of concrete or embankment dams
- Piping and internal erosion of soil in embankment dams
- Inadequate maintenance and upkeep[166]

Dam failures can cause serious downstream flooding either because of partial or complete dam collapse. Failures are usually associated with intense rainfall and prolonged flood conditions, but dam breaks can occur during dry periods as a result of progressive erosion of an embankment or acts of sabotage. Dam breaks pose the greatest threat to people and property immediately downstream. Flooding is the most common secondary effect of dam failure. If the dam failure is severe, a large amount of water will enter

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[165] Association of State Dam Safety Officials. “Dams 101”. Accessed October 13, 2023. https://damsafety.org/dams101.

[166] Association of State Dam Safety Officials. “Dam Failures and Incidents | Association of State Dam Safety.” Accessed July 13, 2023. https://damsafety.org/dam-failures. https://damsafety.org/dam-failures.

the downstream body of water and overflow the stream banks for miles. Environmental vulnerability is dependent on the contents of the water and the path it takes.

A catastrophic failure is characterized by the sudden, rapid, and uncontrolled release of water from a dammed impoundment. Seepages in earthen dams usually develop gradually, and if detected early, downstream residents have anywhere from a few hours to a few days to evacuate. Overtopping of a dam normally gives enough time for evacuation.

Man-made dams can be classified according to type of construction material used; methods applied in construction, slope, or cross-section of the dam; how a dam resists forces of water pressure behind it; means used to control seepage; and purpose of the dam. Materials used for construction of dams include earth, rock, tailings from mining or milling, concrete, masonry, steel, timber, miscellaneous materials (plastic or rubber), and any combination of these materials.[165] More than a third of the country's dams are 50 or more years old. Approximately 14,000 of those dams pose a significant hazard to life and property if failure occurs. About 2,000 unsafe dams are dispersed throughout the United States in almost every state.

Dam failure often occurs as a secondary impact of other hazards. Earthquakes, flooding, wildfire, landslides, or tornados can weaken dam structures, leading to failure, as could traditional or cyber-terrorists or explosions.

Regulatory Oversight of Dams

Potential for catastrophic flooding caused by dam failures led to enactment of the National Dam Safety Act (Public Law 92-367), which for 30 years has protected Americans from dam failures. The National Dam Safety Program (NDSP) is a partnership among states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA's leadership, state assistance funds have allowed all participating states to improve their programs through increased inspections, emergency action planning, and purchases of needed equipment. FEMA has also expanded existing and initiated new training programs. Grant assistance from FEMA provides support for improvement of dam safety programs that regulate most dams in the United States.[167]

Pennsylvania Department of Environmental Protection

The Pennsylvania Department of Environmental Protection (PADEP) holds responsibility for dam safety. Hazard Potential Category 1 dams are those where its failure could result in significant loss of life, excessive economic losses, and significant public inconvenience. Hazard Potential Category 2 dams are those where its failure could result in the loss of a few lives, appreciable property damage, and short-

[167] Federal Emergency Management Agency, "Hazard Mitigation Assistance Program and Policy Guide." March 23, 2023.

duration public inconvenience.[168] Owners of dams classified as Hazard Categories 1 or 2 ("high-hazard" dams) are required to create an Emergency Action Plan (EAP) that describes the dam, the inundation area if the dam were to catastrophically fail, and procedures for responding to the dam failure (such as notification to the vulnerable population). Lehigh and Northampton Counties receive copies of EAPs and inundation maps for high-hazard dams whose failure could impact local residents.

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers (USACE) is responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. USACE has inventoried dams and has surveyed each state's and federal agency's capabilities, practices, and regulations regarding design, construction, operation, and maintenance of the dams. USACE has also developed guidelines for inspection and evaluation of dam safety. The USACE National Inventory of Dams (NID) provides the most recent dates of inspection and whether an EAP is in place for the dams that are identified as having a high hazard potential. Lehigh and Northampton Counties did not have access to the EAPs that the NID indicated were in existence, which the State DEP confirmed were not available to us.

The Federal Energy Regulatory Commission (FERC) has the largest dam safety program in the United States. FERC cooperates with many federal and state agencies to ensure and promote dam safety and, more recently, homeland security. FERC staff inspect hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with terms and conditions of a license

Every 5 years, an independent consulting engineer, approved by FERC, must inspect and evaluate projects with dams higher than 32.8 feet (10 meters) or with total storage capacity of more than 2,000 acre-feet.[169]

FERC monitors and evaluates seismic research in geographic areas where seismic activity is a concern. This information is applied to investigate and analyze structures of hydroelectric projects within these

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[168] 25 PA. Code § 105.91. Classifications of dams and reservoirs. Retrieved on 07/10/23 from: https://www.pacodeandbulletin.gov/Display/pacode?file=/secure/pacode/data/025/chapter105/s105.91.html

[169] Federal Energy Regulatory Commission. "Engineering Guidelines for the Evaluation of Hydropower Projects." 2017. Accessed October 13, 2023. https://www.ferc.gov/industries-data/hydropower/dam-safety-and-inspections/eng-guidelines.

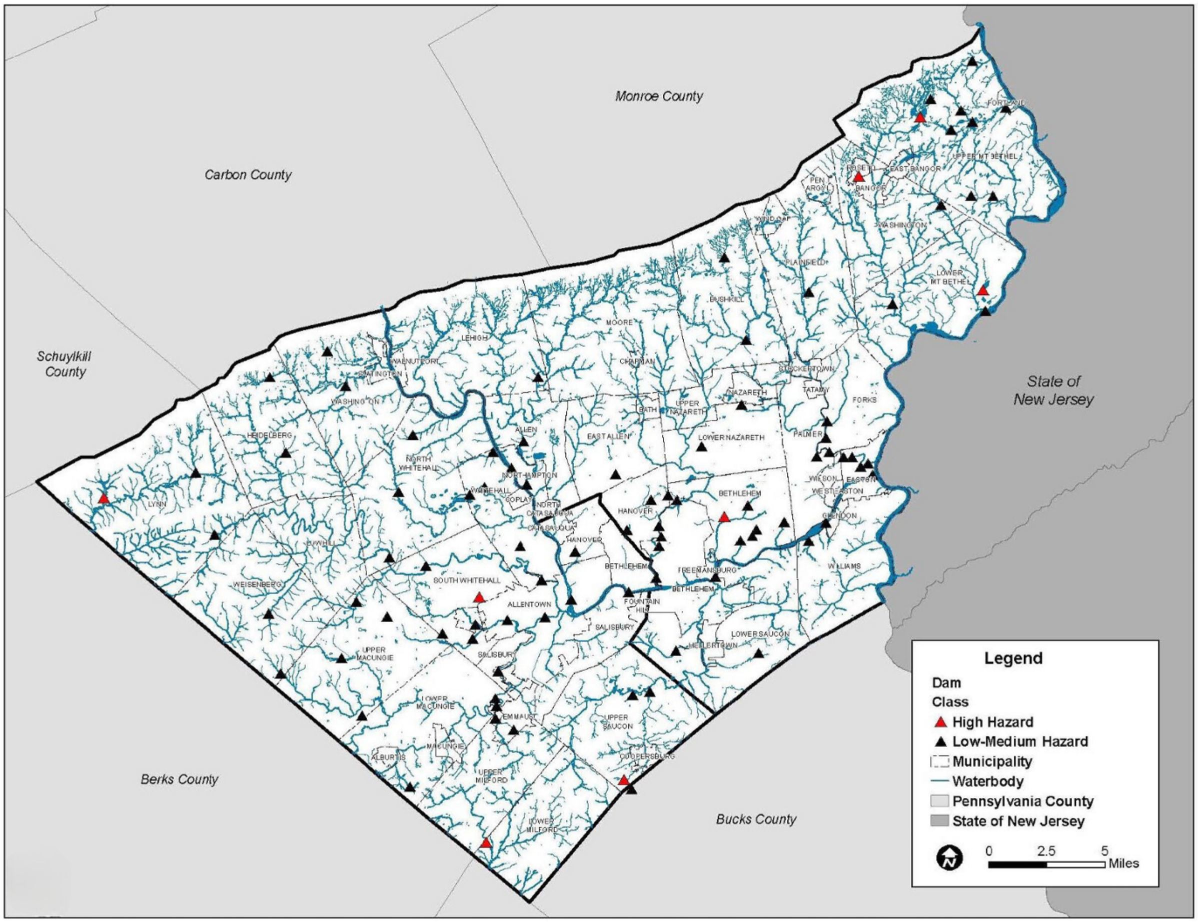
areas. FERC staff also evaluates effects of potential and actual large floods on safety of dams. FERC staff visit dams and licensed projects during and after floods, assess extents of damage, and direct any studies or remedial measures the licensee must undertake. FERC's Engineering Guidelines for the Evaluation of Hydropower Projects guides FERC engineering staff and licensees in evaluations of dam safety. The publication is frequently revised to reflect current information and methodologies.[169]

FERC requires licensees to prepare EAPs and conducts training sessions on developing and testing these plans. The plans outline an early warning system in the event of an actual or potential sudden release of water from a dam failure. The plans include operational procedures that may be implemented during regulatory measures, such as reducing reservoir levels and downstream flows as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that all applicable parties are informed of the proper procedures in emergencies.[169]

Dams in the Lehigh Valley

According to the Pennsylvania Department of Environmental Protection, there are 101 dams in the Lehigh Valley. Based on the PADEP classification, eight of these are high hazard dams. Figure 30 shows the location of these dams within Northampton and Lehigh counties. Table 68 lists dam classification definitions used by the State of Pennsylvania. Table 69 is a complete list of NID-listed dams in Lehigh and Northampton Counties with high-hazard dams listed first.

Figure 30: Lehigh and Northampton County Dams



Source: PA DEP Dam Safety

Table 68: Dam Classification Definitions[168]

Size Category		
Category	**Impoundment Storage (Acre-feet)**	**Dam Height (Feet)**
A	Equal to or greater than 50,000	Equal to or greater than 100
B	Less than 50,000 but greater than 1,000	Less than 100 but greater than 40
C	Equal to or less than 1,000	Equal to or less than 40

Hazard Potential Category		
Category	**Population at Risk**	**Economic Loss**
1	Substantial (Numerous homes or small businesses or a large business or school)	Excessive, such as extensive residential, commercial, or agricultural damage, or substantial public inconvenience
2	Few (A small number of homes or small businesses)	Appreciable, such as limited residential, commercial, or agricultural damage, or moderate public inconvenience
3	None expected (no permanent structures for human habitation or employment)	Significant damage to private or public property and short-duration public inconvenience such as damage to storage facilities or loss of critical stream crossing
4	None expected (no permanent structures for human habitation or employment)	Minimal damage to private or public property and no significant public inconvenience

Table 69: Lehigh and Northampton County Dams[170]

Dam Name	Stream	County	Municipality	Permittee	PA DEP Classification	Purpose	Type
Cedar Crest Boulevard	Jordan Creek Tributary	Lehigh	South Whitehall Township	South Whitehall Township	C-1	Flood Risk Reduction	Earth
Errickson Fish Pond	Tumble Brook Tributary	Lehigh	Upper Saucon Township	Private Resident	C-1	Recreation	Earth
Hosensack No. 4	Indian Creek	Lehigh	Lower Milford Township	Private Resident	C-1	Recreation	Earth, Stone, Masonry
Leaser Lake	Jacksonville Branch of Ontelaunee Creek	Lehigh	Lynn Township	PA Fish & Boat Commission	B-1	Recreation	Earth
Martin's Creek SES Ash Basin No. 4	Tributary of Oughoughton Creek	Northampton	Lower Mount Bethel Township	PPL Martins Creek, LLC	B-1	Other	Earth
Minsi Lake	East Branch of Martins Creek	Northampton	Upper Mount Bethel Township	PA Fish & Boat Commission	B-1	Recreation	Earth
Rolling Greens	Nancy Run Tributary	Northampton	Bethlehem Township	Bethlehem Township	C-1	Flood Risk Reduction	Earth
West Side Detention	Martins Creek Tributary	Northampton	Roseto Borough	Borough of Roseto	C-1	Flood Risk Reduction	Earth
Detention Pond	Lehigh River Tributary	Lehigh	Hanover Township	Private Resident	Not Classified	Other	Not Available
Spring Mill	Spring Creek	Lehigh	Whitehall Township	Northampton Borough Municipal Water Authority	Not Classified	Water Supply	Earth, Rockfill, Masonry
Hensingersville	East Branch Swope Creek	Lehigh	Macungie Borough	Alburtis Borough Authority	Not Classified	Recreation	Earth, Concrete

[170] US Army Corps of Engineers: National Inventory of Dams. Accessed October 13, 2023. https://nid.sec.usace.army.mil/#/

Hamilton Street	Lehigh River	Lehigh	Allentown City	City of Allentown	Not Classified	Recreation	Concrete, Gravity
Little Lehigh	Little Lehigh Creek	Lehigh	Allentown City	City of Allentown	Not Classified	Recreation	Concrete
Kings Crossing	Lehigh River Tributary	Northampton	Bethlehem Township	Bethlehem Township	Not Classified	Flood Risk Reduction	Earth
Palmer Park Mall	Bushkill Creek Tributary	Northampton	Palmer Township	Palmer Park L.P.	Not Classified	Flood Risk Reduction	Earth
Echo Lake	Jacoby Creek Tributary	Northampton	Upper Mt. Bethel Township	Echo Lake Development Co. Inc.	Not Classified	Recreation	Earth, Rockfill
Easton	Lehigh River	Northampton	Easton City	DCNR	Not Classified	Recreation	Stone, Masonry
Chain	Lehigh River	Northampton	Palmer Township	City of Easton	Not Classified	Recreation	Stone, Masonry
Illicks Mill	Monocacy Creek	Northampton	Hanover Township	City of Bethlehem	Not Classified	Recreation	Earth, Stone, Masonry
Upper	Bushkill Creek	Northampton	Easton City	Unknown	Not Classified	Recreation	Concrete
Northampton	Lehigh River	Northampton	Whitehall Township	Whitehall Cement Manufacturing Company	Not Classified	Recreation	Concrete
Lower	Bushkill Creek	Northampton	Easton City	Easton Municipal Authority	Not Classified	Recreation	Concrete

Incorporation of Dam Data

When assembling this plan, the planning team requested that PADEP provide dam-specific information for HHPDs, specifically including

- Number of residents in the inundation zone(s)
- A list of the municipalities impacted by each inundation zone
- A list of the census tracts impacted by each inundation zone
- A list of jurisdictions that have critical facilities or lifelines impacted by inundation zones
- The area (in acres) of the inundation zone
- The number of structures in the inundation zone
- The number of structures in the inundation zone that would be damaged or destroyed in a failure

Unfortunately, PADEP indicated that they do not track and were not able to provide this information. Due to this limitation, information included in this hazard profiles comes largely from federal and other publicly-available sources.

4.3.16.2. Range of Magnitude

The municipalities where these dams are located and the communities downstream are at the greatest risk for a dam failure. The risk a dam poses to communities can be split into the following three components of the total risk[171]:

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

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

3. **Residual Risk:** The risk that remains after all mitigation actions and risk reduction actions have been completed. It is the risk that remains after decisions related to a specific dam safety issue are made and prudent actions have been taken to address the risk. It is the remote risk associated with a condition that was judged to not be a credible dam safety issue.

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[171] Federal Emergency Management Agency (FEMA). 2020. Rehabilitation of High Hazard Potential Dams Grant Program Guidance, June 2020. FP 104-008-7. https://www.fema.gov/sites/default/files/2020-08/fema_hhpd_grantguidance.pdf.

The incremental risk (i.e., the risk from dam failure) is assessed in Section The likelihood of a dam failure in the Lehigh Valley is extremely difficult to predict. However, the risk of such an event increases for each dam as the dam's age increases. Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for dam failure events in the Lehigh Valley is considered 'unlikely,' as defined in the Methodology section.

4.3.16.5. Vulnerability Assessment. Specific assessments of the non-breach risk and residual risk posed by the dams in Lehigh and Northampton Counties were not conducted, as the planning team members did not have the required expertise to objectively assess that risk. However, these types of risk are assessed by registered professional engineers in conducting annual inspections of the dams. The annual inspection includes examining 109 individual characteristics of the following aspects of the dams:[172]

- Embankment: Crest
- Embankment: Upstream Face
- Embankment: Downstream Face
- Embankment: Instrumentation
- Downstream Area
- Spillways: Erodible Channel
- Spillways: Non-Erodible Channel
- Spillways: Drop Inlet
- Outlet Works
- Concrete/Masonry Dams: Upstream Face
- Concrete/Masonry Dams: Downstream Face
- Concrete/Masonry Dams: Crest
- Reservoir Area

Extent or magnitude of a dam failure event can be measured in terms of classification of the dam. FEMA has three classification levels of dam hazard potential: low, significant, and high. The classification levels

[172] PA DEP. No Date. "Dam Inspection Checklist." https://www.dep.pa.gov/Business/Water/Waterways/DamSafety/Pages/default.aspx.

build on each other. The hazard potential classification system should be used with the understanding that failure of any dam or water-retaining structure could represent a danger to downstream life and property.[173]

Each FEMA classification level of dam hazard potential is described as follows:

- Low-hazard potential dams are those where failure or misoperation would result in no probable loss of human life and low economic or environmental losses. Losses are principally limited to the owner's property.
- Significant-hazard potential dams are those where failure or misoperation would result in no probable loss of human life but could cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Significant-hazard potential dams are often located in predominantly rural or agricultural areas.
- High-hazard potential dams are those where failure or misoperation will probably cause loss of human life.

Table 70 lists USACE-developed classifications of hazard potentials of dam failures, based only on potential consequences of a dam failure. This classification does not take into account probability of failure.

Table 70: U.S. Army Corps of Engineers Hazard Potential Classification

Hazard Category	Direct Loss of Life	Lifeline Losses	Property Losses	Environmental Losses
Categories are assigned to overall projects, not individual structures at a project.	Loss-of-life potential is based on inundation mapping of area downstream of the project. Analysis of loss-of-life potential should take into account the population at risk, time of flood wave travel, and warning	Lifeline losses include indirect threats to life caused by the interruption of lifeline services from project failure or operational disruption; for example, loss of critical medical facilities or access	Property losses include damage to project facilities and downstream property and indirect impact from loss of project services, such as impact from loss of a dam and navigation pool, or impact from loss of	Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which

[173] Federal Emergency Management Agency, "Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams." April 2004. Accessed October 13, 2023. https://www.ferc.gov/sites/default/files/2020-04/fema-333.pdf

	time.	to them.	water or power supply.	the failure occurs.
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

Source: USACE 2016

Based on these categories (which differ from the hazard classifications used by the state), the NID identifies three "high-hazard" dams in Northampton County (Minsi Lake, Rolling Greens, and West Side Detention) and three in Lehigh County (Leaser Lake, Errickson Fish Pond, and Cedar Crest Boulevard).

4.3.16.3. Past Occurrence

There have been no recorded dam failures in the Lehigh Valley. However, the Lake Minsi Dam, which is categorized as a high hazard dam in Upper Mt. Bethel Township, was deemed unsafe due to limited spillway capacity. The lake was drained in 2017 for the dam to be repaired.

Historically, the deadliest dam break in the U.S. occurred in Johnstown, Pennsylvania. In 1889, a break in the South Fork dam resulted in more than 14 million cubic meters of water rushing downstream.[174] This wave of water smashed through several communities along the Little Conemaugh River, and 2,208 people were killed as a result. Subsequent analysis of this dam break revealed numerous flaws pertaining to the construction and management of the dam, and the catastrophe focused national

- [174] Coleman, Neil M., Uldis Kaktins, and Stephanie Wojno. "Dam-Breach Hydrology of the Johnstown Flood of 1889–Challenging the Findings of the 1891 Investigation Report." *Heliyon* 2, no. 6 (June 16, 2016): e00120. Retrieved on 07/14/2023 from: https://doi.org/10.1016/j.heliyon.2016.e00120.

attention to the issue of dam safety. Another significant dam failure took place in Austin, Pennsylvania (Potter County) in 1911, claiming seventy-eight lives.

4.3.16.4. Future Occurrence

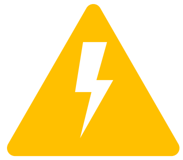
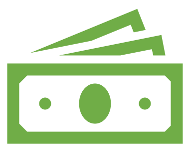
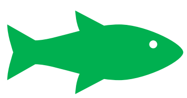
The likelihood of a dam failure in the Lehigh Valley is extremely difficult to predict. However, the risk of such an event increases for each dam as the dam's age increases. Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for dam failure events in the Lehigh Valley is considered 'unlikely,' as defined in the Methodology section.

4.3.16.5. Vulnerability Assessment

Dam failures, although rare, can have catastrophic consequences for communities like the Lehigh Valley, profoundly impacting various community lifelines. The failure of a dam can result from structural issues, extreme weather events, or neglect, leading to sudden and severe flooding downstream. Here's how dam failures can impact community lifelines as seen in the following table.

Table 71: Potential Vulnerabilities to Lifelines due to Dam Failure

Lifelines	Impact Type	Description
Safety & Security		The sudden release of water can pose immediate threats to life and property, necessitating urgent evacuation and rescue operations. Law enforcement and emergency services are vital for managing the situation, ensuring public safety, and coordinating response efforts.
Health & Medical		Injuries and potential loss of life due to flooding require emergency medical services. Healthcare facilities need to be prepared for an influx of patients and possible challenges in maintaining operations, especially if they are in the flood zone.
Housing & Building Infrastructure		Flooding from dam failures can cause extensive damage to homes, businesses, and infrastructure, resulting in displacement of residents, and necessitating significant reconstruction efforts.

Lifelines	Impact Type	Description
Utilities		Dam failures can disrupt essential services such as electricity, water supply, and communication networks, both directly through physical damage and indirectly due to access issues.
Transportation		Roads, bridges, and rail lines may be damaged or rendered impassable, disrupting the movement of people and goods and complicating rescue and recovery efforts.
Economic Stability		The economic impacts include the immediate costs of emergency response and infrastructure repairs, as well as longer-term effects on local economies due to business interruptions and loss of property.
Environmental & Ecological		A dam failure can lead to environmental disasters, impacting water quality, wildlife habitats, and local ecosystems. Remediation and ecological restoration efforts may be required in the aftermath.

The dam failure hazard is of significance to the Lehigh Valley because there are 101 dams across Lehigh and Northampton counties, eight of which are classified as 'high hazard' by the PADEP.

Based on these categories (which differ from the hazard classifications used by the state), the NID identifies three "high-hazard" dams in Northampton County (Minsi Lake, Rolling Greens, and West Side Detention) and three in Lehigh County (Leaser Lake, Errickson Fish Pond, and Cedar Crest Boulevard).

Spatial dam failure inundation areas were not available (and are considered sensitive information) and were not used to assess risk for the 2024 Plan. Therefore, a qualitative assessment was conducted to evaluate the assets exposed and the potential impacts associated with this hazard. All people, buildings and infrastructure in a dam failure inundation zone are considered exposed and vulnerable.

The direct and indirect losses associated with dam failures include injury and loss of life, damage to structures and infrastructure, agricultural losses, power outages and stress on community resources. A dam failure can also result in the displacement of those living in the inundation area. Emergency medical care, food and temporary shelters may be required for injured or displaced persons.

These events are frequently associated with other natural hazard events such as earthquakes, landslides or severe weather, which limits their predictability and compounds the hazard. The shaking associated with earthquakes may weaken the structure of a dam, particularly earthen dams, causing them to fail. Landslides can directly impact a dam, causing damage or failure. Likewise, landslides of the ground around a dam may weaken the ground on which the dam exists, causing the potential for the dam structure to fail. Landslides into the water being impounded by the dam can cause a wave to travel the length of the dam's impoundment area, ultimately crashing on the dam itself. Severe weather can result in large quantities of rain upstream of the dam that will ultimately be impounded by the dam, which could raise water levels behind the dam, resulting in overtopping of the dam and/or flooding of properties upstream of the dam itself.

Impact on Health and Safety

Of the population exposed, the most vulnerable include the economically disadvantaged and people over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the economic impact to their family. People over the age of 65 are also highly vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a flood event, and they may have more difficulty evacuating. There is often limited warning time for a dam failure, and populations without adequate warning of the event are also highly vulnerable to this hazard.

The safety of first responders is at risk in a dam failure scenario due to an anticipated higher-than-normal call volume and demand for first responders. 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 county.

Properties located closest to the dam inundation zone have the greatest potential to experience the largest, most destructive surge of water. Damage to transportation infrastructure in the dam inundation area could cut off evacuation routes, limit emergency access and create isolation issues. Utilities such as overhead power lines, and cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation zones.

Dam failure can cause severe downstream flooding and may transport large volumes of sediment and debris, depending on the magnitude of the event. Widespread damage to buildings and infrastructure affected by an event would result in large costs to repair these locations. In addition to physical damage costs, businesses can be closed while flood waters retreat, and utilities are returned to a functioning state.

Impact on Critical Facilities

Dam failures may also impact critical facilities and infrastructure located in the downstream inundation zone. Consequentially, dam failure can cut evacuation routes, limit emergency access, and/or create isolation issues. Dam failure can cause severe downstream flooding and may transport large volumes of sediment and debris, depending on the magnitude of the event. Widespread damage to buildings and infrastructure affected by an event would result in large costs to repair these locations. In addition to physical damage costs, businesses can be closed while flood waters retreat and utilities are returned to a functioning state. Further, utilities such as overhead power lines, cable lines, and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

Impact on the Economy

Severe flooding that follows an event like a dam failure can cause extensive structural damage and withhold essential services. The cost to recover from flood damages after a surge will vary depending on the hazard risk of each dam. Severe flooding that follows an event like a dam failure can cause extensive damage to public utilities and disruptions to delivery of services. Loss of power and communications may occur, and drinking water and wastewater treatment facilities can become temporarily out of operation.

Impact on the Environment

The environmental impacts of a dam failure can include significant water-quality and debris-disposal issues or severe erosion that can impact local ecosystems. Flood waters can back up sanitary sewer systems and inundate wastewater treatment plants, causing raw sewage to contaminate residential and commercial buildings and the flooded waterway. The contents of unsecured containers of oil, fertilizers, pesticides, and other chemicals may get added to flood waters. Hazardous materials may be released and distributed widely across the floodplain. Water supply and wastewater treatment facilities could be offline for weeks. After the flood waters subside, contaminated and flood-damaged building materials and contents must be properly disposed of. Contaminated sediment must be removed from buildings, yards, and properties.

Risk Prioritization

With this HMP update, Lehigh and Northampton Counties utilized PEMA’s method to prioritize their high hazard dams in terms of the risk they pose, to assist the county and municipalities in determining on which dams to focus mitigation efforts and resources.

The planning team obtained the lists of dams by contacting the Pennsylvania Department of Environmental Protection (PA DEP) Division of Dam Safety (the Division). The Division provided a list of dams in each of the given jurisdiction(s), including the dams’ Hazard Potential Categories. In the Commonwealth, dams with a Hazard Potential Category of 1 (Substantial) or 2 (Few) are considered “high-hazard” dams. The U.S. Army Corps of Engineers (USACE) also categorizes dams through Hazard Potential Classification values of Low, Significant, and High.

Not all dams categorized as “high-hazard” dams by PA DEP are classified as “high-hazard potential” dams by USACE, so the Counties utilized a separate methodology for prioritizing the dams in their jurisdiction(s). Dams that are not considered “high-hazard” dams by PA DEP or “high-hazard potential” dams by the USACE are categorized as having a LOW priority. Dams that are considered “high-hazard” dams by PA DEP but NOT considered “high-hazard potential” dams by the USACE are categorized as having a MEDIUM priority. Dams that are considered “high-hazard” dams by PA DEP AND “high-hazard potential” dams by the USACE must be further evaluated to prioritize their risk, to meet the requirements of FEMA’s Rehabilitation of High Hazard Potential Dams Grant Program (HHPD).

Table 72 provides a set of criteria and categorical values, and a simple risk formula, for prioritizing the high-hazard/high-hazard potential dams. The classification levels build on each other. That is, the higher classification levels add to the list of consequences for the lower classification levels. It should be understood that in any classification system, all possibilities cannot be defined. Judgment and common sense must ultimately be a part of any decision on classification. Further, no allowances for evacuation or other emergency actions by the population should be considered because emergency procedures should not be a substitute for appropriate design, construction, and maintenance of dam structures.

The Dam Risk Prioritization Calculation as follows:

Dam Risk Prioritization Score = Probability x (Impact + Complexity)

Table 72: Dam Prioritization Criteria

Category	Degree of Risk		
	Level	Criteria	Value
Probability of Failure based on USACE Condition Rating	Unlikely for failure	Condition rating of dam is Satisfactory. No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the minimum applicable state or federal regulatory criteria or tolerable risk guidelines.	1
	Possible for failure	Condition rating of dam is Fair. No existing dam safety deficiencies are recognized for normal operating conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.	2
	Likely for failure	Condition rating of dam is Poor. A dam safety deficiency is recognized for normal operating conditions which may realistically occur. Remedial action is necessary. Poor may also be used when uncertainties exist as to critical analysis	3

		parameters which identify a potential dam safety deficiency. Investigations and studies are necessary.	
	Highly likely for failure	Condition rating of dam is Unsatisfactory or N/A. A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution; or the dam has not been inspected, is not under state jurisdiction, or has been inspected but, for whatever reason, has not been rated.	4
Impact	Minor	10% or less of population and structures of affected municipalities are within the inundation area. Only minor property damage and minimal disruption on quality of life. Temporary shutdown of critical facilities.	1
	Limited	More than 10% of population and structures of affected municipalities are within the inundation area. More than 10% of properties in affected area are damaged or destroyed. Minor injuries only. Complete shutdown of critical facilities for more than one day.	2
	Critical	More than 25% of population and structures of affected municipalities are within the inundation area. More than 25% of properties in the affected area are damaged or destroyed. Complete shutdown of critical facilities for more than one week.	3
	Catastrophic	50% or higher of population and structures of affected municipalities are within the inundation area. High number of deaths/injuries possible. More Than 50% of property in the affected area are damaged or destroyed. Complete shutdown of critical facilities for 30 days or more.	4
Complexity	Mild	Single jurisdiction affected and uses its local emergency response agencies.	1
	Moderate	Multiple jurisdictions affected and response agencies require mutual aid support.	2
	High	Multiple jurisdictions that require County coordination.	3

	Very High	Multiple jurisdictions and counties that require Commonwealth coordination.	4

The following list shows the prioritization of the dams based on the Dam Risk Prioritization score:

- Medium risk: scores of less than 17
- High risk: scores of 17 or more

In summary, in terms of assessing risk from dam failure for hazard mitigation planning purposes, specifically to meet the requirements of FEMA's HHPD program, counties and municipalities should prioritize their dams as follows:

- Low Priority: The dam is not considered a "high-hazard" dam by PA DEP or a "high-hazard potential" dam by the USACE.
- Medium Priority: The dam is considered a "high-hazard" dam by PA DEP but is not considered a "high-hazard potential" dam by the USACE OR the dam is considered a "high-hazard" dam by PA DEP and is considered a "high-hazard potential" dam by the USACE, and receives a Dam Risk Prioritization score of less than 17.
- High Priority: The dam is considered a "high-hazard" dam by PA DEP and is considered a "high-hazard potential" dam by the USACE, and receives a Dam Risk Prioritization score of 17 or more.

In its analysis, the planning team found that Dam failure is a "moderate risk" hazard, and all dam failure related actions are "Medium" priority, as articulated in the mitigation strategy. More details on the criteria used to prioritize actions related to HHPDs is available in Section 6.

Future Changes that May Impact Vulnerability

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. Several factors are examined in this section to assess hazard vulnerability.

Projected Development

Section 2.4 discussed areas targeted for future growth and development across the counties. Any areas of growth could be potentially impacted by a dam or levee failure event if the structures are located within the flood protection area and mitigation measures are not considered. Therefore, it is the intention of the county and all participating municipalities to discourage development in vulnerable areas or to encourage higher regulatory standards at the local level.

Projected Changes in Population

As discussed in Section 2.4, the population of the Lehigh Valley is expected to increase by 25.6% from 2010 to 2040. As more people move out of flood zones due to increased regulation and awareness of flood risk, a decreased amount of the population will be vulnerable to dam inundation hazards. However, higher density areas can create issues for local residents during evacuation of a dam failure event and can also have an effect on commuters that travel into and out of the county for work. Refer to Section 2.3 for more information about population trends.

Climate Change

The June 2009 Pennsylvania Climate Impact Assessment indicated that Pennsylvania is very likely to undergo increased temperatures and precipitation in the 21st century (PADEP 2009). Increased precipitation will occur in the form of heavy rainfalls, which have the potential to increase the risk to dam failures. Increases in precipitation may stress the dam wall. Existing dams may not be able to retain and manage increases in water flow from more frequent, heavy rainfall events. Heavy rainfalls may result in more frequent overtopping of these dams and flooding of the county’s assets in adjacent inundation areas. However, the probable maximum flood used to design each dam may be able to accommodate changes in climate.

Change of Vulnerability Since 2018 Hazard Mitigation Plan

Lehigh Valley’s vulnerability has not changed since the 2018 Plan, and the areas of the region located in and around dams continue to be exposed and vulnerable to the impacts of dam failure.

4.3.17 Drug Overdose Crisis

4.3.17.1. Location and Extent

Pennsylvania is in the midst of an unprecedented epidemic of drug abuse and drug-related overdose deaths impacting every corner of the state and all of its residents. In 2022, there were 5,150 drug overdose deaths reported across Pennsylvania.[175] Although the total overdose deaths in 2022 decreased by 4% from 2021, total overdose deaths in 2022 increased 142% from a decade earlier, when 2,132 overdose deaths were reported in 2012.[176] Additional analysis from the CDC on the overdose death rates within each of the 50 US states found that Pennsylvania had the 9th highest overdose death rate in 2021, at 43.2 overdose deaths per 100,000 people.[177]

In 2017, the United States Drug Enforcement Administration (DEA) Philadelphia Division and the University of Pittsburgh prepared "Analysis of Overdose Deaths in Pennsylvania, 2016" to assist law enforcement's efforts to identify and combat drug suppliers, and ultimately drug abuse and related overdoses. The Drug Overdose Crisis hazard was first included in the 2018 Lehigh Valley Hazard Mitigation Plan. The drugs included in the analysis were selected based on law enforcement intelligence regarding frequency of abuse, as well as those identified as the most common drugs present in drug-related overdose deaths by national public safety and public health sources.

The most commonly identified drug category in toxicology reports varied for counties across Pennsylvania in 2022, and overdose deaths commonly involve more than one substance. In Lehigh County, there were 162 reported overdose deaths in 2022, and the opioid class of drugs contributed in 85.8% of these deaths.[178] Troublingly, Fentanyl accounted for 95.7% of all opioid-involved overdose

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[175] Pennsylvania Office of Drug Surveillance and Misuse Prevention. "Drug Overdose Surveillance Interactive Data Report." Tableau Software, July 2023. Retrieved on 07/21/2023 from: https://public.tableau.com/views/PennsylvaniaODSMPDrugOverdoseSurveillanceInteractiveDataReport/Contents?%3Adisplay_static_image=y&%3AbootstrapWhenNotified=true&%3Aembed=true&%3Alanguage=en-US&:embed=y&:showVizHome=n&:apiID=host0#navType=0&navSrc=Parse.

[176] Pennsylvania Office of Drug Surveillance and Misuse Prevention. "Drug Overdose Surveillance Interactive Data Report." Tableau Software, July 2023. Retrieved on 07/21/2023 from: https://public.tableau.com/views/PennsylvaniaODSMPDrugOverdoseSurveillanceInteractiveDataReport/Contents?%3Adisplay_static_image=y&%3AbootstrapWhenNotified=true&%3Aembed=true&%3Alanguage=en-US&:embed=y&:showVizHome=n&:apiID=host0#navType=0&navSrc=Parse.

[177] Centers for Disease Control and Prevention. "Drug Overdose Mortality by State." cdc.gov, March 1, 2022. https://www.cdc.gov/nchs/pressroom/sosmap/drug_poisoning_mortality/drug_poisoning.htm.

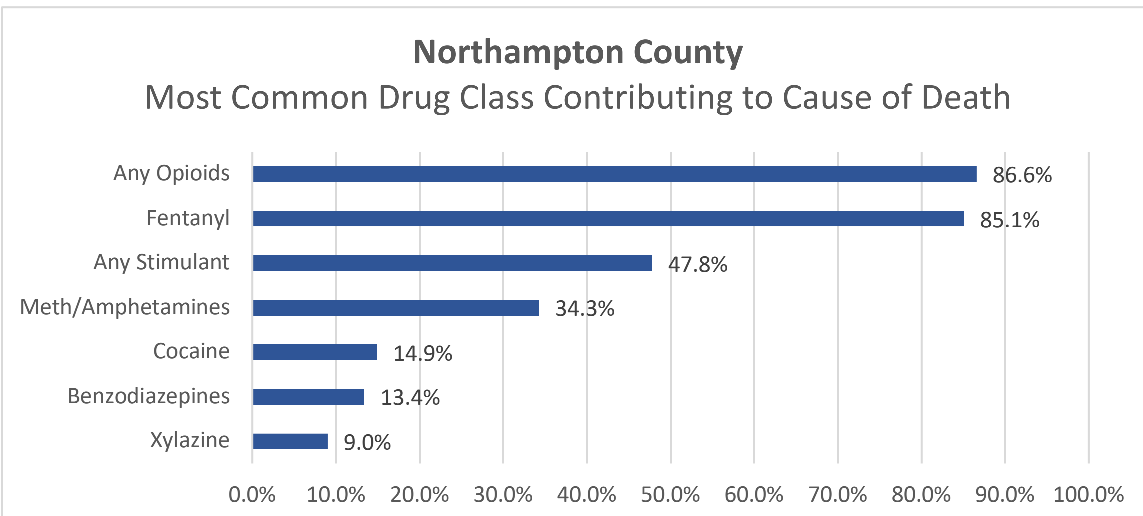
[178] Pennsylvania Office of Drug Surveillance and Misuse Prevention. "Drug Overdose Surveillance Interactive Data Report." Tableau Software, July 2023. https://public.tableau.com/views/PennsylvaniaODSMPDrugOverdoseSurveillanceInteractiveDataReport/Contents?%3Adisplay_static_image=y&%3AbootstrapWhenNotified=true&%3Aembed=true&%3Alanguage=en-US&:embed=y&:showVizHome=n&:apiID=host0#navType=0&navSrc=Parse.

deaths and was specifically identified in 82.1% of all overdose deaths in Lehigh County. Non-fentanyl opioids contributed to only 3.7% of overdose deaths in Lehigh County. The second most common drug class contributing to overdose deaths in Lehigh County in 2022 was stimulants, which contributed to 59.9% of overdose deaths.

For Northampton County, 67 overdose deaths were reported in 2022. The opioid class of drugs was the most common contributor to overdose deaths in Northampton County, accounting for 86.6% of all reported overdose deaths. As was the case in Lehigh County, fentanyl was the specific drug identified in virtually all opioid-related deaths in Northampton County; non-fentanyl opioids contributed to only 1.5% of overdose deaths in Northampton County.

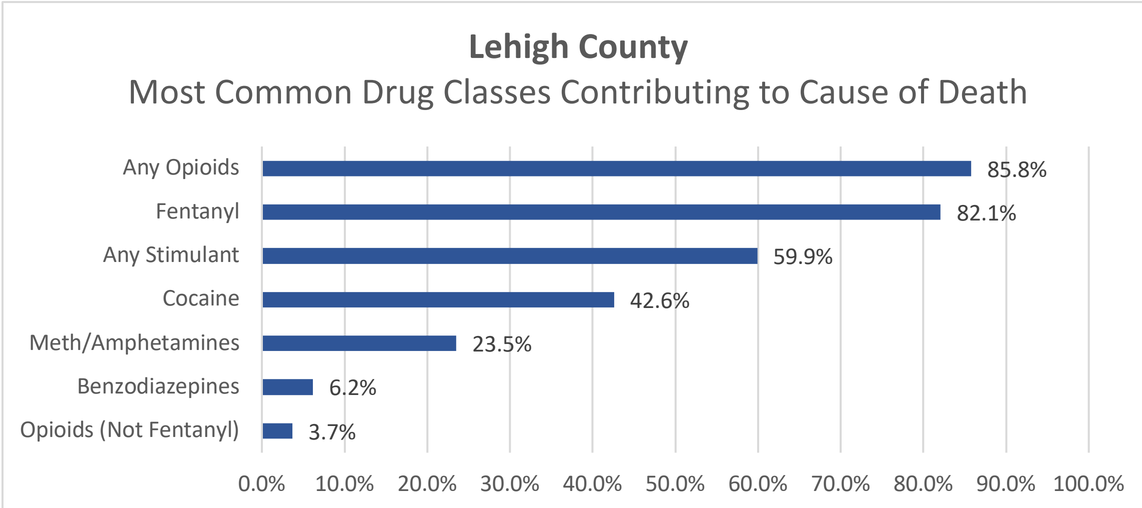
The top drugs present in 2022 drug-related overdose deaths for Lehigh County and Northampton County are shown in below.

Figure 31: Northampton County Overdose Statistics[179]



[179] Overdose deaths can involve more than one substance. Totals do not equal 100%.

Figure 32: Lehigh County Overdose Statistics



[180]

4.3.17.2. Range of Magnitude

Age

Tragically, drug overdoses disproportionately impact the younger generations in both Lehigh and Northampton Counties. In Northampton County in 2022, the 25-34 age group had the highest rate of visits to emergency departments for drug overdoses, at 12.53 per 10,000 visits. The second highest rate was the 15-24 age group, at 10.25 per 10,000 visits.[181] In Lehigh County, the rate of visits to an emergency department for a drug overdose among 15-24 year olds in 2022 was similar to that of Northampton County, at 10.83 per 10,000 visits. However, older age groups in Lehigh County had higher rates than their Northampton County counterparts. The 35-44 age group had the highest rate of overdose-related visits to an emergency department in Lehigh County in 2022, at 18.15 per 10,000 visits.

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[180] Pennsylvania Office of Drug Surveillance and Misuse Prevention. "Drug Overdose Surveillance Interactive Data Report." Tableau Software, July 2023. https://public.tableau.com/views/PennsylvaniaODSMPDrugOverdoseSurveillanceInteractiveDataReport/Contents?%3Adisplay_static_image=y&%3AbootstrapWhenNotified=true&%3Aembed=true&%3Alanguage=en-US&:embed=y&:showVizHome=n&:apiID=host0#navType=0&navSrc=Parse.

[181] Pennsylvania Office of Drug Surveillance and Misuse Prevention. "Drug Overdose Surveillance Interactive Data Report." Tableau Software, July 2023. https://public.tableau.com/views/PennsylvaniaODSMPDrugOverdoseSurveillanceInteractiveDataReport/Contents?%3Adisplay_static_image=y&%3AbootstrapWhenNotified=true&%3Aembed=true&%3Alanguage=en-US&:embed=y&:showVizHome=n&:apiID=host0#navType=0&navSrc=Parse.

The 25-34 age group had the second highest rate of 16.33 per 10,000 visits, followed by the 45-54 age group with 15.30 per 10,000 visits.[182]

Gender

Of the 5,150 drug overdose deaths reported across Pennsylvania in 2022, nearly 70% were reported as male. This indicates that male suffer fatal drug overdoses at a disproportionate rate, as males represented only 49% of the general population in Pennsylvania in 2022.[183]. This disproportionate impact is also noticeable within the Lehigh Valley. For both Lehigh and Northampton Counties, the general population is 49% male, but males comprise more than 70% of the overdose deaths in both counties. Additionally, the disproportionate impact on males has been a trend for at least a decade. Since 2013, the portion of overdose deaths involving a male in either county fluctuated between 62% and 75%.[184]

Race and Ethnicity

In 2022, approximately 69% of the 5,150 drug overdose deaths in Pennsylvania were identified as White, 24% were identified as Black, and 7% were identified as "all additional races" by the Pennsylvania Department of Health. Persons who identify as Asian, Native Hawaiian/Pacific Islander, American Indian/Alaska Native, and "other race" were included in the "all additional races" category. Interestingly, this data begins to diverge when looking specifically at the counties in the Lehigh Valley. Beginning with Lehigh County, the 2022 overdose deaths were identified as 72% white, 10% black, and 18% all other races. When compared to the U.S. Census data available for the region, the portions of overdose deaths in 2022 in Lehigh County identified as White or Black are smaller than the portions of the general population who identified as White (81%) or Black (11%). Troublingly, this also means that the portion of overdose deaths identified as "all other races" is more than double the size of their portion within the general population in Lehigh County (8%).

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[182] Pennsylvania Office of Drug Surveillance and Misuse Prevention. "Drug Overdose Surveillance Interactive Data Report." Tableau Software, July 2023. https://public.tableau.com/views/PennsylvaniaODSMPDrugOverdoseSurveillanceInteractiveDataReport/Contents?%3Adisplay_static_image=y&%3AbootstrapWhenNotified=true&%3Aembed=true&%3Alanguage=en-US&:embed=y&:showVizHome=n&:apiID=host0#navType=0&navSrc=Parse.

[183] U.S. Census Bureau. "U.S. Census Bureau QuickFacts: Pennsylvania," July 1, 2022. https://www.census.gov/quickfacts/fact/table/PA/PST045222.

[184] Pennsylvania Office of Drug Surveillance and Misuse Prevention. "Drug Overdose Surveillance Interactive Data Report." Tableau Software, July 2023. https://public.tableau.com/views/PennsylvaniaODSMPDrugOverdoseSurveillanceInteractiveDataReport/Contents?%3Adisplay_static_image=y&%3AbootstrapWhenNotified=true&%3Aembed=true&%3Alanguage=en-US&:embed=y&:showVizHome=n&:apiID=host0#navType=0&navSrc=Parse.

In Northampton County, the overdose deaths tell a slightly different story than in Lehigh County. In 2022, overdose deaths were identified as 85% White, 10% Black, and 5% all other races. This means that the portion of overdose deaths involving individuals identified as White is much closer to the portion of the general population in Northampton County identified as White (86%). The portion of overdose deaths identified as Black is slightly larger than the portion of Black persons within the general population of Northampton County (8%), and the portion of overdose deaths identified as all other races is slightly smaller than their portion within the general population (6%). Overall, the racial make-up of overdose deaths in Northampton County is roughly proportional to the general population, whereas Lehigh County has a disproportionate and significantly larger portion of drug overdoses attributed to individuals of all other races.

The Lehigh Valley also has a large Hispanic and Latino population. Nearly one sixth of the population of Northampton County identifies as Hispanic or Latino, and more than a quarter of the population in Lehigh County identifies as Hispanic or Latino. For Northampton County, overdose deaths attributed to individuals of Hispanic and Latino heritage accounted for 15% of the total overdose deaths in 2022, which is proportional to the overall Hispanic and Latino population in Northampton County. In Lehigh County, overdose deaths among individuals of Hispanic and Latino heritage represent 36% of overdose deaths in the county in 2022, which is significantly higher than the overall portion of residents in Lehigh County that identify as Hispanic or Latino. Individuals of Hispanic or Latino heritage account for approximately 1 in 4 people in Lehigh County, but they account for 1 in 3 overdose deaths in the county.

4.3.17.3. Past Occurrence

In 2018, Pennsylvania Governor Wolf declared the Heroin and Opioid epidemic a statewide disaster emergency on January 10th. This first-ever public health disaster declaration was meant to enhance state response, increase access to treatment, and save lives. A command center at the Pennsylvania Emergency Management Agency (PEMA) tracks progress and enhances coordination of health and public safety agencies.

4.3.17.4. Future Occurrence

One of the most important components in reducing drug-related overdose deaths is to prevent initial drug use. Therefore, the impact of education and prevention strategies in use today will be shown in future years. The DEA Philadelphia Field Division will continue efforts, in conjunction with law enforcement and public health partners, to define and address the factors impacting availability and abuse of illicit drugs and diverted pharmaceuticals in PA, and ultimately overdose deaths.

As evidenced by the upward trajectory of drug-related overdose deaths over the past several years throughout the Lehigh Valley, Pennsylvania and United States, the drug overdose hazard is likely to continue if something is not done. A crisis exists among law enforcement, public health entities, and educators to address drug availability, drug treatment and drug education.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for drug overdose events in the Lehigh Valley is considered 'highly likely' as defined in the Methodology Section.

4.3.17.5. Vulnerability Assessment

The drug overdose and addiction epidemic presents a unique and complex challenge to community lifelines, particularly in densely populated areas like the Lehigh Valley. This epidemic impacts various aspects of the community, including public health, safety, and social services. Here's how it affects different community lifelines as shown in the table below.

Table 73: Potential Vulnerabilities to Lifelines due to Drug Overdose Epidemic

Lifelines	Impact Type	Description
Safety & Security		Increased drug activity can lead to higher crime rates, including theft and violence, necessitating more robust law enforcement and community safety initiatives. Law enforcement agencies often work closely with community organizations to address the root causes and prevent the escalation of drug-related crimes.
Health & Medical		The overdose epidemic places a significant burden on healthcare systems, from emergency medical services responding to overdose incidents to hospitals and treatment centers dealing with the long-term health consequences of addiction. Mental health services also become increasingly vital.
Housing & Building Infrastructure		The overdose epidemic places a significant burden on healthcare systems, from emergency medical services responding to overdose incidents to hospitals and treatment centers dealing with the long-term health consequences of addiction. Mental health services also become increasingly vital.
Economic Stability		The economic impact includes the costs of healthcare, law enforcement, and social services, as well as broader effects on workforce productivity and local businesses.

Lifelines	Impact Type	Description
Community Services & Cohesion		Addiction can strain community resources, including schools, social services, and support programs. The epidemic can also impact community cohesion, creating stigmas and potentially leading to social isolation of affected individuals and their families.

The entire population of the Lehigh Valley is vulnerable to the drug overdose crisis. The rates of drug overdose deaths are continuing to increase. According to the CDC, in 2016, Pennsylvania had one of the top four highest observed drug overdose death rates in the country. The data provided in this section supports the need to create awareness and provide education to Lehigh Valley residents regarding this hazard of concern.

4.3.18 *Environmental Hazards / Explosion*

4.3.18.1. Location and Extent

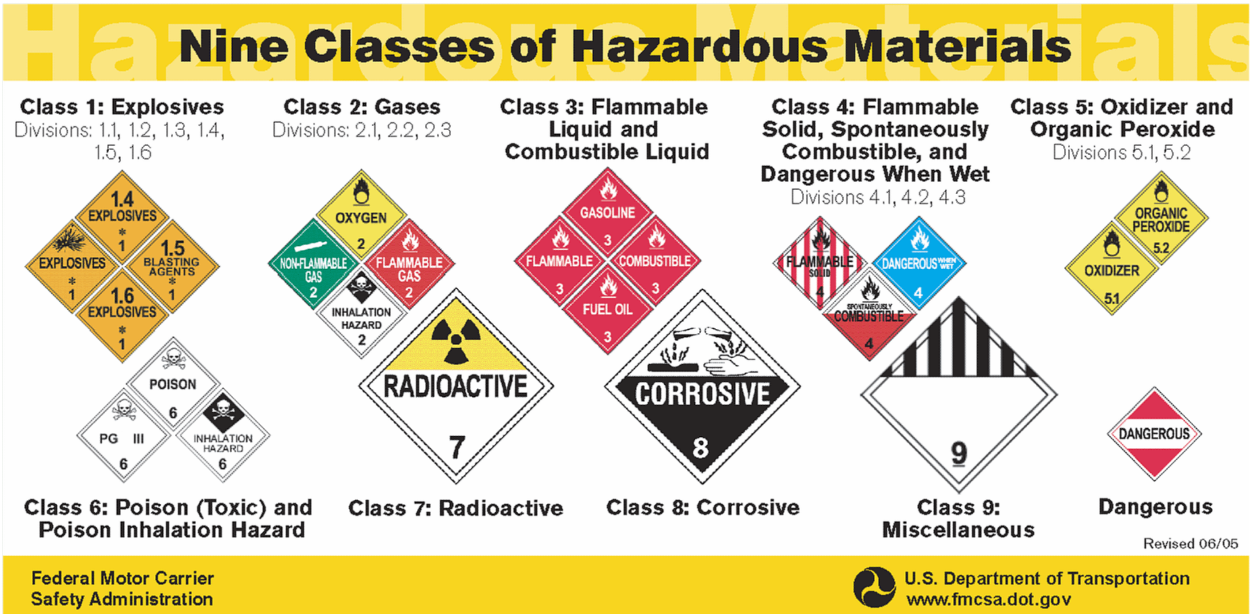
Hazardous material releases can contaminate air, water, and soils and have the potential to cause injury or death. Dispersion can take place rapidly when transported by water and wind. While often accidental, releases can occur as a result of human carelessness, intentional acts, or natural hazards. When caused by natural hazards, these incidents are known as secondary events.

Hazardous materials are substances that are considered severely harmful to human health and the environment, as defined by the United States Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The EPA designates nearly 800 substances as hazardous and identifies many more as potentially hazardous due to their characteristics and the circumstances of their release.[185] Therefore, it is critical for communities to understand the hazardous materials in their jurisdiction and take all reasonable steps to educate the public, reinforce safe handling, and prepare and practice a robust response to incidents involving hazardous materials.

Hazardous material releases pose threats to the natural environment, the built environment, and public safety. Hazardous materials can include toxic chemicals, infectious substances, biohazardous waste and any materials that are explosive, corrosive, flammable or radioactive. The U.S. Department of Transportation divides hazardous materials into 9 categories, and these are illustrated in Figure 33. An uncontrolled release of hazardous materials can occur virtually anywhere hazardous materials are present, including along transportation routes and at fixed-site facilities where hazardous materials are manufactured, used, or stored. Uncontrolled releases of hazardous materials can result in human and wildlife injury, property damage, and contamination of air, water, and soil.

[185] US EPA, OLEM. "CERCLA Hazardous Substances Defined." Overviews and Factsheets, April 10, 2019. https://www.epa.gov/epcra/cercla-hazardous-substances-defined.

Figure 33: Department of Transportation Classes of Hazardous Materials



The National Priorities Lists (NPL) is the 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. Revised annually, the NPL guides the EPA in determining which sites warrant further investigation. As of the date of this Plan, there are five sites in the Lehigh Valley listed on the NPL – three in Lehigh County and two in Northampton County.[186] Additionally, there are four sites which were once on the list but have been removed after sufficient remedial actions. Sites deleted from the NPL may still require five-year reviews to assess protectiveness.[187] Each NPL site receives a score on the EPA's Hazard Ranking System (HRS) corresponding to the potential of a hazardous substance spreading from the site through air, water, or soil, and the minimum score for placement on the list is 28.50.[188]

Table 74: National Priorities List (Superfund) Sites in the Lehigh Valley

NPL Sites in the Lehigh Valley

[186] US EPA, OLEM. "National Priorities List (NPL) Sites - by State." Data and Tools, June 27, 2023. Retrieved on 07/14/2023 from: https://www.epa.gov/superfund/national-priorities-list-npl-sites-state.

[187] US EPA, OLEM. "Superfund: NPL Deletion Guidance and Policy." Other Policies and Guidance, February 16, 2023. Retrieved on 07/14/2023 from: https://www.epa.gov/superfund/superfund-npl-deletion-guidance-and-policy.

[188] US EPA, REG 03. "Hazard Ranking System (HRS)." Overviews and Factsheets, April 3, 2023. https://www.epa.gov/norwood/hazard-ranking-system-hrs.

Site Name	County	HRS Score	Date Added to NPL
Heleva Landfill	Lehigh	50.23	09/08/1983
Novak Sanitary Landfill	Lehigh	42.31	10/04/1989
Rodale Manufacturing Co., Inc.	Lehigh	50.00	10/14/1992
Hellertown Manufacturing Co.	Northampton	51.91	03/31/1989
Industrial Lane	Northampton	42.47	09/21/1984

Table 75: Deleted National Priorities List (Superfund) Sites in the Lehigh Valley

Deleted NPL Sites in the Lehigh Valley			
Site Name	**County**	**HRS Score**	**Deletion Date**
Dorney Road Landfill	Lehigh	46.10	09/24/2018
Hebelka Auto Salvage Yard	Lehigh	31.94	09/20/1999
Reeser's Landfill	Lehigh	30.35	05/31/1990
Voortman Farm	Lehigh	28.62	05/31/1989

Hazardous materials are utilized for a wide variety of purposes, and it is not unprecedented for them to be found relatively close to residential areas. Concerns about this proximity contributed to Congress passing the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986. As part of the requirements set for by EPCRA for hazardous chemical storage reporting, facilities must submit annually an Emergency and Hazardous Chemical Inventory Form to the Local Emergency Planning Committees (LEPC), the State Emergency Response Commissions Contacts (SERC), or the Tribal Emergency Response Commissions (TERC), and the local fire department(s).

Many hazardous materials incidents occur during transportation. The Lehigh Valley contains a network of roadways linking large population centers within the region, and freight carries frequently utilize this network. Some of the freight transported to and through the Lehigh Valley is considered hazardous, and the presence of hazardous materials on the roads and railways inevitably creates the potential for these materials to be involved in transportation accidents. The exception is I-476, from Route 22 north to Route 209 in Carbon County, which is listed on the National Hazardous Materials Route Registry. The Registry prohibits passage of any explosives, poisonous substances, organic peroxides, and radioactive materials along this roadway. The movement of oxidizers and flammable, corrosive, and/or spontaneously combustible materials in bulk packaging is also prohibited.[189]

Hazardous Materials Regulations (49 CFR) require reporting of hazardous materials incidents which occur during transportation. Among other requirements, a qualifying incident must be reported to PHMSA through an Incident Report Form 5800.1 (Form 5800.1) within 30 days of the incident. These forms collect various information about an incident, and PHMSA maintains a public database containing the information gathered through the forms. According to PHMSA records, there have been 2,321 transportation incidents involving hazardous materials in the Lehigh Valley.

Table 76: Methods of Transportation Involved in Hazardous Materials Incidents in the Lehigh Valley Since 1971

Methods of Transportation Involved in Hazardous Materials Incidents			
County	**Highway**	**Rail**	**Air**
Northampton	1516	3	23
Lehigh	616	126	36

PHMSA records document 2,321 transportation incidents involving hazardous materials in the Lehigh Valley since 1971. Of these events, 1,542 (66%) occurred in Northampton County and 779 (34%) occurred in Lehigh County. In both counties, a significant majority of these incidents occurred via road transportation. Railway transportation accounts for approximately 15% of transportation incidents involving hazardous materials in Lehigh County, but railway transportation was involved in less than 1% of such incidents in Northampton County. Lastly, air traffic was involved in approximately 4% of incidents in Lehigh County and 1% in Northampton County.

[189] Pennsylvania Turnpike Commission (PTC). "Hazardous Materials Tunnel Restrictions | PA Turnpike." Accessed July 14, 2023. https://www.paturnpike.com/commercial/permits-restrictions/hazardous-materials-(placarded-loads).

4.3.18.2. Range of Magnitude

Hazardous material releases can contaminate air, water and soils, possibly resulting in death or injuries. Dispersion can take place rapidly when 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. Hazardous materials vary greatly in the types of health risks they pose to humans. Individuals who are exposed to hazardous materials may face one or more of the following health risks:[190]

Thermal harm: Thermal harm results from exposure to extreme temperatures. 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: Radiological harm results from exposure to radioactive materials. Different types of radiation have different energy levels, and not all types are dangerous. The most harmful types of radiation cannot be seen, felt, or smelled. The radiation that poses a threat to humans is ionizing radiation, which is strong enough to strip electrons from atoms and can damage living cells and DNA. Receiving a high dose of ionizing radiation in a short period of time can result in Acute Radiation Syndrome, while lower doses can increase the likelihood of cancer and other longer-term health conditions.

Asphyxiation: 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 can't supply enough oxygen to the body and the victim suffocates. Many asphyxiants (e.g., carbon dioxide, methane) are odorless and tasteless (unless odorants are added).

Chemical harm: 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. More information on the effects of exposure to different chemicals is available on the Department of Health and Human Services (HHS) Chemical Hazards Emergency Medical Management (CHEMM) website.

Etiological (biological) harm: Etiological (or biological) harm results from exposure to biological materials, which include bacteria, viruses, and biological 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.

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[190] Federal Emergency Management Agency. "Hazardous Materials Incidents," August 2019. https://www.fema.gov/sites/default/files/2020-07/hazardous-materials-incidents.pdf.

Mechanical harm: 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. Sources of injuries can occur fragmentation and flying debris, blast overpressure, and secondary blast injuries (such as being thrown into other objects). The degree of mechanical harm is closely related to the size of the blast and distance between the epicenter and the victim(s).

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

- Weather conditions that affect how the hazard occurs and develops
- Micro-meteorological effects of buildings and terrain that alters dispersion of hazardous materials
- Non-compliance with building or fire codes and maintenance failures such as fire protection and containment features
- Type of material(s) released
- Distance from emergency response teams
- Training of emergency response teams/familiarity with hazardous material(s) properties
- Accessibility of area

The areas within closest proximity to the releases are generally at greatest risk, yet depending on the agent, a release can travel great distances or remain present in the environment for centuries in the case of radioactive materials.

Environmental hazard incidents within the Lehigh Valley range from minor petroleum spills to large facility-based incidents that lead to the loss of life, property, environment and economy. Environmental hazard and explosion incidents can contaminate soil and surface water, and groundwater supplies can result in many direct impacts on surrounding ecosystems. Local flora and fauna within hazard areas are also at risk. The application of salt to de-ice roads may impact groundwater and contaminate potable drinking water sources near major highway corridors and state highway routes in the Lehigh Valley. The environmental impacts of hazardous material releases include:

- Hydrologic effects, such as surface and groundwater contamination
- Other effects on water quality such as changes in water temperature
- Damage to streams, lakes ponds, estuaries, and wetland ecosystems

- Air quality effects, such as pollutants, smoke, and dust
- Loss of quality in landscape
- Reduced soil quality
- Damage to plant communities, including loss of biodiversity and damage to vegetation
- Damage or death to animals, through the degradation of habitat, pollution of drinking water, loss of biodiversity or disease[191]

4.3.18.3. Past Occurrence

The Lehigh Valley's location between two major metropolitan areas provides for an increase in transportation of hazardous materials through rail, air and road. These routes of transportation combined with the large number of fixed facilities and end users of hazardous materials have provided for an incidence of frequent chemical and petroleum product releases with several being deemed as serious.

The region has been the location of several significant hazardous materials incidents. In 1999, a large containment vessel used to distill hazardous material ruptured, and the subsequent blast led to the deaths of 5 employees and 14 injuries. The explosion damaged numerous buildings within the industrial park as well as residential structures in the adjacent area. As a result of this incident, local zoning laws were changed, and additional resources were made available for utilization in future events. Furthermore, Pennsylvania amended Act 165, the Hazardous Materials Emergency Planning and Response Act. The changes in were implemented to enable planning, training and funding within local communities for facilities utilizing hazardous materials.[192]

Additionally, in March of 2009, Wind Gap Borough in Northampton County was impacted by the spill of hydrogen fluoride following a motor vehicle accident. The incident took place on Route 33 just south of the borough. A truck carrying more than 33,000 pounds of chemical products rolled onto its side, closing the road for hours and forcing 5,000 people to evacuate.[193]

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[191] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[192] U.S. Chemical Safety and Hazard Investigation Board. "The Explosion at Concept Sciences: Hazards of Hydroxylamine." *Process Safety Progress* 23, no. 2 (March 1, 2002). Retrieved on 07/14/2023 from: https://doi.org/10.1002/prs.10013.

[193] The Associated Press. "Chemical Spill Forces Evacuation in Pennsylvania." *The New York Times*, March 21, 2009, sec. U.S. Retrieved on 07/18/2023 from: https://www.nytimes.com/2009/03/22/us/22evacuate.html.

Another incident occurred in August 2011 on Interstate 78 near the Route 100 interchange. A tractor-trailer involved in a collision spilled more than 7,000 gallons of motor oil on the roadway and into the nearby soil and waterways.[194] This incident lasted approximately 18 hours, prompting Pennsylvania Department of Transportation to mill and resurface the roadway. In total, the initial response was able to collect just over 4,000 gallons of product, leaving almost 3,000 gallons for the state and environmental cleanup agencies to handle.

Since the passage of SARA Title III, facilities that produce, use, or store hazardous chemicals must notify the public through their county's emergency dispatch center and PEMA if an accidental release of a hazardous substance meets or exceeds a designated reportable quantity, and affects or has the potential to affect persons and/or the environment outside the facility. Table 77 shows the number of hazardous material incidents in the Lehigh Valley from 2018 through April 2023 as reported to PEMA's incident management system, PEMA Knowledge Center. The environmental hazard incidents reported to PEMA are not a comprehensive listing, as the reporting requirements from the state changed in 2007, allowing state agencies to categorize the incident as something other than "Hazardous Materials." For instance, a vehicle collision resulting in a spill of gas or motor oil may be reported as a vehicle accident instead of a hazardous materials release.

Table 77: Hazardous Material Incidents in the Lehigh Valley Reported to PEMA-KC 2018-2022

Year	Lehigh	Northampton
2018	24	220
2019	40	259
2020	57	452
2021	52	294
2022	42	244
TOTALS	**215**	**1469**

[194] Fire and Film. "Rollover Causes Large Oil Spill." *Fire and Film* (blog), July 29, 2011. Retrieved on 07/18/2023 from: https://www.fireandfilm.com/?p=388.

4.3.18.4. Future Occurrence

Due to the wide scope definition of environmental hazards, ranging from a small spill to a large release of a highly volatile or toxic hazardous material, incidents can and will happen at any time. While many hazardous materials release incidents have occurred in the Lehigh Valley in the past, they are generally considered difficult to predict. An occurrence is largely dependent upon the accidental or intentional actions of a person or group. Furthermore, recent trends indicate that the transportation of potentially hazardous materials to and through the Lehigh Valley is not likely to slow down in the near future. According to the Pennsylvania Department of Environmental Protection, there are multiple pipelines under development which will transit the Lehigh Valley.[195] Additionally, data from the U.S. Department of Transportation (DOT) reveals that 63,311 miles of pipeline was constructed across the U.S. in 2022, which is the most in a single year since DOT began tracking this in 2006. It is also a 70% increase from the total pipeline mileage constructed in 2021 (45,532 miles).[196]

The Lehigh Valley is also experiencing significant growth in the number of warehouses. The proliferation of warehouses is likely to lead to an increase in the volume of hazardous materials in the Lehigh Valley, and improper storage and handling of these materials can cause injuries and require an emergency response. It is recommended that warehouses maintain a detailed record of the materials which are being stored so that emergency responders can better understand what hazards may be present in the event that an emergency arises at a warehouse.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for environmental hazard/hazardous materials incidents in the Lehigh Valley is considered 'highly likely' as defined in the Methodology Section.

4.3.18.5. Vulnerability Assessment

Hazardous Materials (HazMat) incidents, such as chemical spills, gas leaks, or radiological hazards, can have serious implications for community lifelines, especially in areas like the Lehigh Valley with diverse industrial and transportation networks. These incidents can occur due to accidents, natural disasters, or, in rare cases, deliberate acts. Here's how HazMat incidents can impact various community lifelines shown below.

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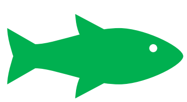
[195] Department of Environmental Protection. "Pennsylvania Pipeline Portal." Accessed July 18, 2023. Retrieved on 07/18/2023 from: https://www.dep.pa.gov:443/Business/ProgramIntegration/Pennsylvania-Pipeline-Portal/Pages/default.aspx.

[196] US DOT Pipeline and Hazardous Materials Safety Administration. "Oracle BI Interactive Dashboards - Public Reports," July 17, 2023. Retrieved on 07/08/2023 from: https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages&PortalPath=%2Fshared%2FPDM%20Public%20Website%2F_portal%2FPublic%20Reports&Page=New%20Construction.

Table 78: Potential Vulnerabilities to Lifelines from HazMat Incidents

Lifelines	Impact Type	Description
Safety & Security		HazMat incidents pose immediate threats to public safety, requiring prompt evacuation and emergency response. Law enforcement and HazMat response teams play a crucial role in securing the area, managing the situation, and preventing further harm.
Health & Medical		Exposure to hazardous materials can lead to acute and chronic health issues. Medical facilities need to be prepared to treat victims of such exposure, which may require specialized treatment and decontamination procedures.
Housing & Building Infrastructure		Chemical spills or gas leaks can lead to the contamination of buildings, requiring evacuation and extensive cleanup before they are safe for reoccupation. In severe cases, infrastructure may be permanently damaged.
Economic Stability		The economic impacts include the immediate costs of emergency response, cleanup, and potential fines, as well as longer-term effects on local businesses and industries, especially if the incident leads to a loss of public trust or environmental damage.
Environmental & Ecological Systems		Spills and leaks can have devastating effects on the environment, contaminating soil, water, and air, and harming wildlife. Cleanup and remediation efforts can be extensive and costly.

Overall, the Lehigh Valley's vulnerability has not changed since the 2018 Plan, and the region continues to be exposed and vulnerable to environmental hazards. Environmental hazards have the greatest impact on the residential population. The majority of incidents reported within the Lehigh Valley are the result of motor vehicle incidents or spills within a residential structure. In the Pennsylvania 2023 State Hazard Mitigation Plan, PEMA assessed the vulnerability of people and property in each Pennsylvania

County to hazardous materials incidents. All people and property within one-quarter mile of major interstates, U.S. highways, state highways, and railways, as well as those within 1.5 miles of hazardous materials sites were considered vulnerable. The findings of this assessment are listed in table below:

Table 79: Vulnerability of People and Buildings in the Lehigh Valley to Hazardous Material Releases

County	Vulnerable Population	Vulnerable Buildings	Value of Exposed Buildings (Thousand $)	Percent of County Building Value
Lehigh	263,454	86,643	$54,372,866	72%
Northampton	231,277	79,562	$43,528,554	74%

Damage to the surrounding environment can result in indirect impacts, such as temporary loss of function due to hazard response or damage in the area. Economic losses from environmental hazards range from non-recordable to those exceeding millions of dollars. Impacts on the local economy from a single incident are almost impossible to measure because of the complexities of predicting losses of work, revenue and future business.

4.3.19 Fire (Urban / Structural)

4.3.19.1. Location and Extent

Urban fire and explosion hazards include vehicle and building/structure fires as well as overpressure rupture, overheat, or other explosions that do not ignite. This hazard occurs in denser, more urbanized areas statewide and most often occurs in residential structures. Nationally, fires caused over 3,790 civilian fire deaths and 13,250 injuries in 2022. Furthermore, the deaths from residential fires constitute most fire deaths, accounting for 72% of all civilian fire deaths in 2022.[197] Statistically, urban fires are most likely to start because of human actions; in particular, cooking was identified as the cause of nearly 66% of residential fires in 2021.[198] For comparison, electrical malfunctions were identified as the cause of only 9% of residential fires in that same year.[199] Urban fires can also begin as a result of other hazards, such as storms, lightning strikes, drought, transportation accidents, hazardous material releases, criminal activity (arson), and terrorism.[200]

Urban fires are a more significant threat in areas where a relatively high number of buildings are more than 50 years old. Older residential structures that were built with lower standards for building construction and materials have created a regularly occurring threat of fire loss that. According to the US Census Bureau's 2017-2021 American Community Survey (ACS) 5-Year Estimates, more than half (51.1%) of the housing units in Northampton County were built before 1970, and more than 25% were built in 1939 or earlier. The same source estimates that 52.9% of all housing units in Lehigh County were built before 1970, and 24.2% were built in 1939 or earlier.[201] These data points reveal that more than half of all housing units in the Lehigh Valley are more than 50 years old.

4.3.19.2. Range of Magnitude

Structural fires in urban settings can vary significantly in their effects, which can range from minor smoke or water-related issues to the complete destruction of homes, businesses, and public spaces. In

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[197] NFPA Research. "Fire Loss in the United States." nfpa.org, October 31, 2023. https://www.nfpa.org/education-and-research/research/nfpa-research/fire-statistical-reports/fire-loss-in-the-united-states.

[198] U.S. Fire Administration. "Residential Building Fire Causes," April 28, 2023. Retrieved on 07/20/2023 from: https://www.usfa.fema.gov/statistics/residential-fires/causes.html.

[199] U.S. Fire Administration. "Residential Building Fire Causes," April 28, 2023. Retrieved on 07/20/2023 from: https://www.usfa.fema.gov/statistics/residential-fires/causes.html.

[200] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[201] U.S. Census Bureau American Community Survey 2017-2021. "DP04: SELECTED HOUSING CHARACTERISTICS," 2021. Retrieved on 07/18/2023 from: https://data.census.gov/table?g=040XX00US42_050XX00US42077,42095&tid=ACSDP5Y2021.DP04.

extreme cases, these fires can lead to significant injuries or even fatalities, displacing residents for extended periods.

The impact of such fires is partially determined by the type and significance of the structure. While a single home's destruction might have a limited economic effect, the loss of a large manufacturing facility, critical facility, or community resource can have extensive economic repercussions. Similarly, the environmental consequences of a residential fire might be negligible, but an industrial or commercial blaze can leave an environmental imprint that lasts for years.

Residential fires, given their timing and the materials often found in homes, pose a higher risk of fatalities compared to commercial or industrial fires. Most structural fires tend to be minor, predominantly impacting residential properties. These incidents are typically short-lived and fall within local jurisdictional control. Yet, it's crucial to recognize that the threat of larger, more destructive fires exists. Numerous industrial and commercial facilities in the area are susceptible to small fires, which, if not managed promptly, can escalate dramatically. Given the presence of volatile materials in many of these locations, the fire risks in the region are constantly evolving and amplifying.

Table 80: Reported Structural Fires in the Lehigh Valley, 2001 to 2022

Year	Lehigh County	Northampton County
2001	9	4
2002	5	2
2003	2	0
2004	2	0
2005	15	2
2006	16	7
2007	19	91
2008	10	73

2009	195	90
2010	194	135
2011	189	82
2012*	14	N/A
2013	16	82
2014	27	140
2015	21	96
2016	26	81
2017	21	62
2018	N/A	84
2019	N/A	40
2020	N/A	64
2021	N/A	39
2022	N/A	34
TOTAL	**781**	**1208**

Source: Lehigh and Northampton County Knowledge Center Databases 2017; *2012 data not available for Northampton County; 2018-2022 data not available for Lehigh County.

4.3.19.3. Past Occurrence

Since 2001, nearly 2,000 structural fires in the Lehigh Valley have been reported. Please note that due to archiving processes and reporting requirements prior to 2007, databases may not be complete and do not necessarily represent every structural fire that occurred. However, using these sources represents the most accurate probability estimates possible.

The Lehigh Valley has seen some notable fires since the turn of the century. In March of 2008, the City of Bethlehem, Northampton County reported a fire loss in a row of joined homes. The fire claimed the lives of four children, injured one child and injured four emergency workers, making the fire the second deadliest in the history of the City of Bethlehem.[202]

Plainfield Township experienced a catastrophic fire at an industrial site in 2011. The site provided the plastics industry with plastic, glass and metal separation and grinding services. In March of 2011, a fire was reported within the structure, which led to a five-county fire response that continued for more than 36 hours. At one point fire crews were using approximately 8,000 gallons of water per minute and special foam trucks from Lehigh Valley International Airport to extinguish the flames.[203] Once extinguished, the building and all products on-site were deemed a loss, with a total cost in excess of $9 million.

In April 2023, a massive fire broke out at a warehouse in West Easton. In addition to destroying the warehouse, the blaze also damaged several surrounding structures before firefighters were able to extinguish it. The response required hazmat crews because of the chemicals believed to be stored at the site, and the Pennsylvania Department of Environment performed air and water quality tests in the area. Despite more than 20 fire marshals from across the area being involved with the investigation, officials eventually determined that it was not safe or feasible to determine the specific cause of the fire.[204]

4.3.19.4. Future Occurrence

Human behavior significantly influences the occurrence of structural fires. While most fires will be considered small and may not cause any significant damage, the possibility of a catastrophic loss due to

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[202] 6abc. "Identities Released of Children Killed in Fire | 6abc Philadelphia | 6abc.com." 6abc Philadelphia. Retrieved on 07/19/2023 from: https://6abc.com/archive/6010703/.

[203] McClatchy-Tribune News Service. "Pa. Crews Battle Blaze at Plastics Recycling Plant." Firehouse, August 2, 2011. Retrieved on 07/19/2023 from: https://www.firehouse.com/home/news/10461672/pa-crews-battle-blaze-at-plastics-recycling-plant.

[204] McHugh, WFMZ-TV, Blakely. "'Investigation Came to a Pretty Abrupt Halt': Cause of West Easton Warehouse Fire Undetermined." WFMZ.com, May 23, 2023. https://www.wfmz.com/news/area/lehighvalley/investigation-came-to-a-pretty-abrupt-halt-cause-of-west-easton-warehouse-fire-undetermined/article_decd5064-f96f-11ed-8611-1b9e1aececb2.html.

fire is present. Minor urban fires can be expected every day, and research by the National Fire Prevention Association (NFPA) found that a U.S. fire department responds to a fire every 24 seconds.[205] Major fires will continue to occur several times a year, particularly in dense, urban areas with aging building stock. Future occurrence of structural fire is thus "highly likely" as defined in the methodology section.

In recent years, the number of warehouses and storage facilities in the Lehigh Valley has significantly increased, leading to an increase in fire-related risk since the 2018 plan. According to the Lehigh Valley Planning Commission (LVPC), the footprint of the warehouse industry grew from approximately 6 million sq. ft. in 2015 to more than 18 million sq. ft. in 2022.[206] An additional 4.2 million sq. ft. was approved in 2022, and this trend is expected to continue as the industry benefits from the Lehigh Valley's proximity to multiple major population centers. These warehouses can be used to store an enormous variety of cargo, some of which may be highly flammable. Fertilizers, batteries, household cleaning supplies, and many other household products can create significant risk of fire, and proper storage, surveillance, and handling of these items is necessary to reduce the possibility of mishaps. It is also important for warehouses to maintain a current and detailed record of their cargo so that first responders have an accurate understanding of hazards when responding to a fire.

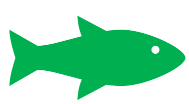
4.3.19.5. Vulnerability Assessment

Urban and structural fires, ranging from small-scale residential fires to large-scale industrial blazes, pose significant threats to the well-being and stability of the Lehigh Valley. These fires can result from various causes, including accidents, negligence, or, in some cases, arson. The impact of such fires on community lifelines is profound and multifaceted as shown below.

[205] National Fire Prevention Association, Marty Ahrens, and Birgitte Messerschmidt. "Fire Safety in the United States since 1980," 2021. Retrieved on 07/19/2023 from: https://www.nfpa.org/~/media/Files/News%20and%20Research/Fire%20statistics%20and%20reports/US%20Fire%20Problem/osNFPAEcosystemFireSafetyReport2021.ashx?utm_source=emil&utm_medium=email_medium&utm_campaign=emil0358&utm_content=mbrs&order_src=e827

[206] Lehigh Valley Planning Commission. "Data LV Development." lvpc.org, 2023. https://www.lvpc.org/data-lv-development.html.

Table 81: Potential Vulnerabilities of Lifelines due to Urban Fires

Lifelines	Impact Type	Description
Safety & Security		Fires pose immediate threats to life and property. Emergency services, including fire departments and law enforcement, are crucial for firefighting, evacuation, and maintaining public order. Ensuring the safety of residents and responders is the top priority.
Health & Medical		Fires can result in injuries from burns and smoke inhalation, necessitating emergency medical response and treatment. Healthcare facilities must be prepared for the sudden influx of patients during major fire incidents.
Housing & Building Infrastructure		Fires can destroy homes and businesses, leading to displacement and long-term housing needs for affected residents. The rebuilding process can be lengthy and complex, involving insurance claims, construction services, and community support.
Utilities		Fires can damage utility infrastructure, leading to disruptions in electricity, gas, water supply, and telecommunications. Restoring these services is critical for recovery and normalcy.
Environmental & Ecological Systems		Urban and structural fires can release pollutants and toxic materials into the environment, affecting air quality and potentially contaminating water and soil.

Structural fires frequently affect residential communities within the Lehigh Valley. While the impact of most structure fires is considered minimal due to the availability of support services, these fires need to be classified as a high threat due to the frequency and potential for injury and loss of life. A 2021 report from the NFPA concluded that while the U.S. experiences fewer fires than in past decades, statistically, individuals are more likely to die than they were 40 years ago if a fire is reported in their home.[207]

As population density grows in the Lehigh Valley, so does the risk of structural fires. The convergence of a rising population and closely-packed buildings amplifies this risk, making larger-scale fires more probable. Key areas of concern due to their dense nature include Alburtis, Allentown, Bangor, Bath, Bethlehem, Catasauqua, Coplay, Easton, Emmaus, Freemansburg, Fountain Hill, Hellertown, Macungie, Nazareth, Northampton, North Catasauqua, West Easton, and Wilson. The trajectory of the Lehigh Valley's development, both in residential and commercial spheres, is poised to further influence the threat of fires in the foreseeable future.

Furthermore, studies from the CDC and the National Center for Health Statistics highlight that certain demographics face higher fire-related mortality risks. Regions with elevated fire death rates often have a higher proportion of individuals who:

- Have a disability
- Have incomes below the poverty line
- Are current smokers
- Live in rural areas
- Are either African-American or Black or are Native American or Alaskan Native[208]

In 2021, the NFPA reviewed these risk factors for each U.S. state. For Pennsylvania, the results were comparable to the national averages.[209] The vulnerability of people and buildings to urban fires in each Pennsylvania county was also examined as part of the Pennsylvania 2023 State Hazard Mitigation Plan (SHMP). Within Northampton County, the 2023 SHMP concluded that 111,940 people and 38,243 buildings were vulnerable. The estimated total value of the vulnerable buildings in Northampton County was $16,857,284. For Lehigh County, the 2023 SHMP concluded that 181,377 people and 57,971

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[207] Lehigh Valley Planning Commission. "Data LV Development." lvpc.org, 2023. https://www.lvpc.org/data-lv-development.html.

[208] NFPA Research, and Marty Ahrens. "US Fire Death Rates by State," December 2021. Retrieved on 07/19/2023 from: https://www.nfpa.org//-/media/Files/News-and-Research/Fire-statistics-and-reports/US-Fire-Problem/osFireDeathsByStateTables.pdf.

[209] NFPA Research, and Marty Ahrens. "US Fire Death Rates by State," December 2021. Retrieved on 07/19/2023 from: https://www.nfpa.org//-/media/Files/News-and-Research/Fire-statistics-and-reports/US-Fire-Problem/osFireDeathsByStateTables.pdf.

buildings were vulnerable. The total value of the vulnerable buildings in Lehigh County was estimated to be $27,928,557.[210]

Ultimately, the potential for structural fire is not limited to any one area of the Lehigh Valley, but structures most at risk include the aging building stock constructed prior to established building codes. Vulnerability may increase over time as the building stock continues to age and population growth continues. However, existing structures becoming compliant with code and increasing fire service capabilities will help to reduce losses and overall risk. Also, continued efforts to increase public awareness of the dangers of urban fires will help to mitigate injury, death, and property loss.[211]

The secondary effects of urban/structural fire events relate to the ability of public, private and non-profit entities to provide post-incident relief. Human services agencies can be affected by fire events as well. Effects may consist of physical damage to facilities and equipment, disruption of emergency communications, loss of health and medical facilities and supplies and an overwhelming load of victims who are suffering from the effects of the urban fire, including loss of their home or place of business.

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[210] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[211] NFPA Research, and Marty Ahrens. "US Fire Death Rates by State," December 2021. Retrieved on 07/19/2023 from: https://www.nfpa.org//-/media/Files/News-and-Research/Fire-statistics-and-reports/US-Fire-Problem/osFireDeathsByStateTables.pdf.

4.3.20 Levee Failure

4.3.20.1. Location and Extent

Levees serve as vital barriers safeguarding the built landscape from the encroachment of floodwaters. These protective structures consist of a network of culverts, canals, ditches, storm sewers, or pump stations, collectively referred to as "interior drainage" systems. Their primary function is to channel excess water from the land side of the levee to the water side. However, when floodwaters rise beyond the height of the levee, a precarious situation arises, known as overtopping. During overtopping, water cascades over the levee's crest, posing a risk of erosion, exacerbating flooding, and potentially leading to a breach or opening in the levee's integrity. Levee breaches can manifest gradually or suddenly, with the most perilous breaches occurring swiftly during periods of high water. These catastrophic events can inundate large areas behind the compromised levee, often catching residents off guard and leaving minimal time for evacuation or property protection.

According to the National Committee on Levee Safety, properly functioning levees play a pivotal role in reducing the risk of flooding for communities they protect. However, the consequences of an unexpected levee breach or failure can be devastating. Such breaches result in loss of life, necessitate emergency evacuations, and offer insufficient time to mitigate property damages effectively.

FEMA conducted a comprehensive inventory of known levees throughout Pennsylvania in 2009, with subsequent updates in 2012, known as the Mid-Term Levee Inventory (MLI). This inventory encompasses data primarily related to structures designed to safeguard against the 1% annual chance flood event. The area protected by a maintained and certified levee designed to withstand this base flood is referred to as a Levee Protected Area. Notably, the MLI also includes information about levees not engineered to withstand the 1% annual chance event. Nevertheless, it's essential to recognize that the inventory may not encompass every levee in every county, especially smaller and agricultural levees that lack engineering or accreditation for the 1% annual chance event. FEMA's inventory compilation drew upon effective Flood Insurance Rate Maps, Flood Insurance Study reports in Pennsylvania, the US Army Corps of Engineers (USACE) levee inventory, summaries from the Pennsylvania Department of Environmental Protection (PADEP) Flood Control Projects, data from local governments, aerial imagery, as well as information from sources like news articles and websites.

There are four USACE levees or floodwalls in the Lehigh Valley: Allentown (Sewer Treatment Plant) Levee, Salisbury Levee, Allentown-Jordan Creek Floodwall and Bethlehem Levee System.

Complete levee failures, akin to dam failures, are relatively rare occurrences and are typically associated with heavy rainfall, storm surges, or hurricanes. When a levee fails, it can result in the inundation of previously protected land in its vicinity. The extent of this inundation hinges on the severity of the flooding event. During a 1% annual chance flood, a levee failure leads to the flooding of the approximately 100-year floodplain that was previously shielded by the levee. The most significant damage from the initial breach or overtopping of the levee typically affects residential and commercial buildings closest to the breach point, while properties farther inland may suffer damage due to inundation.

Ensuring the continued effectiveness of levees necessitates regular maintenance, upholding the level of protection they were originally designed to provide. The responsibility for maintenance falls upon various entities, including local, state, and federal governments, as well as private landowners. Well-maintained levees may earn certification through independent inspections, signifying their reliability in flood protection. However, when levee owners neglect maintenance or fail to undergo independent inspections, certification for flood protection may be withheld. The consequences of an uncertified levee are twofold: an elevated risk of levee failure and the potential for increased insurance rates, as FEMA designates on Flood Insurance Rate Maps that structures are not certified to withstand a 1% annual chance flood event.

4.3.20.2. Range of Magnitude

Levees introduce a spectrum of flood-related hazards, spanning from overtopping and water flowing around the back of the levee to catastrophic failures akin to what occurred during Hurricane Katrina. Levees are typically designed with three feet of freeboard to mitigate overtopping, though older levees may not adhere to this standard. The consequences of a levee failure hinge on the intended flood protection level and the degree of urban development in the area. In some cases, the impact of a levee failure can be more severe compared to a typical flooding event, particularly if the failure is sudden and leads to the rush of a flood wave, resulting in catastrophic losses.[212]

The most perilous scenario involves a levee failure that transpires abruptly with minimal warning, sending fast-moving floodwaters surging through densely populated or highly developed areas. Levees safeguarding extensive regions have the potential to cause the most significant damage. If a levee failure stems from overtopping, communities may struggle to detect the impending disaster and evacuate in time. In cases of sudden levee failures, evacuation may become virtually impossible.

The failure of the Allentown Sewer Treatment Plant Levee or the Salisbury Levee would primarily impact the facilities they protect, namely, the Allentown Sewer Treatment Plant and the Lehigh County Men's Community Correction Center. However, flooding of the Allentown Sewer Treatment Plant could affect a substantial population in and around the City of Allentown, potentially leading to widespread contamination of floodwaters and, if the contamination reaches a drinking water system intake, posing a threat to the drinking water supply. This might necessitate advisories for boiling water before use and restrictions on water usage. Flood damage to the Men's Community Correction Center could require evacuation of the facility.

Neither the Jordan Creek Floodwall nor the Bethlehem Levee System is accounted for on the official Digital Flood Insurance Rate Maps (DFIRMs). Consequently, the DFIRMs do not consider the existence of these levees in flood zone delineations. In the event of a failure during the 1% annual chance flood,

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[212] Pennsylvania 2023 State Hazard Mitigation Plan

floodwaters would extend to the areas identified on the DFIRMs as within the 1% annual chance floodplain, making a failure of either levee a worst-case scenario.

The environmental repercussions of a levee failure encompass significant challenges related to water quality and debris disposal. Sanitary sewer systems would back up, and wastewater treatment plants would be inundated, leading to the contamination of residential and commercial buildings and waterways with raw sewage. Floodwaters would carry the contents of unsecured containers containing oil, fertilizers, pesticides, and other chemicals. Water supplies and wastewater treatment facilities might remain offline for extended periods. After floodwaters recede, the proper disposal of contaminated and flood-damaged building materials and contents becomes imperative. Contaminated sediment must also be removed from buildings, yards, and properties. Additionally, levee failures can trigger landslides, bank erosion, and habitat destruction, compounding the environmental impact.

4.3.20.3. Past Occurrence

There have been no levee failures in the Lehigh Valley.

4.3.20.4. Future Occurrence

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for levee failure events in the Lehigh Valley is considered "unlikely" as defined in section 4.4.2.

4.3.20.5. Vulnerability Assessment

A 1% annual chance flood event would inundate the 1% annual chance floodplain that was previously safeguarded by the levee. Residential and commercial structures situated closest to the point of levee overtopping or breach would endure the most extensive damage from the initial floodwave resulting from the embankment failure. In a manner akin to dam failures, individuals residing within the inundation path and downstream of the levee face considerable risk and would necessitate evacuation in the event of a failure or breach.

Areas, structures, and populations situated downstream of a levee are inherently vulnerable should a failure occur. Furthermore, the failure of levees during a 1% annual chance flood event would lead to floodwaters reaching regions delineated on the Digital Flood Insurance Rate Maps (DFIRMs). Overall, the vulnerability of the Lehigh Valley remains unchanged since the 2018 Plan, with areas surrounding levees persisting as exposed and susceptible to the hazard of levee failures.

Regrettably, data pertaining to levee failure inundation areas was unavailable for conducting a spatial assessment to estimate potential impacts for the 2024 Plan.

Utilizing a 2,000-foot buffer, similar to the approach utilized in the 2023 State Hazard Mitigation Plan, an estimate of jurisdictional losses was computed. In Lehigh County, this translates to 5,686 impacted buildings with an exposure value for building and contents totaling approximately $1.4 billion. In Northampton County, the figures indicate 4,088 impacted buildings with an exposure value for building and contents amounting to about $935 million. It's essential to note that the building and exposure analysis considered only the 2,000-foot buffer, as not all levees possess designated Levee Protected Areas.

4.3.21 Nuclear Incident

4.3.21.1. Location and Extent

Nuclear hazards and incidents generally refer to incidents involving a release of significant levels of radioactive materials or the exposure of workers or the public to radiation. Nuclear explosions can cause significant damage and casualties from blast, heat, and radiation. Primary concerns following a nuclear incident or accident are the impact on public health from direct exposure to a radioactive plume, inhalation of radioactive materials, ingestion of contaminated food, water or milk. Long-term exposure to deposited radioactive materials in the environment can also lead to radiation sickness or death, or chronic health effects such as cancer.

The U.S. Nuclear Regulatory Commission (NRC) encourages the use of Probabilistic Risk Assessments (PRA) to estimate 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 radioactive core and that may challenge containment. The Federal Emergency Management Agency (FEMA), Pennsylvania Emergency Management Agency (PEMA), and county governments have formulated Radiological Emergency Response Plans to prepare for radiological emergencies at the five nuclear power-generating facilities in Pennsylvania. Each of these plans establish two Emergency Planning Zones (EPZ) around their site:

Plume Exposure Pathway EPZ – The first EPZ is a plume exposure pathway extending about 10 miles in radius around the reactor site. Protective action plans within this area are designed to avoid or reduce doses from potential exposures such as inhaling radioactive particles. These actions include sheltering, evacuation, and the use of potassium iodide pills where appropriate.

Ingestion Exposure Pathway EPZ – The second EPZ is an ingestion exposure pathway extending about 50 miles in radius around the reactor site. Protective action plans for this area are designed to avoid or reduce doses from eating or drinking radioactive materials. These actions include a ban of contaminated food and water.[213]

The Limerick Generation Station and the Susquehanna Steam Electric Station are both located outside the Lehigh Valley but maintain 50-mile ingestion exposure pathway zones that include parts of the region. Limerick is south of the Lehigh Valley in central Montgomery County, and Susquehanna is northeast of the region in Luzerne County. Limerick maintains two General Electric Mk 2 boiling water reactors (BWR) producing approximately 2,310 megawatts of power, which is enough energy to power

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[213] U.S. Nuclear Regulatory Commission. “Emergency Planning Zones.” nrc.gov, November 13, 2020. https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/planning-zones.html.

approximately 1.7 million homes.[214] Like Limerick, the Susquehanna nuclear power plant maintains two General Electric Mk 2 BWRs producing approximately 2,500 megawatts of power.[215]

Lehigh County maintains a nuclear planning annex to their Emergency Operations Plan (EOP), trains regularly, and completes exercise programs set forth by state and federal entities. Lehigh County, in support of Limerick, maintains two reception centers designed to provide residential population monitoring and decontamination. In addition, the state-designated regional trauma center—Lehigh Valley Health Network Cedar Crest Campus—is prepared to provide medical decontamination for the general public and emergency workers. These medical services require additional annual training and exercise programs.

4.3.21.2. Range of Magnitude

The magnitude of a nuclear incident differs between the Plume Exposure Pathway and the Ingestion Exposure Pathway. In the Plume Exposure Pathway, whole-body external exposure to gamma radiation from a radioactive plume and from deposited materials and inhalation exposure from the passing radioactive plume are possible. The duration of primary exposures could range in length from hours to days. In the Ingestion Exposure Pathway, potential exposure is primarily from ingestion of water or foods such as milk and fresh vegetables that have been contaminated with radiation.

Nuclear accidents themselves are classified into three categories[216]:

- **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 so that the coolant inventory in the system cannot be maintained by the normally operating system.
- **Loss-of-containment Accidents** - Involves the release of radioactivity from materials such as tritium, fission products, plutonium, and natural, depleted or enriched uranium. Previous points of release have included containment vessels at fixed facilities and damaged packages during transportation accidents.

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[214] Constellation Energy Generation, LLC. "Limerick Generating Station," January 2023. https://www.constellationenergy.com/content/dam/constellationenergy/images/location-sites/nuclear/Limerick%20Generating%20Station_Fact%20Sheet.pdf.

[215] Talen Energy. "About Susquehanna – Susquehanna Nuclear Site." Susquehannanuclear.com, 2022. https://susquehannanuclear.com/about-susquehanna/.

[216] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

All facilities are required to notify jurisdictional agencies of an incident or occurrence within the facility. PEMA, in coordination with the facility owners, has established notification levels that are based upon an internal trigger:

1. **Notice of Unusual Event (NOUE)** – A situation is in progress or already completed which could potentially degrade the plant's level of safety or indicate a security threat to the facility. No releases of radioactive material requiring offsite actions are expected unless safety systems degrade further. *Note: the terms Notification of Unusual Event and Unusual Event are used interchangeably.*

2. **Alert** – Events are in progress or have occurred which have (or could) substantially degrade the plant safety; or, a security event that could threaten site personnel or damage to site equipment is in progress. Any offsite releases of radioactive material that could occur are expected to be minimal and far below limits established by the Environmental Protection Agency's (EPA) protective action guides (PAGs).

3. **Site Area Emergency (SAE)** – Events are in progress or have occurred which have caused (or likely will cause) major failures of plant functions that protect the public, or involve security events with intentional damage or malicious acts that could lead to the likely failure of (or prevent effective access to) equipment needed to protect the public. Any offsite releases of radioactive material are expected to remain below EPA PAG exposure levels beyond the site boundary.

4. **General Emergency** – Events are in progress or have occurred which: a) have caused (or shortly will cause) substantial reactor core damage, with the potential for uncontrolled releases of radioactive material; or, b) involve security events that deny plant staff physical control of the facility. Offsite releases can be reasonably expected to exceed EPA PAG exposure levels beyond the plant.[217]

After a nuclear incident, the primary concern is the effect on the health of people near the incident. The duration of primary exposure could range in length from hours to months depending on the proximity to radioactive release. External radiation, inhalation, and ingestion of radioactive isotopes can cause acute health effects, cancers and psychological effects.

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[217] U.S. Nuclear Regulatory Commission. "Emergency Classification." nrc.gov, March 29, 2021. https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/emerg-classification.html.

The southern and northern regions of the Lehigh Valley are closest in proximity to Limerick and Susquehanna, respectively, but fall well outside the prescribed 10-mile evacuation zone for either facility. In the event of an incident within either of the locations, the Lehigh Valley could become a temporary staging location for the hundreds of thousands of residents needing to evacuate the 10-mile emergency planning zone. Additionally, jurisdictions found within the 50-mile ingestion exposure pathway could receive radioactive particles on crops, water and ground surfaces, rendering local agricultural harvest unusable for consumption by people or livestock.

4.3.21.3. Past Occurrence

While no fixed facility nuclear emergencies have occurred in the Lehigh Valley, Pennsylvania is home to the only recorded nuclear emergency in the US. In 1979, the Three Mile Island Nuclear Generating Station declared a General Emergency following an internal system failure. This event led to significant changes to the regulatory environment surrounding nuclear power plants, significant decline in public confidence in the nuclear industry, and a gradual decrease in the number of nuclear stations in the country. While reports show conflicting information on the medical impact on the residential population following the disaster, cleanup costs exceeded $1 billion.

The Limerick and Susquehanna plants have both experienced unplanned, sudden shutdowns – also known as scrams – of their nuclear reactors as recently as 2020. On May 3, 2020, the Susquehanna unit 1 reactor automatically shut down due to a trip of the main turbine. The reactor water level lowered to -1 inch causing Level 3 (+13 inches) isolation. However, the operations crew subsequently maintained reactor water level at the normal operating band, and neither the Emergency Core Cooling System nor Reactor Core Isolation Cooling were necessary.[218] This event was classified as a non-emergency by the NRC.

On November 13, 2020, the Limerick unit 1 reactor automatically shut down due to a valid Reactor High Pressure signal (1096psig). The NRC determined that the closure of the 1B Inboard Main Steam Isolation Valve (MSIV) caused the pressure within the reactor to rise until it exceeded the Reactor Protection System setpoint of 1096psig. Once the setpoint was exceeded automatic systems shut down the reactor, and the pressure was normalized via steam bypass valves. Like the scram at the Susquehanna plant in the same year, the 2020 scram at Limerick was classified as a non-emergency by the NRC. Despite the classification of non-emergency, both events were reported to NRC Resident Inspectors, Berks, Chester, and Montgomery Counties, as well as the Pennsylvania Emergency Management Agency.[219]

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[218] U.S. Nuclear Regulatory Commission. "Licensee Event Report Search." lersearch.inl.gov, May 3, 2020. https://lersearch.inl.gov/ENView.aspx?DOC::54691.

[219] U.S. Nuclear Regulatory Commission. "Licensee Event Report Search." lersearch.inl.gov, November 13, 2020. https://lersearch.inl.gov/ENView.aspx?DOC::54996..

4.3.21.4. Future Occurrence

Since the Three Mile Island incident, nuclear power has become significantly safer and is now one of the most heavily regulated industries in the nation. However, it is still possible for a similar accident to occur at one of the four nuclear generating facilities in the Commonwealth.

In 2010, the NRC conducted a study of all nuclear reactors across the country to quantify the risk of seismic activity damaging their cores. A review of this study shows that in any given year the Limerick reactors each have a 1 in 18,868 chance of experiencing seismic activity resulting in damage to the core, while the reactors at Susquehanna each have a 1 in 76,923 chance.[220] Across the 104 US nuclear reactors reviewed in the NRC study, the average risk of seismic activity damaging a reactor core in any given year is 1 in 74,176. These findings indicate that the seismic risk for the Limerick reactors is greater than the national average, and the seismic risk for the Susquehanna reactors is slightly below the national average. However, the NRC study concluded that there are no immediate concerns about seismic protection of US nuclear reactors, and no operational changes are needed.[221] Nuclear incident occurrences may also occur as a result of intentional actions. These acts are addressed in the Terrorism profile.

Due to the extreme rarity of nuclear emergencies in the United States and the complexity of safety regulations guiding the actions of nuclear facilities, the probability of occurrence for a nuclear incident which impacts the Lehigh Valley is 'unlikely'.

4.3.21.5. Vulnerability Assessment

A nuclear incident, such as a reactor malfunction, radiological contamination, or a nuclear power plant accident, can have far-reaching and long-lasting impacts on community lifelines. In an area like the Lehigh Valley, which has diverse populations and infrastructure, the effects of such an incident can be particularly complex. Here's how a nuclear incident might impact various community lifelines.

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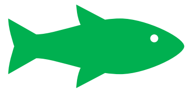
[220] Dedman, Bill. 2011. "What Are the Odds? US Nuke Plants Ranked by Quake Risk." NBC News. March 16, 2011. https://www.nbcnews.com/id/wbna42103936.

[221] U.S. Nuclear Regulatory Commission. "Quake NRC Risk Estimates," March 16, 2011. https://web.archive.org/web/20170525170632/http:/msnbcmedia.msn.com/i/msnbc/Sections/NEWS/quake%20nrc%20risk%20estimates.pdf.

Table 82: Potential Vulnerabilities of Lifelines due to Nuclear Incident

Lifelines	Impact Type	Description
Safety & Security		Immediate concerns revolve around ensuring public safety, including evacuations, controlling access to affected areas, and preventing unauthorized entry. Law enforcement and emergency services play critical roles in managing the situation and maintaining public order.
Health & Medical		A nuclear incident poses serious health risks due to radiation exposure. This requires emergency medical response, specialized treatment for radiation sickness, and long-term health monitoring of affected populations. Healthcare facilities need to be equipped with the necessary resources and training to handle such cases.
Housing & Building Infrastructure		Depending on the severity and proximity of the incident, buildings and homes may become uninhabitable due to radiological contamination, leading to displacement of residents and long-term housing challenges.
Utilities		Utilities, especially water supply, can be contaminated by radioactive materials. Ensuring the safety and functionality of energy and water services is paramount. Communication networks are vital for disseminating information and coordinating response efforts.
Transportation Services		Transportation networks may be disrupted, particularly in evacuation zones. Roads may be closed, and public transportation could be halted or rerouted to facilitate evacuation and prevent exposure.

Lifelines	Impact Type	Description
Environmental & Ecological Systems		A nuclear incident can have devastating effects on the environment, including long-term contamination of land, water, and air, and harm to wildlife and ecosystems.

Most of the Lehigh Valley jurisdictions are identified as vulnerable to nuclear incidents due to their proximity to the Limerick Generating Station and the Susquehanna Steam Electric Station. These jurisdictions will continue to be vulnerable as long as these facilities operate. Jurisdictions that fall within the 10-mile EPZ and 50-mile ingestion zones have the greatest vulnerability to an incident within the facility. All of Lehigh County and all municipalities except for Portland Borough and Upper Mt. Bethel Township in Northampton County are located within the 50-mile ingestion zone of the Limerick Generating Station.

The following Lehigh County jurisdictions are within the Susquehanna Steam Electric Station 50-mile ingestion zone:

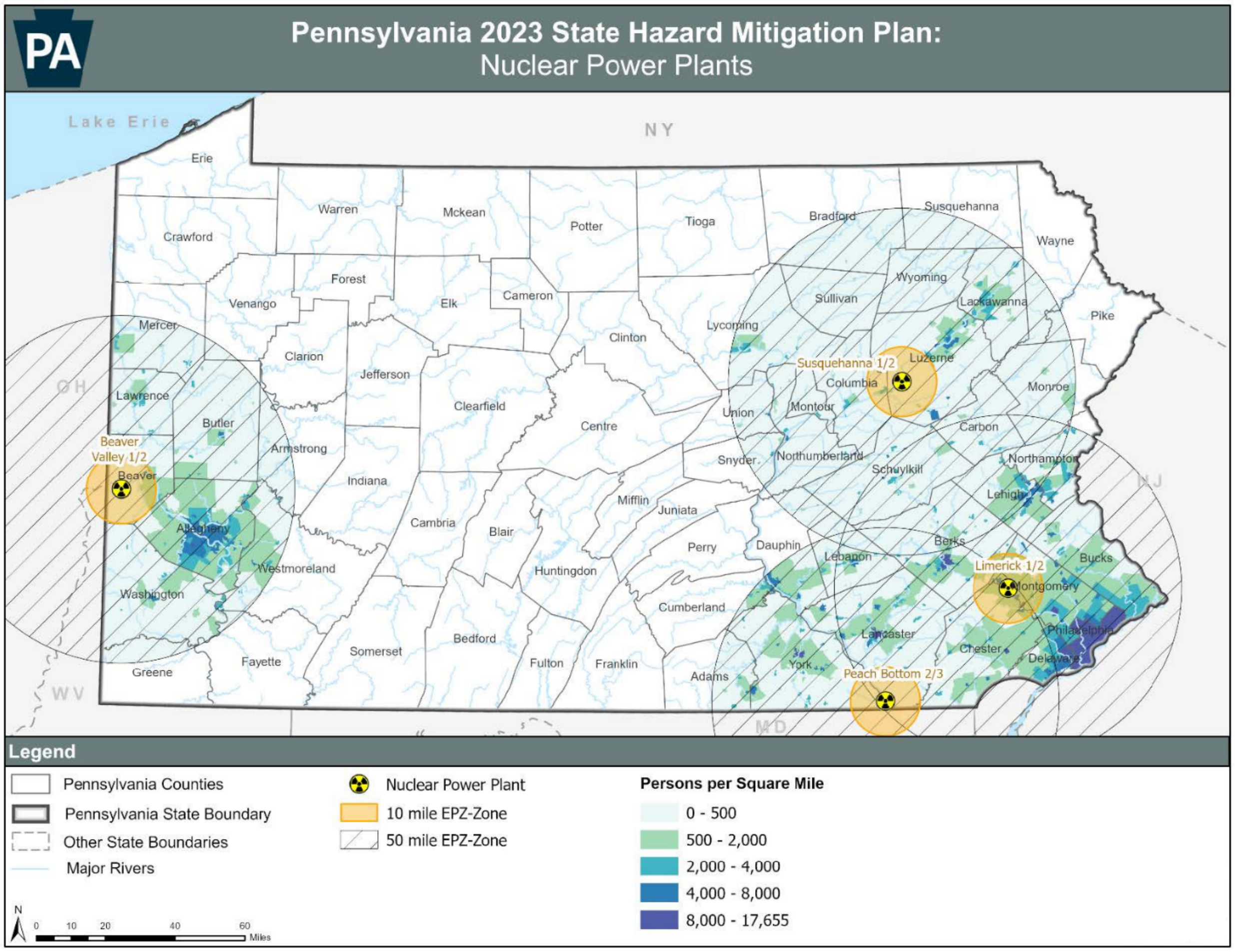
- Alburtis Borough
- City of Allentown
- City of Bethlehem
- Catasauqua Borough
- Coplay Borough
- Hanover Township
- Heidelberg Township
- Lowhill Township
- Lower Macungie Township
- Lynn Township
- Macungie Borough
- North Whitehall Township
- Salisbury Township
- Slatington Borough
- South Whitehall Township
- Upper Macungie Township
- Washington Township
- Weisenberg Township
- Whitehall Township

The following Northampton County jurisdictions are within the Susquehanna Steam Electric Station 50-mile ingestion zone:

- Allen Township
- Bath Borough
- City of Bethlehem
- Bushkill Township
- Chapman Borough
- East Allen Township
- Hanover Township
- Lehigh Township
- Lower Nazareth Township
- Lynn Township
- Moore Township
- Northampton Borough
- North Catasauqua Borough
- Nazareth Borough
- Pen Argyl Borough
- Plainfield Township
- Upper Nazareth Township
- Walnutport Borough

- Wind Gap Borough

Figure 34: Map of Nuclear Power Plants and their Emergency Planning Zones



In the Lehigh Valley, if an incident were to occur at the Limerick Station, Emmaus High School and Southern Lehigh High School are identified reception centers. Additionally, evacuation routes away from the Limerick Generating Station go through Lehigh County.[222] The Lehigh Valley may experience an influx in population due to residents evacuating areas closer to the nuclear facilities.

Within the Lehigh Valley, there are 716 critical facilities which are within the 50-mile radius EPZs of the Limerick and Susquehanna power plants. All the facilities within the Susquehanna EPZ also are within the Limerick EPZ, but not vice-versa, as illustrated in Figure 34.

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[222] Constellation Energy. "Emergency Planning for the Limerick Area," 2022. https://www.constellationenergy.com/content/dam/constellationenergy/pdfs/2023_2024_English_Limerick.pdf.

Table 83: Critical Facilities within EPZs in the Lehigh Valley by County

	Critical Facilities / Infrastructure within Susquehanna ***and*** Limerick EPZs	**Critical Facilities /** Infrastructure within only Limerick EPZ	**TOTALS** (by county)
Northampton County	150	320	470
Lehigh County	179	67	246
TOTALS (by EPZ)	**329**	**387**	**716**

Table 84: Type and Count of Critical Facilities within EPZs in the Lehigh Valley

Type of Critical Facility / Infrastructure	**Number of** Assets within Limerick and Susquehanna EPZs	Number of Assets within Only Limerick EPZ
Airports	2	1
Bus Facilities	2	2
Communications	12	22
Electric Power Facilities	3	5
Emergency Operations Centers	17	22
Fire Stations/EMS	63	59
Hazardous Materials Facilities	65	116
Medical Care Facilities	16	12
Police Stations	20	32

Type of Critical Facility / Infrastructure	Number of Assets within Limerick and Susquehanna EPZs	Number of Assets within Only Limerick EPZ
Potable Water Facilities	1	2
Railway Facilities	1	2
Schools	117	107
Wastewater Facilities	10	5
TOTALS	**329**	**387**

To manage this vulnerability, Lehigh and Northampton counties maintain a radiological emergency response plan in accordance with the regulations set forth by the NRC and PEMA. The plan addresses actions that are to be taken to mitigate and respond to a possible radiological release. In support of the radiological response plan, Lehigh County participates in a variety of exercises designed to validate the planning found within the county documents. These exercises run once every five years for all counties within the 50-mile ingestion zone.

In addition to these exercise programs, Lehigh County participates annually in the Medical Service Agreement (MS-1) radiological decontamination-training program. The MS-1 program provides classroom and practical training to emergency medical services in areas of decontamination and patient handling. Additionally, the MS-1 designated hospitals receive two training sessions focusing on proper patient management and levels of care. At the completion of these training programs each year, the staff at both the hospital and EMS agency are provided with the opportunity to validate plans, policies and training levels through a full-scale exercise program. The exercise is federally evaluated once every seven years, with the remaining six years being evaluated by PEMA.

Due to the higher number of potentially exposed critical facilities, Northampton County has a higher vulnerability to nuclear incidents than Lehigh County, although both jurisdictions have hundreds of critical facilities within the 50-mile radius EPZs of the Susquehanna and Limerick power plants. As for the specific types of critical facilities exposed, schools are the most common (224), followed by hazardous materials facilities (181) and fire/EMS stations (122). The exposure of schools in the Lehigh Valley is particularly concerning as many students may be dependent on others for transportation, and parents may surge to these locations in an effort to reach their children. This may lead to significant congestion on the roads which could make evacuations more difficult for everyone. Likewise, a significant number of fire and EMS stations may need to be evacuated, and this has the potential to temporarily limit the availability of first responders. Although the likelihood of a nuclear power plant suffering an incident severe enough to prompt widespread evacuations is exceedingly rare, such an event could be catastrophic for the Lehigh Valley.

4.3.22 *Structural Collapse*

4.3.22.1. Location and Extent

Collapse of a building or structure refers to the loss of the load-carrying capacity of a component of the structure or the entire structure itself. Structural collapse can range from the failure of a single load-bearing element, weakening the structure, to the failure of all load-bearing elements, bringing about a complete collapse.

Based upon building age, construction type, maintenance and modification, structural collapses could happen anywhere within the limits of the Lehigh Valley. In addition, incidents of structural collapse may be reported as a cascading event following the identification of another incident. For example, a water main break under a residence may cause the failure of any of its load bearing elements.

4.3.22.2. Range of Magnitude

Following any type of collapse, partial or complete, the development of additional cascading effects must be anticipated. Building construction utilizes load bearing and non-load bearing voids to house transmission lines for gases, liquids and other products based upon the use of the structure. The failure of any of these elements can create the release of an unwanted material into the environment either from utilities such natural gas, water or electricity or used in the building's construction, such as sheetrock dust or asbestos.

In winter storm events, critical facility buildings are vulnerable to widespread utility disruptions, including loss of heat and electricity, as well as building collapse or damage from downed trees. Structural vulnerability frequently depends on the age of the structure in question and its roof pitch. The older the structure, especially the roof, the less snow load it can handle. Similarly, roofs with a more gradual pitch are less able to have snow and ice slide off of them, increasing the weight of snow and ice sitting on top and thus the potential for damage.

The structural collapse of bridges can have severe impacts. First and foremost, the collapse of a bridge can cause severe bodily harm or death among individuals on, below, or near the structure at the time of collapse. Bridge collapses can also interrupt traffic flows by eliminating or reducing access across - as well as below - the structure. This can increase the vulnerability of nearby residents to additional hazards if they are unable to access critical facilities, and emergency responders may have reduced access to those in need of assistance. Negative economic impacts can also emerge if a bridge collapse interrupts traffic flows along major transit routes such as interstates and shipping lanes.

4.3.22.3. Past Occurrence

Historical records for the Lehigh Valley, submitted annually to the state, note two incidents of structural collapse, not generated as a cascading impact from a separate incident, over the past two decades. In 2006, while constructing a new apartment building in Upper Macungie Township, Lehigh County construction crews reported a catastrophic failure of the structure. No injuries resulted from this incident. In 2007, a ceiling within a commercial building in Bangor Borough, Northampton County failed, temporarily trapping four individuals.

In addition to stand-alone incidents, some notable structural failures based upon other incidents have caused significant damage within the Lehigh Valley. Lehigh County has been home to notable structural collapses suspected of being generated from incidents such as water main breaks or sinkholes. The most notable of these incidents happened in 1994 in the City of Allentown. A commercial structure valued at more than $9 million was impacted by a large sinkhole, which caused the failure of systems within the structure. Following unsuccessful mitigation attempts, the structure was imploded to minimize any additional damage to surrounding structures.

Similar to Lehigh County, Northampton County has also been impacted by structural collapses based upon cascading events. In 2008, a large sinkhole at an apartment complex in Hanover Township forced the evacuation of more than 40 residents. The incident caused the failure of load bearing walls within the structures, ultimately leading to the demolition of the two buildings. In addition, the City of Easton evacuated an apartment complex in 2004 following the development of a large sinkhole. The structure sustained partial failure of load bearing elements forcing the relocation of 25 residents. Additional information on land subsidence (sinkhole) frequency can be found in the Subsidence / Sinkhole profile.

There have been two notable bridge collapses within the Commonwealth of Pennsylvania since 2021. On January 28, 2022, the 447-foot-long Fern Hollow Bridge in Allegheny County fell approximately 100 feet into the ravine below. At the time of its collapse, there were four passenger vehicles and a bus on the bridge, and 10 people were injured in the collapse. Thankfully, there were no fatalities, and the Pittsburg Bureau of Fire Chief stated that it was fortunate that the bridge collapse occurred before the morning rush hour.[223] The NTSB issued a primary report on February 7, 2022, but this did not identify any cause(s) of the collapse. At the time of writing the 2024 Lehigh Valley Hazard Mitigation Plan, the NTSB has not provided a final report identifying the events and conditions which led to the collapse of the Fern Hollow Bridge. The Philip J. Fahy Memorial Bridge in the City of Bethlehem uses a rigid K frame design similar to what was used for the Fern Hollow Bridge. The similarity of the design led PennDOT to review the structural adequacy of the Philip J. Fahy Memorial Bridge, along with 4 other bridges in Pennsylvania, immediately after the collapse of the Fern Hollow Bridge. PennDOT assessed the condition of the bridges as "fair" and did not require posting weight restrictions. However, the cause of the Fern Hollow Bridge Collapse has not been officially determined, and officials in the Lehigh Valley should watch for any updates from the NTSB which may be relevant to the Philip J. Fahy Memorial Bridge.

On June 11, 2023, an overpass along I-95 in Philadelphia collapsed after a truck hauling gasoline crashed and started a fire underneath the overpass. The heat from the fire caused the northbound lanes of I-95 to collapse, and the southbound lanes of I-95 were significantly damaged. The NTSB is investigating the

[223] Wadas, Amy. "Bridge Collapse: Family of Victims Share Story." https://www.wdtv.com, January 29, 2022. https://www.wdtv.com/2022/01/29/bridge-collapse-family-victims-share-story/.

incident, and the exact mechanism(s) of the collapse have not been determined.[224] The Pennsylvania Transportation secretary estimated that, prior to its collapse, 160,000 motorists crossed the segment each day, and motorists had to utilize a 43-mile detour after the collapse.[225] Officials in the Lehigh Valley should consider the possibility of a similar event unfolding along major transit routes like I-476 and I-78.

4.3.22.4. Future Occurrence

Structural collapse within the Lehigh Valley is generally considered as a cascading event following another incident. The regional geography, geology and age of infrastructure leave it prone to incidents such as land subsidence, which based upon location can lead to a partial to total structural collapse. Aging infrastructure is a pervasive issue across most of the country. As part of its 2023 State Hazard Mitigation Plan, PEMA assessed the condition of two categories of bridges in each Pennsylvania county:

1. Bridges on state route system, length 8’ or greater
2. Bridges on local route system, length 20’ or greater

PEMA identified 472 bridges in Lehigh County and 445 bridges in Northampton County. 66 bridges in Lehigh County (14%) and 65 bridges in Northampton County (15%) were considered structurally deficient in PEMA’s review.

To help communities understand infrastructure conditions in their state, the American Society of Civil Engineers (ASCE) provides annual report cards with letter grades for each state. Overall, the ASCE gave Pennsylvania a grade of C-, which is on par with the surrounding states. However, the ASCE notes in their report that Pennsylvania has the ninth largest bridge inventory in the nation and the second highest number of “poor condition” bridges.[226]

Based on the Lehigh and Northampton County Emergency Management Agencies’ operational viewpoint, the probability of occurrence for structural collapse events in the Lehigh Valley is considered ‘possible’ as defined in the Methodology Section.

4.3.22.5. Vulnerability Assessment

Structural collapse incidents, such as the failure of buildings, bridges, or other significant structures, can have a profound impact on communities like the Lehigh Valley. These collapses may occur due to

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[224] National Transportation Safety Board. “Combination Vehicle Fire and Interstate 95 Overpass Collapse.” NTSB, June 29, 2023. https://www.ntsb.gov/investigations/Pages/HWY23FH014.aspx.

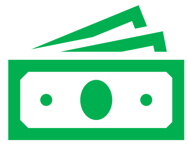
[225] Ron Todt. “Section of Heavily Traveled I-95 Collapses in Philadelphia after Tanker Truck Catches Fire.” AP News, June 12, 2023. https://apnews.com/article/philadelphia-interstate-i95-highway-collapse-fire-a90c5e3dd85de025050229bb6a37b780.

[226] American Society of Civil Engineers. “Pennsylvania Infrastructure | ASCE’s 2021 Infrastructure Report Card.” November 15, 2022. https://infrastructurereportcard.org/state-item/pennsylvania/.

various reasons, including design flaws, construction errors, natural disasters, or lack of maintenance. The consequences of such incidents can disrupt multiple community lifelines.

Table 85: Potential Vulnerabilities to Lifelines from Structural Collapses

Lifelines	Impact Type	Description
Safety & Security		Immediate efforts focus on search and rescue operations to locate and assist survivors. Emergency services, including firefighters and police, play a crucial role in securing the site, managing the situation, and ensuring public safety.
Health & Medical		Victims may suffer from injuries ranging from minor to life-threatening. Emergency medical services are crucial for on-site treatment and transporting the injured to hospitals. Medical facilities must be prepared for a sudden influx of patients.
Housing & Building Infrastructure		A structural collapse can result in significant property damage, leading to displacement of residents or businesses. Rebuilding and repair efforts are often extensive and require coordination between various agencies and organizations.
Utilities		Collapsed structures can disrupt utility services, including electricity, gas, water, and telecommunications. Restoring these services is essential for recovery and normalcy.
Transportation Services		Transportation networks can be impacted, especially if major roads, bridges, or transit hubs are involved. This can hinder access for emergency responders and affect the mobility of residents.

Lifelines	Impact Type	Description
Economic Stability		Economic impacts include direct costs associated with emergency response, rescue operations, property loss, and rebuilding. Indirect costs may arise from disruptions to business operations and transportation networks.

Virtually any area with development across the Lehigh Valley continues to be exposed and vulnerable to the structural collapse hazard. All infrastructure, commercial and industrial businesses, and residential structures within the Lehigh Valley are vulnerable to loss due to structural collapse whether due to a cascading event or a catastrophic structural failure. This vulnerability is compounded due to the ground composition, which is prone to subsidence throughout much of the region.

Following the initial events of a structural collapse, residents and businesses may be displaced. Depending on the type of structural collapse, it could cause disruption to the local economy, housing and healthcare access.

With any type of collapse, additional impacts should be anticipated. Structures can house transmission lines for gases, liquids and other products such as sheetrock dust and asbestos, which could be released into the environment during a failure.

4.3.23 Terrorism

4.3.23.1. Location and Extent

Terrorism is a widespread threat in today's world. While there is no universal definition of terrorism, the Federal Bureau of Investigation (FBI) identifies two general types of terrorism and differentiates them through the following definitions[227]:

International terrorism: Violent, criminal acts committed by individuals and/or groups who are inspired by, or associated with, designated foreign terrorist organizations or nations (state-sponsored).

Domestic terrorism: Violent, criminal acts committed by individuals and/or groups to further ideological goals stemming from domestic influences, such as those of a political, religious, social, racial, or environmental nature.

FEMA defines the three primary goals of terrorism as (1) causing public fear, (2) convincing citizens that the government cannot protect against terrorism, and (3) making the motivating causes known to the public.

Terrorism can take many forms, and may include armed attacks, the use of improvised or professional weapons of mass destruction such as chemical, biological, radiological, nuclear and high-yield explosive weapons, and industrial sabotage such as cyber-terrorism, and other means. Additionally, terrorists may harbor a wide range of personal, political, or cultural agendas. The range of motivations driving such heinous activity unfortunately means that virtually any location could be a potential target for terrorists. Therefore, evaluating at-risk locations as well as the hazards associated with terrorism involves numerous factors, including the presence of internationally, nationally, or regionally significant facilities, landmarks, or other structures.

According to FEMA, military installations, civilian government facilities, international airports, major urban areas, and high-profile landmarks are categorized as high-risk targets.[228] Additionally, large public assemblies, water and food resources, utility systems, and corporate hubs can also be targeted.

4.3.23.2. Range of Magnitude

The impact of terrorist events is influenced by a wide variety of factors including, but not limited to, the method of attack, the proximity of the attack to people, animals, or other assets, and the duration of

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[227] Federal Bureau of Investigation. "Terrorism." Folder. fbi.gov. Accessed October 31, 2023. https://www.fbi.gov/investigate/terrorism.

[228] Federal Emergency Management Agency. "Terrorism." fema.gov, November 3, 2004. https://www.fema.gov/pdf/areyouready/terrorism.pdf.

exposure to the incident or attack device. Terrorist attacks can take many forms, but FEMA identifies the following as being among the common tactics of terrorism:

- Agriterrorism (food contamination or destruction of crops via pest introduction or disease agents)
- Arson/incendiary attack
- Armed attack
- Assassination
- Biological agent
- Chemical agent
- Cyberterrorism
- Conventional bomb
- Hijackings
- Intentional hazardous material release
- Kidnapping
- Nuclear bomb
- Radiological agent

The threat of international terrorism continues to be a concern, and there is evidence that the threat of domestic terrorism in the U.S. is increasing. According to U.S. Government Accountability Office (GAO), domestic terrorism-related investigations have grown by 357% over the past 10 years.[229] In the summer of 2020, the Center for Strategic and International Studies (CSIS) conducted a detailed analysis of the targets and tactics used by domestic terrorists carrying out attacks in the U.S. since 1994. As part of its analysis, CSIS organized domestic terrorist attacks into three categories: right-wing, left-wing, and religious terrorism. It is important to note that terms like right-wing and left-wing terrorism do not—in any way—correspond to mainstream political parties in the United States. Instead, terrorism is orchestrated by a small minority of extremists, and the categories used in CSIS's analysis are defined as[230]:

"Right-wing" terrorism: Refers to the use or threat of violence by sub-national or non-state entities whose goals may include racial or ethnic supremacy; opposition to government authority; anger at women, including from the involuntary celibate (or "incel") movement; and outrage against certain policies, such as abortion.

"Left-wing" terrorism: Refers to the use or threat of violence by sub-national or non-state entities that oppose capitalism, imperialism, and colonialism; advocate black nationalism; pursue environmental or

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[229] U. S. Government Accountability Office. "The Rising Threat of Domestic Terrorism in the U.S. and Federal Efforts to Combat It | U.S. GAO." Gao.gov, March 2, 2023. https://www.gao.gov/blog/rising-threat-domestic-terrorism-u.s.-and-federal-efforts-combat-it.

[230] Jones, Seth G., Catrina Doxsee, and Nicholas Harrington. "The Tactics and Targets of Domestic Terrorists," July 30, 2020. https://www.csis.org/analysis/tactics-and-targets-domestic-terrorists.

animal rights issues; espouse pro-communist or pro-socialist beliefs; or support a decentralized social and political system such as anarchism.

“Religious” terrorism: Refers to the use or threat of violence in support of a faith-based belief system, such as Islam, Judaism, Christianity, and Hinduism. The primary threat from religious terrorists in the United States comes from Salafi-jihadists inspired by the Islamic State and al-Qaeda.

After organizing U.S. domestic terrorist events into one of the categories listed above, the CSIS analysis examined the number of attacks, target(s), and tactic(s) of each event. This data was then used to gain an overall understanding of the characteristics and trends of each of the three categories of domestic terrorism. For right-wing domestic terrorists, attacks between 1994 and 2020 most frequently targeted abortion-related facilities and women’s health clinics. During the same time span, left-wing domestic terrorism primarily targeted businesses, particularly those associated with the lumber, meat, and fur industries. Finally, religious domestic terrorist attacks in the U.S. between 1994 and 2020 most frequently targeted government, military, and police facilities[231]. When carrying out attacks, explosives and incendiary devices were the most common tool used by right-wing terrorists, being utilized in 50% of their attacks. Left-wing terrorists tended to favor firearms, which were utilized in 81% of their attacks. Explosives and firearms were equally utilized by religious domestic terrorists, with each accounting for 31% of such attacks.[232]

Terrorism events can cause public fear regarding the use of mass transportation or leaving home in the event of a biological or nuclear attack. Communication systems, both public and private, can fail because of an overwhelming amount of usage or damage to its infrastructure. Healthcare facilities can become quickly inundated and must be prepared to triage injured patients, handle mass casualties and conduct decontamination operations. The secondary hazards resulting from a terrorist attack depend on the size and scope of the incident. Some possible secondary hazards include widespread utility failure, health effects such as epidemics or pandemics, flooding if a dam is destroyed, and environmental contamination.

The worst-case scenario for a terrorism event in the Lehigh Valley – as well as many other communities across the country – would be the detonation of a “dirty bomb” within a major population center like Allentown. As defined by the U.S. Nuclear Regulatory Commission (NRC), a dirty bomb is a type of radiological dispersal device that combines a conventional explosive with radioactive material. The blast generated by conventional explosives is far weaker than that of a traditional nuclear weapon, and the primary purpose of a dirty bomb is to spread radioactive material across an area ranging from a few

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[231] Jones, Seth G., Catrina Doxsee, and Nicholas Harrington. “The Tactics and Targets of Domestic Terrorists,” July 30, 2020. https://www.csis.org/analysis/tactics-and-targets-domestic-terrorists.

[232] Jones, Seth G., Catrina Doxsee, and Nicholas Harrington. “The Tactics and Targets of Domestic Terrorists,” July 30, 2020. https://www.csis.org/analysis/tactics-and-targets-domestic-terrorists.

blocks to a few miles.[233] In the event of a dirty bomb being used within the Lehigh Valley, the extent of local contamination would depend on a number of factors including the location of detonation, size of the blast, the amount and type of radioactive material used, and the weather conditions.

The NRC notes that most dirty bombs would not release enough radiation to kill people or cause severe illness – rather, the conventional explosive itself would be more harmful to personal health than the radioactive material(s) released. However, the detonation of a dirty bomb could cause widespread fear and panic, and a substantial amount of time and energy would likely be required to decontaminate the affected area and restore a sense of normalcy.

4.3.23.3. Past Occurrence

There has been a high consciousness of terrorist activity due to the few catastrophic events experienced across the country. Fortunately, the Lehigh Valley has not experienced any terrorist attacks approaching the magnitude of the Boston Marathon bombing or the attacks on September 11, 2001. However, violence that was suspected to be or resembled terrorist activity of a lesser degree has been documented in the Lehigh Valley. One of the worst armed attacks to have occurred in the region took place in June 2019 when 10 people were shot while waiting outside of a nightclub in Allentown. Police eventually determined that the shooting was targeted rather than indiscriminate, possibly involving gang activity.[234] Other reported terrorism events are detailed in the table below.

Table 86: Reported Terrorism Events in the Lehigh Valley 2018-2023 To-Date

Year	Active Shooter	Bomb threat/ Bomb found	Hostage situation	Suspicious Activity / device / package	Terroristic Threat	TOTALS
2018	0	11	0	4	ND	**15**
2019	0	14	0	5	16	**35**
2020	0	12	2	11	5	**30**

[233] U.S. Nuclear Regulatory Commission. "Backgrounder on Dirty Bombs." nrc.gov, February 23, 2022. https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-dirty-bombs.html.

[234] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

2021	0	6	0	5	9	**20**
2022	0	10	0	1	3	**14**
2023 TD	2	9	0	2	0	**13**
NOTES: Data received from Northampton WebEOC and reflects best available data 2023 To-Date runs through 09/04/2023 ND = not documented Events may reflect suspected terrorism events which have not yet been confirmed through the U.S. legal system.						

4.3.23.4. Future Occurrence

The U.S. government, including the FBI and the Department of Homeland Security, continually reviews and evaluates intelligence and information from multiple sources to ensure it appropriately identifies and categorizes national security threat, including those that are criminal in nature, to the Homeland. In 2011, the Department of Homeland Security replaced the Homeland Security Advisory System (HSAS) with the National Terrorism Advisory System (NTAS). The intent of NTAS is to communicate information about existing terrorist threats by providing timely, detailed information to the American public. Through this system, the Department of Homeland Security provides assessments of the current threat environment pertaining to acts of terrorism targeting U.S. citizens. As of the writing of the 2024 Lehigh Valley Hazard Mitigation Plan, the latest NTAS bulletin was published on May 24, 2023. The latest bulletin states:

“The United States remains in a heightened threat environment. Lone offenders and small groups motivated by a range of ideological beliefs and personal grievances continue to pose a persistent and lethal threat to the Homeland. Both domestic violent extremists (DVEs) and those associated with foreign terrorist organizations continue to attempt to motivate supporters to conduct attacks in the Homeland, including through violent extremist messaging and online calls for violence. In the coming months, factors that could mobilize individuals to commit violence include their perceptions of the 2024 general election cycle and legislative or judicial decisions pertaining to sociopolitical issues. Likely targets of potential violence include US critical infrastructure, faith-based institutions, individuals or events associated with the LGBTQIA+ community, schools, racial and ethnic minorities, and government facilities and personnel, including law enforcement."[235]

The bulletin issued on May 24, 2023 is set to expire on November 24, 2023, and officials in the Lehigh Valley will monitor future bulletins for operationally relevant information. Renewed instability in the middle east and continuing hostilities around the globe could alter the Department of Homeland Security's general assessment of the risk of terrorism events in the U.S. Prediction of terrorist attacks is almost impossible because terrorism is a result of human factors. As long as fringe groups maintain radically different ideas than that of the government or general population, terrorism is a possibility.

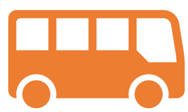
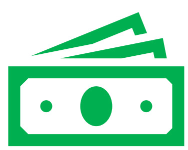
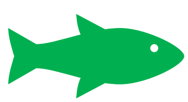
4.3.23.5. Vulnerability Assessment

Terrorism, characterized by deliberate acts of violence intended to create fear and achieve specific ideological, religious, or political objectives, can have devastating impacts on communities like the Lehigh Valley. The nature of these incidents can vary widely, from bombings and shootings to cyber-attacks and other forms of violence. The impacts of terrorism on community lifelines are significant and multifaceted.

Table 87: Potential Vulnerabilities to Lifelines due to Terrorism

Lifelines	Impact Type	Description
Safety & Security		Immediate response involves ensuring public safety, managing the scene, and preventing further attacks. Law enforcement and emergency services are crucial for securing the area, conducting investigations, and maintaining public order.
Health & Medical		Terrorist incidents can result in casualties and injuries, necessitating prompt medical response and treatment. Hospitals and emergency medical services must be prepared for the sudden influx of patients and potential mass casualty situations.

[235] Department of Homeland Security. "National Terrorism Advisory System Bulleting May 24, 2023." dhs.gov, May 24, 2023. https://www.dhs.gov/sites/default/files/ntas/alerts/23_0524_S1_NTAS-Bulletin-508.pdf.

Lifelines	Impact Type	Description
Housing & Building Infrastructure		Depending on the attack's nature, buildings and infrastructure can be damaged or destroyed, leading to displacement and long-term housing needs for affected residents.
Utilities		Terrorist attacks may target or inadvertently affect utility infrastructure, leading to disruptions in electricity, water supply, and communications. Quick restoration of these services is crucial for recovery and normal operations.
Transportation Services		Transportation networks, including roads, public transit, and airports, may be disrupted or targeted in terrorist attacks. This can impede emergency response efforts and the movement of people and goods.
Economic Stability		The economic impact of terrorism includes direct costs of damage and emergency response, as well as broader effects on local and regional economies, such as disruptions to trade and tourism.
Environmental & Ecological Systems		Certain types of attacks, like those involving hazardous materials, can have environmental impacts, contaminating air, water, and soil.

All communities in the Lehigh Valley are vulnerable on some level, directly or indirectly, to a terrorist attack. However, as the largest population center in the region, Allentown and the adjoining communities are the most vulnerable to terrorist attacks due to the size of the urban area, density of the population, and concentration of critical infrastructure located there. Additionally, the largest airport in the Lehigh Valley is nearby, and attacks on this location could interrupt logistics at a regional or even national level due to the facility being a major operation center for both Amazon and FedEx.

To reduce their vulnerability to terrorist activities, Lehigh and Northampton counties are part of the Northeast Pennsylvania Regional Counter-Terrorism Task Force, which is a group of eight counties that collaborate to prevent, prepare for and respond to terrorism and other hazards on a regional level. As of 2019, the Task Force capabilities include 8 SWAT teams, 3 HAZMAT teams, 3 bomb disposal teams, and 2 urban search and rescue teams.[236] This organization, like the other regional task forces in Pennsylvania, is funded by PEMA using the US Department of Homeland Security's State Homeland Security Program. The counties use this funding to conduct emergency planning, training and exercise activities, and to purchase equipment to reduce the region's vulnerability to terrorism.

[236] Pennsylvania Emergency Management Agency, and Northeast Pennsylvania Regional Counter-Terrorism Task Force. "Homeland Security: A Return on Our Investment," January 14, 2019. https://www.pema.pa.gov/Documents/Regional-Task-Force-ROI/Northeast-ROI.pdf.

4.3.24 *Transportation Crash*

4.3.24.1. Location and Extent

Transportation accidents are defined by PEMA as accidents involving highway, air, and rail travel. In their Pennsylvania 2023 State Hazard Mitigation Plan, PEMA noted that transportation accidents were costlier than any other hazard in Pennsylvania in terms of lives lost, injuries, and economic losses.[237] Pennsylvania has the fifth largest state highway system in the U.S., which is larger than the state highway systems of New York, New Jersey, and New England combined. Portions of Pennsylvania's highway system cut through the Lehigh Valley, and the metropolitan area of Allentown, as well as others nearby like Philadelphia and New York City, generates a steady volume of traffic using the roads in the Lehigh Valley. The Lehigh Valley Planning Commission (LVPC) estimated that, collectively, road traffic in the Lehigh Valley travels 14.3 million miles each day.[238] The traffic in the Lehigh Valley is not limited to daily commuters, as the region is identified by the LVPC as the fastest-growing corridor in the nation for warehousing and logistics.[239]

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[237] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[238] Lehigh Valley Planning Commission and Lehigh Valley Transportation Study. "FutureLV Regional Plan." lvpc.org, November 2019. https://lvpc.org/pdf/2020/FutureLV%20Website/FutureLV%20Regional%20Plan.pdf.

[239] Lehigh Valley Planning Commission and Lehigh Valley Transportation Study. "FutureLV Regional Plan." lvpc.org, November 2019. https://lvpc.org/pdf/2020/FutureLV%20Website/FutureLV%20Regional%20Plan.pdf.

Figure 35: High Traffic Corridors in the Lehigh Valley

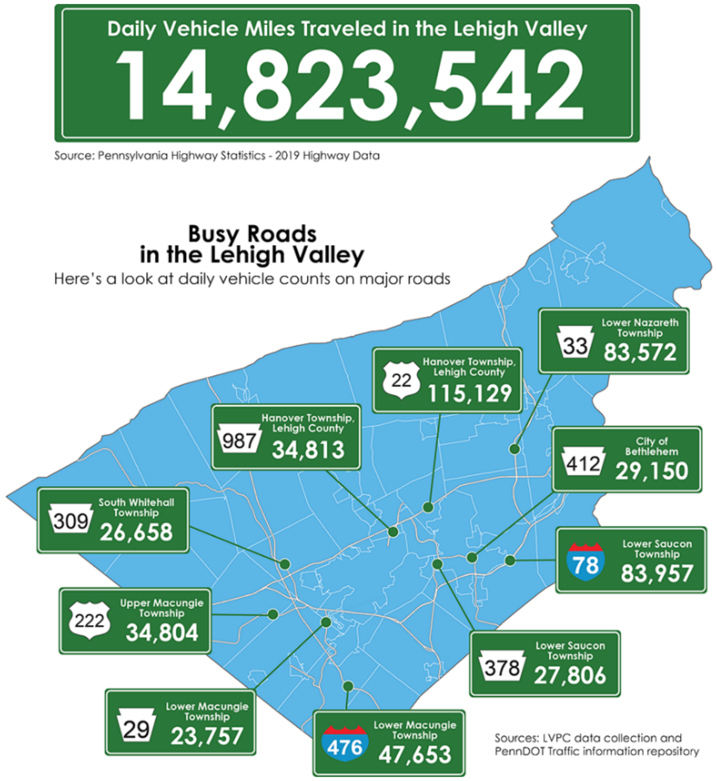
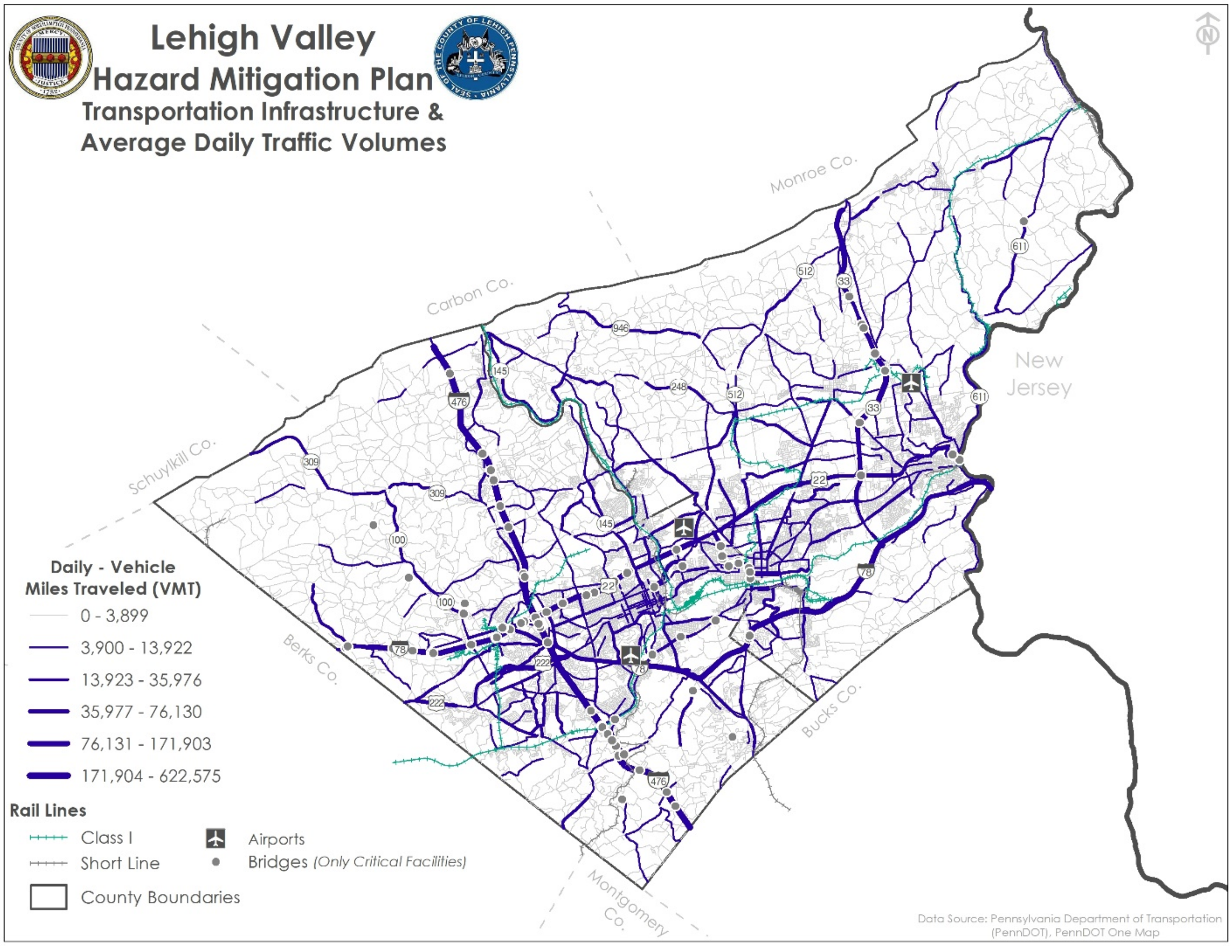


Table 88: Average Daily Traffic Volume in the Lehigh Valley



Some parts of the Lehigh Valley have experienced a statistically disproportionate number of automobile crashes. As part of the LV Traffic Safety Plan 2016, the Lehigh Valley Planning Commission and the Lehigh Valley Traffic Study reviewed the areas where crashes most frequently occurred, and they were able to identify 17 high-crash corridors and 10 high-crash intersections. These corridors and intersections are listed in the tables below. It is important to note that at the time these corridors and intersections were identified, improvements were underway for Route 22 and Route 145.

Table 89: High Crash Corridors in the Lehigh Valley

Road Name	From	To	Municipality	On TIP*
Schoenersville Rd.	Weaversville Rd.	Hanover Ave.	Hanover (LC) and (NC)	No

Road Name	From	To	Municipality	On TIP*
Route 248	W. Mountain View Dr.	Walnut Dr.	Lehigh	Yes
Route 329	Mauch Chunk Rd.	Bellview Rd.	N. Whitehall	No
Route 222	Dorney Park	Prior to Rt. 100 Interchange	S. Whitehall, Lower Macungie, Upper Macungie	No
Route 29, Chestnut St.	PA Turnpike	Mill Rd.	Upper Milford	No
Kings Highway	Zionsville Rd.	Palm Rd.	Lower Milford	No
Tilghman St.	Poplar St.	Airport Rd.	Allentown	No
Route 22	MacArthur Rd.	Lehigh River Bridge	Whitehall, Hanover (LC)	Yes
William Penn Hwy	Stones Crossing Rd.	S. Greenwood Ave.	Palmer	No
Rt 222 & Schantz Rd	Schantz Rd.	Independent Rd.	Upper Macungie	Yes
Route 145	Riverview Dr.	Main St.	Lehigh, Walnutport	No
Cedar Crest Blvd.	Albright Ave.	Tilghman St.	S. Whitehall, Allentown	No
15th St.	Tilghman St.	Hamilton Blvd.	Allentown	No
Lehigh St.	Jefferson St.	Oxford Dr.	Allentown	No

Road Name	From	To	Municipality	On TIP*
Center St.	W. Broad St.	Church St.	Bethlehem (NC)	No
East Susquehanna St.	Seidersville Rd.	Fretz Ave.	Salisbury	No
4th Street Corridor	Normandy St.	Gordon St.	Allentown	No
*TIP = Transportation Improvement Program. Data is from LV Traffic Safety Plan 2016				

Table 90: High Crash Intersections in the Lehigh Valley

Location	Municipality
Freemansburg Ave. – Coolidge St. – Willow Park Rd	Bethlehem (Twp.)
I-78 at Morgan Hill Road Interchange	Williams
Main Street and W. Union Blvd	Bethlehem (LC) and (NC)
Nazareth Park – Hanoverville Rd. – Hecktown Rd. – Schlegel Ave.	Lower Nazareth
Park Ave. and Oakwood Lane	Washington (LC), North Whitehall
Riverview Drive and Birch Road	Lehigh, North Whitehall
Rose Inn Ave. and Robin Drive	Bushkill
Route 22 at Nazareth Pike Interchange	Bethlehem (Twp.)
Route 873 – Mountain Road	Lehigh
South 4th St. and West Federal St.	Allentown

The Lehigh Valley also experiences rail traffic, although this has been limited to freight traffic since 1981.[240] Norfolk Southern owns a majority of the railways in the Lehigh Valley, and Norfolk Southern also operates most of the freight trains that travel on these rails. There are a few small sections of rail - particularly around Bethlehem – that are owned by other entities, although these entities do not operate any significant rail traffic.

The Lehigh Valley's main public airport is the Lehigh Valley International Airport. The airport is approximately 4 miles northeast of Allentown, and it has been supporting commercial air service since 1935. Data made available by the Lehigh-Northampton Airport Authority, which owns and operates the airport, indicates that 912,256 passengers used the airport in 2022.[241] The airport is also frequently used by freight carriers. It is one of eleven U.S. locations supporting Amazon Air, and FedEx Ground recently built its largest terminal in the country adjacent to the airport to enhance its operations. Considering the number of commercial air traffic flyovers that occur every day, there exists a potential extent for air transportation accidents statewide. However, a five-mile radius around each airport can be considered a high-risk area since most aviation incidents occur near take-off and landing sites.

4.3.24.2. Range of Magnitude

The circumstances and consequences of transportation accidents can vary greatly, but most accidents tend to be relatively minor. However, the potential for major transportation accidents cannot be fully eliminated, and it is important to acknowledge this reality so that it does not catch a community off-guard. Most motor vehicle crashes are non-fatal in Pennsylvania, but PennDOT estimates that every hour nine people are injured in a car crash, and every seven hours someone dies as a result of a car crash.[242] Most air incidents are non-fatal and cause minor injuries or property damage, but they have the possibility to cause widespread damage in a worst-case scenario. Areas impacted by transportation accidents involving trains are typically more limited than road or air accidents, but an event such as the derailment of a freight train transporting hazardous materials through a populated area can have severe impacts on people and property. This threat of hazardous materials is discussed in more detail in section 4.3.18.

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[240] Lehigh Valley Planning Commission. "Lehigh Valley Rail Freight Study 2007." lvpc.org, August 2007. https://lvpc.org/pdf/lehighValleyRail/railFreightStudy2007.pdf.

[241] Lehigh-Northampton Airport Authority. "Lehigh Valley International Airport Monthly Traffic Report January 2023." flyabe.com, January 2023. https://cdn.flyabe.com/wp-content/uploads/sites/2/2023/06/06091343/traf1-23.pdf.

[242] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

4.3.24.3. Past Occurrence

The Pennsylvania Department of Transportation (DOT) publishes yearly reports containing data on transportation crash statistics. According to the most recent report, there were 38,146 documented crashes within the Lehigh Valley between 2018 and 2022. The DOT report also documents 238 fatalities which occurred as a result of these crashes. It is notable that in 2020 both counties recorded the lowest yearly crash totals during the 2018–2022 time frame, and this could be a reflection of lower overall traffic following the outbreak of COVID-19. Conversely, the yearly fatalities because of crashes do not follow the same trend, and both counties experienced an increase in the number of crash fatalities from 2019 to 2020. For Lehigh County, the crash fatalities in 2020 were higher than any other year during the same 2018-2022 time frame.

Table 91: Recorded Crashes in the Lehigh Valley by County 2018-2023

Location	2018	2019	2020	2021	2022
Lehigh County	4,713	5,089	4,186	4,853	4,920
Northampton County	2,975	3,081	2,510	2,856	2,963

Table 92: Crash Fatalities in Lehigh Valley by County 2018-2022[243]

Location	2018	2019	2020	2021	2022
Lehigh County	26	26	32	30	31
Northampton County	21	14	21	13	24

While most transportation crashes only involve automobiles, there have been a small number of incidents involving trains or aircraft. For data pertaining to rail transportation, the Federal Railroad Administration (FRA) documents the number of accidents/incidents including collisions, derailments, and other events involving the operation of on-track equipment and causing reportable damage above an established threshold, impacts between railroad on-track equipment and highway users at crossings, and all other incidents or exposures that cause a fatality or injury to any person, or an occupational

[243] Pennsylvania Department of Transportation. "2022 Pennsylvania Crash Facts & Statistics," 2022. https://www.penndot.pa.gov/TravelInPA/Safety/Documents/2022_CFB_linked.pdf.

illness to a railroad employee.[244] The number of accidents/incidents which occurred in the Lehigh Valley as documented by the FRA between 2018 and 2022 are detailed in the following table.

Table 93: Count of Rail Accidents/Incidents in the Lehigh Valley 2018 - 2022

Location	2018	2019	2020	2021	2022
Lehigh County	4	9	8	8	6
Northampton County	6	6	2	6	6

Of the 26 rail accidents/incidents documented in Northampton between 2018 and 2022, there were 13 reported injuries and no fatalities. For the 35 events in Lehigh County, there were 15 reported injuries and 1 fatality.[245]

While air travel is generally considered to be among the safest forms of transportation, aircraft are not inherently immune to mishaps. The National Transportation Safety Board (NTSB) investigates on all U.S. air carrier accidents, commuter and air taxi crashes, mid-air collisions, serious mishaps involving public use (government) aircraft, and all fatal general aviation accidents. Additionally, accidents involving military aircraft are also investigated by the NTSB when the functions of the Federal Aviation Administration (FAA) are at issue. According to the NTSB's Case Analysis and Reporting Online (CAROL) system, there were 3 aircraft-related accidents which occurred in the Lehigh Valley between 2018 and 2022 which resulted in investigations.

Table 94: Aircraft Accidents in the Lehigh Valley Investigated by NTSB 2018 - 2022

Event Date	Location	Aircraft Details	Highest Injury	NTSB Report Status
08/11/2019	Allentown	Schweizer 269C	Serious	Completed
09/28/2022	Allentown	Piper PA-28-140	Fatal	In work

[244] Federal Railroad Administration. "Accident/Incident Definitions." railroads.dot.gov, November 3, 2019. https://railroads.dot.gov/forms-guides-publications/guides/accidentincident-definitions.

[245] Federal Railroad Administration. "Accident/Incident Dashboards & Data Downloads." railroads.dot.gov, 2023. https://railroads.dot.gov/safety-data/accident-and-incident-reporting/accidentincident-dashboards-data-downloads.

11/09/2022	Allentown	Piper PA-28-140	Serious	Completed

4.3.24.4. Future Occurrence

Population growth and development trends in the Lehigh Valley will likely result in a corresponding increase of the risk of transportation crashes as more people and goods move within and through the area. If the transportation crash statistics recorded between 2018 and 2022 are representative of near-future conditions, the Lehigh Valley can anticipate an average of 7,629 automobile crashes and 48 automobile crash fatalities per year.

While transportation crashes involving trains and/or aircrafts are far less frequent than those involving automobiles, the possibility of such incidents will likely remain for as long as these modes of transportation travel to and through the Lehigh Valley. Based on the available data from 2018-2022, the Lehigh Valley can reasonably anticipate approximately 12 accidents/incidents involving rail traffic per year. Historical data indicates that the Lehigh Valley can also anticipate approximately one aircraft accident every 20 months. Aircraft accidents in the Lehigh Valley are most likely to occur near the Lehigh Valley International Airport in Allentown.

One relatively recent development which will likely have an impact on the future of transportation in the Lehigh Valley is the emergence of self-driving or autonomous vehicles. As of October 2023, Pennsylvania law requires a driver be present during the testing of Highly Automated Vehicles (HAVs), but future legislation could remove this requirement. The Pennsylvania DOT does not currently require reporting on testing activities and no crash records specific to HAVs are maintained.[246]

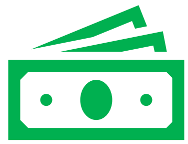
4.3.24.5. Vulnerability Assessment

Transportation crash incidents, encompassing various modes of transport such as road vehicles, trains, airplanes, and boats, can significantly impact communities like the Lehigh Valley. These incidents can range from minor accidents to major disasters, and their effects on community lifelines are varied.

[246] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Table 95: Potential Vulnerabilities to Lifelines due to Traffic Crashes

Lifelines	Impact Type	Description
Safety & Security		Immediate response is essential for ensuring public safety, managing traffic, securing the crash site, and preventing secondary incidents. Emergency services, including police, fire, and rescue teams, are vital for controlling the situation.
Health & Medical		Crashes often result in injuries or fatalities, requiring prompt medical attention. Emergency medical services provide on-site treatment and transport victims to hospitals. Healthcare facilities must be prepared for a sudden influx of patients, especially in mass casualty incidents.
Housing & Building Infrastructure		Significant crashes, especially those involving large vehicles or trains, can cause damage to nearby buildings and infrastructure. This may lead to temporary displacement of residents and businesses.
Utilities		Crashes can disrupt utility services, particularly if infrastructure like power lines, water pipes, or communication towers are damaged. Restoring these services is crucial for community functioning.
Transportation Services		Transportation crashes directly impact the transport network. Roads may be closed, rail services disrupted, and air or sea travel affected. This disrupts the movement of people and goods and can have wider economic implications.

Lifelines	Impact Type	Description
Economic Stability		The economic impacts include direct costs associated with emergency response, medical care, and infrastructure repair, as well as indirect costs like traffic delays and loss of business.

Transportation accidents remain a threat in virtually any part of the Lehigh Valley that can be reached by automobile, train, and aircraft. Transportation hazards could lead to potential losses in human health and life, property, and natural resources. The property vulnerable to this hazard includes critical facilities, although the risk may vary by structure as some facilities are hardened against impacts. Road and rail bridges and tunnels are of particular concern as they are inherently close to the hazard, and damage to these structures may result in wider disruptions and harm. Loss of roadway use and public transportation services would affect thousands of commuters, employment, day-to-day operations within the Lehigh Valley, and delivery of critical municipal and emergency services. Disruption of one or more of the modes of transportation can lead to congestion of another and have cascading impacts on the region as a whole. As of 2023, PEMA estimates that there are 69,476 buildings and 209,425 people in the Lehigh Valley within one-quarter mile of major interstates, US highways, and/or state highways.[247] PEMA considers one-quarter mile to be a representative distance within which death, injury, or significant property damage could occur because of a crash occurring on these roadways.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for a transportation crash is considered "highly likely" in the Lehigh Valley.

[247] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

4.3.25 *Utility Interruption*

4.3.25.1. Location and Extent

Utility interruption hazards are hazards that impair the functioning of important utilities in the energy, telecommunications, public works, and information network sectors. Utility interruption hazards include the following:

- Geomagnetic Storms
- Fuel or Resource Shortage
- Electromagnetic Pulse
- Information Technology Failure
- Ancillary Support Equipment
- Public Works Failure
- Telecommunications System Failure
- Transmission Facility or Linear Utility Accident
- Major Energy, Power, Utility Failure

The term "utility interruption" encompasses any disruption in the operational capacity of networks such as telecommunications, gas, electricity, water, or waste management systems. These disruptions, often termed as outages, arise due to a variety of factors including weather phenomena, scarcity of fuel or other resources, electromagnetic pulses (EMP), failures in information technology, accidents involving transmission facilities or linear utilities, and significant failures in energy, power, or utility equipment. The core concern of utility interruptions as a hazard is centered around failures in fuel, energy, or utility systems. Often, this hazard is secondary in nature, typically resulting from other hazardous incidents like transportation accidents, lightning strikes, extreme heat, flooding, and winter storms.

Utility interruptions can occur throughout the Lehigh Valley anywhere there is utility service, but most utility interruptions are small-scale and short in duration. Utilities that employ above-ground wiring, such as power or phone lines, are vulnerable to the effects of numerous weather-related hazards such as high wind, fires, heavy rain, snow, and ice. Utility infrastructure can also be damaged by transportation accidents, terrorism, and other human-caused hazards. Some utility facilities are especially vulnerable to flood damage, such as potable water facilities, wastewater treatment plants and substations located within the 1% annual chance floodplain.

4.3.25.2. Range of Magnitude

Utility interruptions most commonly affect lighting, heating, air conditioning, communications, ventilation/circulation, household appliances, and office equipment. The impacts of utility outages can be exacerbated by the presence of other hazards; unpowered sump pumps will be unable to mitigate basement flooding, and unpowered homes can quickly become too hot or too cold if the Lehigh Valley is experiencing extreme temperatures. Extreme temperatures – both hot and cold – can impact the health and safety of vulnerable populations like children, the elderly, disabled individuals, people who lack access to transportation, and others. More severe interruptions can impact fire, medical, and security systems, although these systems often have a back-up power source. The impacts of interruptions can also be dire for people who are dependent on electronic medical equipment. Utility interruptions can significantly hamper first responders in their efforts to provide aid during or following a disaster, especially with the loss of telecommunications and wireless capabilities. Additionally, internet outages could significantly disrupt the economy, especially as recent industry changes have led to significant increases in employees working from home.

In a possible worst-case scenario, a winter storm event results in widespread power and communication outages. This scenario would leave citizens without heat during subzero temperatures, and the lack of communications also means that vulnerable populations are unable to call for assistance. If there is a substantial amount of snow, individuals may also be unable to safely leave their home. In this possible worst-case scenario, the outage would last for several days or even weeks as formidable conditions make it impossible to properly repair power and communications infrastructure. Additionally, downed power lines and iced-over roads may significantly slow the efforts of emergency responders as well as delay outside assistance getting into the Lehigh Valley.

4.3.25.3. Past Occurrence

Utility interruptions are typically short in duration and small in magnitude, but there have been several major disasters within Pennsylvania that led to extended and widespread utility interruption.

The Lehigh Valley suffered a significant utility interruption in October 2011, when an early snowstorm dropped between six and ten inches of wet snow on trees that still had leaves on them, causing historic numbers of tree limbs and wires down, resulting in massive power outages. PPL and FirstEnergy, the two largest electric utility companies in the Lehigh Valley, reported over 109,000 customers without power for up to a week. Regional shelters and warming stations were opened throughout the Lehigh Valley to care for people without power.

In March 2018, a series of major nor’easters created widespread power outages across much of the U.S. Northeast, including the Lehigh Valley. The initial storm impacted Lehigh Valley on the morning of March 2, and by the evening of the same day there were at least 35,000 customers without power in the region.[248] By the end of the next day, that number was reported to be closer to 100,000.[249] This storm was only the first of four nor'easters to hit the Lehigh Valley that month, and reports of power outages accompanied each subsequent event.

The table below describes known utility interruptions that have occurred since the previous plan update. This table reflects data from 911 dispatch; smaller outages that did not necessitate reporting to county government would not be included, and thus this is not a comprehensive accounting of all interruptions in the planning period.

Table 96: Reported Utility Interruptions in the Lehigh Valley 2018 – 2023 To-Date

Includes best-available data from WebEOC. 2023 Year-To-Date includes incidents reported through 09/04/2023.

Year	Phone / Comms Outage	Power Outage	Underground Utility	Water Shortage / Outage	Water Supply Contamination	Natural Gas Release	Other	TOTAL
2018	9	435	14	57	0	186	39	**740**
2019	11	257	5	17	0	69	21	**380**
2020	20	427	39	9	0	217	70	**782**
2021	6	429	66	3	0	107	45	**656**
2022	6	256	42	4	4	108	19	**439**

[248] Bresswein, Kurt. "More than 35K without Power in Region as Winds, Heavy Snow Hit." lehighvalleylive, March 2, 2018. https://www.lehighvalleylive.com/weather/2018/03/power_outages_from_winds_heavy_wet_snow_hit_lehigh.html.

[249] Bresswein, Kurt. "100K Still without Power in Lehigh Valley, Northwestern N.J." lehighvalleylive, March 3, 2018. https://www.lehighvalleylive.com/weather/2018/03/101k_still_without_power_in_lehigh_northampton_war.html.

2023 YTD*	3	147	29	3	0	104	11	**297**

Metropolitan Edison Company (Met-Ed) is one of several large power utility providers operating in the Lehigh Valley. According to Met-Ed's data from 2013 to 2022, power outages experienced by their customers ranged in duration from 10 minutes to 11,663 minutes, and the average length of a power outage was 353 minutes.[250] While power outages can be concerning for any customer – particularly during the winter – they are especially troublesome when critical facilities are impacted. Between 2013 and 2022, there were 25 instances of critical facilities without access to Met-Ed power for at least two days. Among these outages, 20 occurred in early March 2018, part of the widespread outages affecting thousands of residential customers following a series of significant winter storms.[251] Detailed power outage data was not received from other power utility providers operating in the Lehigh Valley.

According to DOE-417 Electric Emergency Incident and Disturbance Reports (DOE-417 forms) submitted to the U.S. Department of Energy between 2000 and 2022, there were 83 power outages each impacting 50,000 customers or more in Pennsylvania during this time, although the exact number of impacted customers in the Lehigh Valley is not known. 81 of these 83 outages are considered "weather related" events, being attributable to severe thunderstorms, winter storms, high winds, and hurricanes Isabel, Wilma, Ernesto, Ike, and Sandy.

4.3.25.4. Future Occurrence

Historical data of utility outages in the Lehigh Valley show that brief power interruptions are a common experience, occurring multiple times annually. Most outages tend to be resolved within a matter of hours, although longer duration outages have occurred. More significant outages, which extend over longer periods, tend to manifest once every several years, and they are most commonly the result of inclement weather like severe thunderstorms, high winds, and heavy snow/ice. These weather conditions are common in the region, and the Lehigh Valley should anticipate and prepare for future utility outages resulting from these conditions.

Another concern which could increase the frequency and magnitude of utility outages is aging infrastructure. As utility distribution equipment ages, it deteriorates from the constant wear and tear of service, and is susceptible to eventual failure. In the Pennsylvania 2023 State Hazard Mitigation Plan PEMA cites a report from the American Society of Civil Engineers which states that most of the power

[250] Data provided to Lehigh County Emergency Management by Metropolitan Edison Company

[251] Bresswein, Kurt. "More than 35K without Power in Region as Winds, Heavy Snow Hit." lehighvalleylive, March 2, 2018. https://www.lehighvalleylive.com/weather/2018/03/power_outages_from_winds_heavy_wet_snow_hit_lehigh.html.

transmission and distribution infrastructure in Pennsylvania was built in the 1950s and 1960s.[252] Some transmission lines date as far back as the 1920s. For similar reasons, aging infrastructure also threatens the availability and reliability of water, sewer, and gas utilities in the Lehigh Valley.

The Lehigh Valley is susceptible to the impacts of climate change, which can generate more frequent and severe weather events. There is also evidence that climate change is extending or shifting the typical season for seasonal hazards like wildfires and hurricanes.[253] Increasing severity and frequency of natural hazards, combined with less predictability, increase the potential of disruption to utility services like electricity, water, and gas. The American Society of Civil Engineers recently recommended increased weatherization of utility infrastructure in Pennsylvania as a whole.[254]

Lastly, a relatively recent development which threatens the availability and reliability of power grids is the emergence of sophisticated and targeted cyber-attacks against critical infrastructure. These events are difficult to predict due to the complexity of motives and circumstances which drive them, but several recent and high-profile examples have highlighted the vulnerability of utility infrastructure to these attacks. Based on historical reports from 911 dispatch, small outages are likely to continue and should be considered "**highly likely"**.

4.3.25.5. Vulnerability Assessment

Utility interruptions, encompassing disruptions in essential services such as electricity, water supply, natural gas, and telecommunications, can significantly impact communities like the Lehigh Valley. These interruptions can occur due to various reasons, including natural disasters, technical failures, maintenance issues, or deliberate acts. The effects on community lifelines are substantial.

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[252] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[253] Voiland, Adam. "Study: Fire Seasons Getting Longer, More Frequent." Climate Change: Vital Signs of the Planet, July 27, 2015. https://climate.nasa.gov/news/2315/study-fire-seasons-getting-longer-more-frequent.

[254] American Society of Civil Engineers. "2022 Report Card for Pennsylvania's Infrastructure." infrastructurereportcard.org, 2022. https://infrastructurereportcard.org/wp-content/uploads/2016/10/PA-Report-Card-2022.pdf.

Lifelines	Impact Type	Description
Safety & Security		Utility disruptions can compromise safety systems, street lighting, and security alarms, increasing risks for accidents and crime. Emergency services must adapt to these challenges, ensuring public safety in the absence of regular utilities.
Health & Medical		Hospitals and healthcare facilities rely heavily on utilities. Power outages can affect medical equipment, refrigeration of medicines, and comfort of patients. Backup systems are crucial for maintaining healthcare operations during interruptions.
Housing & Building Infrastructure		Residential and commercial buildings depend on utilities for lighting, heating, cooling, and running essential appliances. Extended interruptions can make buildings uninhabitable, leading to displacement.
Utilities		The interruption itself directly impacts this lifeline. Restoring these services swiftly is critical for the functioning of all other community aspects.
Transportation Services		Traffic control systems, public transit, and fuel stations rely on utilities. Disruptions can lead to traffic congestions, accidents, and hinder the mobility of residents and emergency responders.
Economic Stability		Utility interruptions can halt business operations, affect commerce, and lead to significant economic losses. Industries that depend on consistent power and water supply are particularly vulnerable.

According to the U.S. Energy Information Administration (EIA), approximately two-thirds of Pennsylvania homes used natural gas as their primary heating fuel in 2021. An additional 16% used electricity as their primary heating source, and a further 10% relied on distillate fuel oil as the primary heating source.[255] The number of households in Pennsylvania – as well as other states in the U.S. Northeast – which rely on distillate fuel oil makes the region particularly vulnerable to heating oil shortages and price spikes. In recognition of this vulnerability, the federal government created the 1-million-barrel Northeast Home Heating Oil Reserve in 2000 to offset supply disruptions in the region.[256]

Virtually all structures connected to the power grid in the Lehigh Valley are vulnerable to loss of power incidents. While some facilities may have increased initial resiliency due to the presence of backup power sources like generators, these systems are not typically intended to operate indefinitely. Additionally, climate change may bring more frequent and severe weather events which can damage or destroy utility infrastructure, particularly components which were constructed multiple decades ago. In recent years, cyber-attacks have emerged as a novel threat to utilities infrastructure. While redundancy and other strategies can help build resiliency into utilities infrastructure, the overall vulnerability of these systems in the Lehigh Valley has remained the same or increased slightly since the 2018 Plan.

[255] U.S. Energy Information Administration. "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." eia.gov, November 17, 2022. https://www.eia.gov/state/analysis.php?sid=PA.

[256] U.S. Energy Information Administration. "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." eia.gov, November 17, 2022. https://www.eia.gov/state/analysis.php?sid=PA.

4.3.26 Gas / Liquified Pipelines

4.3.26.1. Location and Extent

Pipelines can transport hazardous liquids and flammable substances such as natural gas. Incidents can occur when pipes corrode, when they are damaged during excavation, incorrectly operated, or damaged by other forces. Pipelines exist in all but three counties in Pennsylvania. Pipelines transporting natural gas compose the largest percent of pipeline in the Commonwealth. Of the active liquid pipelines in Pennsylvania, approximately 1/3 is used to carry highly volatile liquids (HVLs). HVLs are liquid at normal storage temperatures and pressures, but they quickly vaporize when released into the atmosphere. In addition, hazardous materials can be transported by aircraft or by watercraft. Crashes, spills of materials, and fires on these vessels can pose a hazard. According to the National Pipeline Mapping System (NPMS), the Lehigh Valley contains more than 300 miles of gas transmission pipelines and hazardous liquid pipelines.

4.3.26.2. Range of Magnitude

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

- Weather conditions that affect how the hazard occurs and develops
- Micro-meteorological effects of buildings and terrain that alters dispersion of hazardous materials
- Non-compliance with building or fire codes and maintenance failures such as fire protection and containment features
- Type of material(s) released
- Distance from emergency response teams
- Training of emergency response teams/familiarity with hazardous material(s) properties
- Accessibility of area
- The areas within closest proximity to the releases are generally at greatest risk, yet depending on the agent, a release can travel great distances or remain present in the environment for centuries in the case of radioactive materials.
- The environmental impacts of hazardous material releases include:
- Hydrologic effects, such as surface and groundwater contamination
- Other effects on water quality such as changes in water temperature
- Damage to streams, lakes ponds, estuaries, and wetland ecosystems
- Air quality effects, such as pollutants, smoke, and dust
- Loss of quality in landscape
- Reduced soil quality
- Damage to plant communities, including loss of biodiversity and damage to vegetation

- Damage or death to animals, through the degradation of habitat, pollution of drinking water, loss of biodiversity or disease[257]

The age of infrastructure in the region has led to an increase in reported explosions from gas utility failures. These events range from simple building property incidents through large-scale loss of life, property, economy and environment.

4.3.26.3. Past Occurrence

In February 2011, the City of Allentown was impacted by a catastrophic failure of a large gas main under a row of homes in the 500 Block of North 13th Street. The explosion killed five people and destroyed six homes. The incident forced the evacuation of hundreds of residential and commercial properties, including a senior living complex on the adjoining block. Since that incident, the Lehigh Valley has been impacted by numerous failures of infrastructure causing smaller explosions with less impact.

PHMSA records of pipeline incidents since 2003 lists 13 separate events which occurred in the Lehigh Valley, all within Lehigh County. These incidents are detailed in Table 97Table 97. The PHMSA records show no pipeline incidents occurring in Northampton County since 2003.

Table 97: PHMSA Pipeline Incidents in Lehigh County 2003-2023

Date	System Type	Cause of Failure	Cost (in 2023 dollars)	Barrels Spilled	Net Barrels Lost	Injuries	Fatalities
7/22/04	Hazardous liquids	Excavation damage	$1,223,261	450	415	0	0
8/2/04	Hazardous liquids	Excavation damage	$152,475	14	9	0	0
2/1/05	Hazardous liquids	Natural force damage	$7,221,312	1145	727	0	0
6/21/05	Hazardous liquids	External corrosion	$43,730	48	42	0	0

[257] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Date	System Type	Cause of Failure	Cost (in 2023 dollars)	Barrels Spilled	Net Barrels Lost	Injuries	Fatalities
7/13/05	Hazardous liquids	Excavation damage	$44,874	24	12	0	0
10/17/05	Hazardous liquids	Material/weld/ equipment failure	$22,343,622	1,020	420	0	0
2/28/08	Hazardous liquids	Material/weld/ equipment failure	$21,113	1	0	0	0
2/9/11	Gas distribution	Natural force damage	$2,115,082	0	0	3	5
6/17/12	Hazardous liquids	Incorrect operations	$108,454	100	74	0	0
7/13/12	Hazardous liquids	External corrosion	$474,379	9	9	0	0
2/1/14	Hazardous liquids	Material/weld/ equipment failure	$30,888	12	0	0	0
5/10/16	Gas distribution	Excavation damage	$92,531	0	0	0	0
10/1/19	Hazardous liquids	Incorrect operation	$29,693	2	0	0	0
TOTALS			$33,901,414	2,825	1,708	3	5
Note: Net Barrels Lost reflects the volume which could not be recovered through cleanup efforts.							

Date	System Type	Cause of Failure	Cost (in 2023 dollars)	Barrels Spilled	Net Barrels Lost	Injuries	Fatalities
Source: Pipeline and Hazardous Materials Safety Administration. "All Reported Incidents." portal.phmsa.dot.gov, November 13, 2023. https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages.							

4.3.26.4. Future Occurrence

According to the Pennsylvania Department of Environmental Protection, there are multiple pipelines under development which will transit the Lehigh Valley.[258] Additionally, data from the U.S. Department of Transportation (DOT) reveals that 63,311 miles of pipeline was constructed across the U.S. in 2022, which is the most in a single year since DOT began tracking this in 2006. It is also a 70% increase from the total pipeline mileage constructed in 2021 (45,532 miles).[259]

The data from PHMSA for pipeline incidents since 2003 shows that the Lehigh Valley averages roughly one incident every 18 months. Of the 13 incidents documented by the PHMSA, 4 incidents (31%) caused more than $1 million in damages.[260] Material/weld/equipment failures were identified as the cause for 2 of these incidents, and the other 2 were caused by natural force damage and excavation damage. One incident (8%) resulted in injuries and fatalities. The Lehigh Valley can anticipate these rates to remain the same or increase slightly as additional pipelines are introduced to the region. Aging infrastructure may also increase the risk of future incidents, although property maintenance and monitoring can help offset this. Lastly, although there have been no pipeline incidents – as reported by the PHMSA – in Northampton County, the possibility of a future incident remains.

4.3.26.5. Vulnerability Assessment

Pipeline incidents, involving accidents or failures in the network of pipelines transporting oil, natural gas, chemicals, and other hazardous materials, can significantly affect communities like the Lehigh Valley.

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[258] Department of Environmental Protection. "Pennsylvania Pipeline Portal." Accessed July 18, 2023. Retrieved on 07/18/2023 from: https://www.dep.pa.gov:443/Business/ProgramIntegration/Pennsylvania-Pipeline-Portal/Pages/default.aspx.

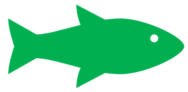
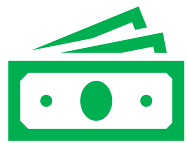
[259] US DOT Pipeline and Hazardous Materials Safety Administration. "Oracle BI Interactive Dashboards - Public Reports," July 17, 2023. Retrieved on 07/08/2023 from: https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages&PortalPath=%2Fshared%2FPDM%20Public%20Website%2F_portal%2FPublic%20Reports&Page=New%20Construction.

[260] Pipeline and Hazardous Materials Safety Administration. "All Reported Incidents." portal.phmsa.dot.gov, November 13, 2023. https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages.

These incidents can range from minor leaks to major explosions or spills, with varying impacts on community lifelines are shown below.

Table 98: Potential Vulnerabilities to Lifelines due to Pipeline Incidents

Lifelines	Impact Type	Description
Safety & Security		Pipeline incidents can pose immediate safety risks, including fires, explosions, and hazardous material exposure. Emergency services must quickly secure the area, evacuate residents if necessary, and manage the incident to prevent further harm.
Health & Medical		Exposure to hazardous materials or injuries from explosions requires prompt medical response. Health care facilities must be prepared to treat affected individuals, potentially dealing with a surge in emergency cases.
Housing & Building Infrastructure		Significant pipeline incidents can cause damage to nearby buildings and infrastructure, potentially leading to displacement of residents and disruption of services.
Utilities		Pipeline incidents, especially those involving energy supplies, can disrupt utility services like heating and electricity. This can have a wider impact on community functions, including water treatment and communication services.
Transportation Services		Pipeline incidents can lead to transportation disruptions, especially if they occur near critical transportation infrastructure or necessitate road closures for safety and repair work.

Lifelines	Impact Type	Description
Environmental & Ecological Systems		Leaks or spills of hazardous materials can have severe environmental consequences, contaminating soil, water sources, and air quality, and affecting local ecosystems.
Economic Stability		The economic impacts of pipeline incidents include the direct costs associated with emergency response, environmental cleanup, and infrastructure repair. There are also indirect costs, such as disruptions to energy supply chains and local businesses.

Potential sources of hazardous materials include four natural gas transmission lines that cross the Lehigh Valley. Three pipelines cross through Northampton County from Bushkill Township to Lower Mt. Bethel Township, from Upper Mt. Bethel Township to the southern point of Lower Saucon Township, and from Williams Township into Lower Saucon Township.

Table 99: Vulnerability of People and Buildings to Pipeline Failure[261]

County	Vulnerable Population	Vulnerable Buildings	Value of Exposed Buildings, in Thousand $	Percent of Total County Building Value
Lehigh	33,507	11,975	$8,115,729	11%
Northampton	14,374	5,886	$2,861,531	5%

The other pipeline crosses the southern portion of Lower Milford Township in Lehigh County. Breaks in the pipelines could result in hazardous material releases as well as explosions and utility interruptions. Municipalities most vulnerable to pipeline accidents include the townships of Bethlehem, Bushkill, Forks, Lower Milford, Lower Mt. Bethel, Lower Saucon, Palmer, Plainfield, Upper Mt. Bethel, Upper

[261] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

Saucon, Washington, and Williams, and Tatamy Borough. Other pipeline facilities are being proposed for the Lehigh Valley.

4.3.27 *Cyber-Terrorism*

4.3.27.1. Location and Extent

Cyber-terrorism is a broad term that refers to acts associated with the convergence of terrorism and cyberspace. Generally, Acts of terrorism committed using computers, networks, and the Internet are typically classified as cyber-terrorism. The most widely cited definition comes from Dorothy E. Denning's Testimony before the Special Oversight Panel on Terrorism:

"Cyberterrorism…is generally understood to mean unlawful attacks and threats of attack against computers, networks, and the information stored therein when done to intimidate or coerce a government or its people in furtherance of political or social objectives. Further, to qualify as cyberterrorism, an attack should result in violence against persons or property, or at least cause enough harm to generate fear."[262]

The threat of cyber-terrorism has continually grown as technology becomes an increasingly integral component of day-to-day life. Acts of cyber-terrorism can range from taking control of a host website to using networked resources to directly cause destruction and harm. Information technology utilized to support critical facilities and essential functions of government are of particular interest to perpetrators of cyber-terrorism because interference with these components can result in widespread disruptions to transportation, public safety, utility services, communications, and many other critical systems that are highly dependent on information technology. Attacks on healthcare, finance, and other industries are also of particular concern due to the potential repercussions.

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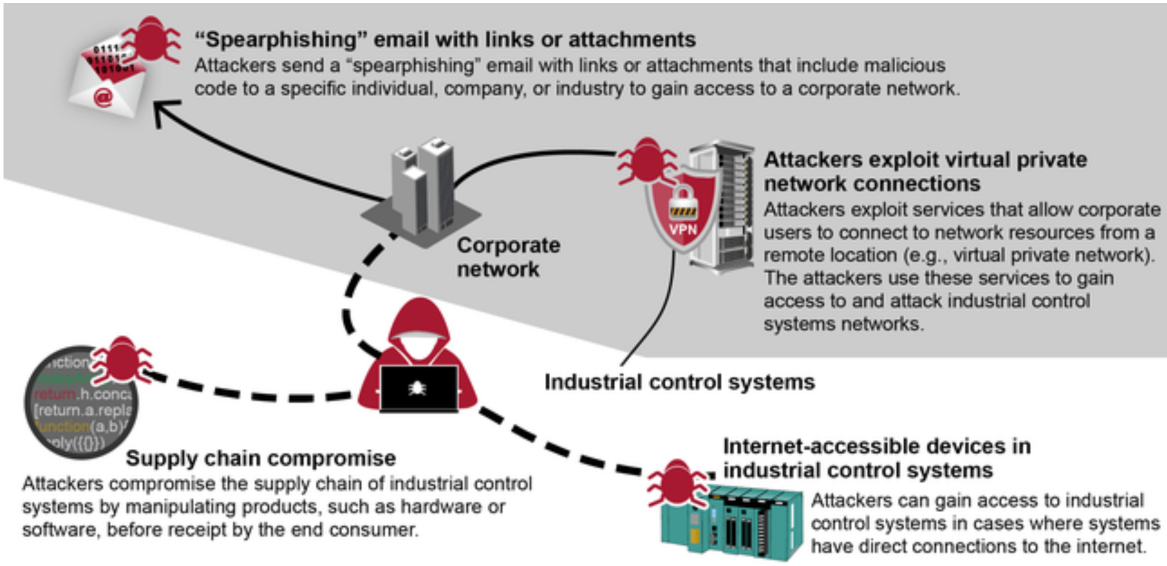
[262] Pennsylvania Emergency Management Agency, and Michael Baker International. "Pennsylvania Hazard Mitigation Plan Standard Operating Guide 2020," https://www.pema.pa.gov/Mitigation/Planning/Documents/All-Hazard-Mitigation-Planning-Standard-Operating-Guide.pdf.

Figure 36: Examples of Techniques for Gaining Initial Access to Industrial Control Systems



Source: GAO analysis of industry and federal documents. | GAO-23-106441

Cyber-terrorists can be difficult to identify. The internet allows individuals or groups from across the globe to plan a cyber-attack without being organized in a traditional manner, as they are able to effectively communicate over long distances immediately. Many cyber-attacks originate from groups outside of the U.S., and there have been multiple instances of complex cyber-attacks which appear to have been supported by foreign governments.[263]

4.3.27.2. Range of Magnitude

Like conventional terrorism, the impacts of cyber-terrorism can vary greatly, and the targets of cyber-terrorism can range from individuals to national governments and multinational corporations. Additionally, cyber-terrorism is not confined to any single form of cyber-attack. Sophisticated acts of cyber-terrorism may even attempt to utilize multiple methods of attack to increase the likelihood of exploiting a weakness and/or overwhelming the defense capabilities of their target(s). The FBI estimates that cyber-attacks – some of which may rise to the level of cyber-terrorism – can result in billions of

[263] Max Fisher. "Constant but Camouflaged, Flurry of Cyberattacks Offers Glimpse of New Era." nytimes.com, July 26, 2021. https://www.nytimes.com/2021/07/20/world/global-cyberattacks.html.

dollars of damages over the course of any given year.[264] According to the Pennsylvania Governor's Office of Homeland Security, types of cyber-attacks include any of the following:

Table 100: Methods and Descriptions of Cyber-Attacks[265]

Attack Type	Description of Attack
Botnets or "Zombies"	A collection of computers subject to control by an outside party, usually without the knowledge of the owners, using secretly installed software robots. The robots are spread by trojan horses and viruses. The botnets can be used to launch denial-of-service attacks and transmit spam.
Card Skimming	The act of using a skimmer to illegally collect data from the magnetic stripe of a credit, debit or ATM card. This information, copied onto another blank card's magnetic stripe, is then used by an identity thief to make purchases or withdraw cash in the name of the actual account holder. Skimming can take place at an ATM and can occur at restaurants, taxis, or other places where a user surrenders his or her card to an employee.
Denial-of-service attacks	Flooding the networks or servers of individuals or organizations with false data requests so they are unable to respond to requests from legitimate users.
Malicious code (also malware)	Any code that can be used to attack a computer by spreading viruses, crashing networks, gathering intelligence, corrupting data, distributing misinformation and interfering with normal operations.

[264] Federal Bureau of Investigation Public Affairs and Laura Eimiller. "FBI Warns of Cyber Scammers Using Various Methods to Deceive and Defraud Elderly Victims for Financial Gain." Press Release. Federal Bureau of Investigation. Accessed November 6, 2023. https://www.fbi.gov/contact-us/field-offices/losangeles/news/press-releases/fbi-warns-of-cyber-scammers-using-various-methods-to-deceive-and-defraud-elderly-victims-for-financial-gain.

[265] Pennsylvania Governor's Office of Homeland Security. "Cybersecurity Terminology," February 2, 2023. https://www.homelandsecurity.pa.gov/Documents/Cybersecurity%20Terminology.pdf.

Attack Type	Description of Attack
Pharming	The act of sending an e-mail to a user falsely claiming to be an established legitimate enterprise in an attempt to scam the user into surrendering private information that will be used for identity theft. The e- mail directs the user to visit a website where they are asked to update personal information, such as passwords and credit card, social security, and bank account numbers that the legitimate organization already has. The website, however, is bogus and set up only to steal the user's information.
Phishing	Using fake e-mail to trick individuals into revealing personal information, such as social security numbers, debit and credit card account numbers and passwords, for nefarious uses.
Spam	Unsolicited bulk e-mail that may contain malicious software. Spam is now said to account for around 81 percent of all e-mail traffic.
Spear phishing	A type of phishing attack that focuses on a single user or department within an organization, addressed from someone within the company in a position of trust and requesting information such as login IDs and passwords. Spear phishing scams will often appear to be from a company's own human resources or technical support divisions and may ask employees to update their username and passwords. Once hackers get this data, they can gain entry into secured networks. Another type of spear phishing attack will ask users to click on a link, which deploys spyware that can thieve data.
Spoofing	Making a message or transaction appear to come from a source other than the originator.
Spyware	Software that collects information without a user`s knowledge and transfers it to a third party.
Trojan Horse	A destructive program that masquerades as a benign application. Unlike viruses, Trojan horses do not replicate themselves, but they can be just as destructive. One of the most insidious types of Trojan horse is a program that claims to rid your computer of viruses but instead introduces viruses onto your computer.
Virus	A program designed to degrade service, cause inexplicable symptoms, or damage networks.

Attack Type	Description of Attack
Worm	Program or algorithm that replicates itself over a computer network and usually performs malicious actions, such as using up the computer's resources and possibly shutting the system down. A worm, unlike a virus, has the capability to travel without human action and does not need to be attached to another file or program.

While all cyber-attacks can be harmful and destructive, not every instance of cyber-attack is an act of cyber-terrorism. A cyber-attack is generally considered an act of cyber-terrorism when the following motivations are present:

- Effects-based: When computer attacks result in effects that are disruptive enough to generate fear comparable to a traditional act of terrorism.
- Intent-based: When unlawful or politically motivated computer attacks are carried out to intimidate or coerce a government or people to further a political objective, or to cause grave harm or severe economic damage.[266]

The magnitude of cyber-terrorism and cyber-attacks will vary based upon which specific system is affected by an attack, the ability to preempt an attack, and an attack's effect on continuity of operations. The largest threat to institutions from cyberterrorism comes from any processes that are networked and controlled via computer. Worst-case scenarios for cyber-terrorism include loss of functions at nuclear power plants, dams, and other structures and systems which require careful and constant monitoring. Conceivably, an entity which gains control of such facilities could threaten the lives of tens of thousands of people in the Lehigh Valley. A large-scale cyber-terrorism event could also disrupt and threaten the economic stability of the Lehigh Valley. In addition to the direct impacts of a cyber-attack, the resulting investigation, the need to develop new security systems, and the process of rebuilding public trust are all likely consequences.[267]

In addition to large-scale acts of cyber-terrorism, smaller cyberattacks are a daily occurrence. Billions of emails are sent each day, and spam and phishing emails account for a significant share of all email traffic. Additionally, brute force attacks, which are trial and error attempts to obtain user passwords and pins, are frequently used by criminals to attempt to crack encrypted data or gain access to private

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[266] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

[267] Pennsylvania Emergency Management Agency and Michael Baker International. "Pennsylvania 2023 Standard State All-Hazard Mitigation Plan," October 12, 2023. https://www.pema.pa.gov/Mitigation/Planning/Documents/2023%20Hazard%20Mitigation%20Plan.pdf.

accounts. Firewalls can be effective at keeping security threats such as these out, but once a cybercriminal gains access to a system, they can attack from within.

4.3.27.3. Past Occurrence

One of largest cyber-attacks targeting an entity within the Lehigh Valley was detected in Allentown on February 15, 2018. Unfortunately, the attack was well underway by the time it was discovered, and many devices used by the Allentown city government had already been infected by a serious computer virus known as Emotet. The virus stole credentials of city workers and severely disrupted government functions, as well as other services which used information technology assets belonging to Allentown. Among other things, the finance department of Allentown could not complete any external banking transactions, video surveillance networks were down, and local law enforcement was unable to access databases controlled by the Pennsylvania State Police. It took Allentown nearly two weeks to restore some of the impacted services, and the cost to remove the virus from Allentown systems was approximately $1 million.[268] Unfortunately, the ease with which the perpetrators of these attacks can remain anonymous makes it difficult to determine the motivation behind this attack. However, the circumstances of the attack seem to indicate that its purpose was disruption rather than personal gain, and this is a characteristic of cyber-terrorism.

Another serious incident occurred in February 2023, when the Lehigh Valley Health Network was targeted by an advanced cyber-attack. In this instance, malicious software (malware) named "BlackCat" obtained access to highly personal and sensitive information, and the group behind the attack threatened to publish this information unless a ransom was paid. The attack was traced back to a nefarious cyber group associated with Russia, and the U.S. Department of Health and Human Services has stated that the BlackCat attack is a new but "exceptionally capable" malware.[269] While the attack appears to have been motivated by personal gain, the nature of the attack is alarming and exemplifies some of the difficulties associated with preventing cyber-attacks and cyber-terrorism. First, it can be exceptionally difficult to stop or hold accountable the perpetrators of such attacks when they originate from outside of the U.S. Second, the possibility of foreign governments providing implicit or explicit support for malicious cyber-activity may significantly increase the sophistication of attacks.

4.3.27.4. Future Occurrence

Societal trends and the increasing complexity and interconnectivity of technology create an environment where the frequency of cyber-attacks and cyber-terrorism risks are likely to continue to rise. Concern about cyber-terrorism throughout the U.S. is growing as its impacts could have potentially

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[268] ZDNET. "Microsoft: How One Emotet Infection Took out This Organization's Entire Network." Accessed November 6, 2023. https://www.zdnet.com/article/microsoft-how-one-emotet-infection-took-out-this-organizations-entire-network/.

[269] U.S. Department of Health and Human Services and Health Sector Cybersecurity Coordination Center. "HC3: Analyst Note." hhs.gov, December 12, 2022. https://www.hhs.gov/sites/default/files/blackcat-analyst-note.pdf.

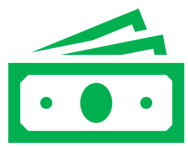
crippling effects. Although advancements in defenses against these attacks are continuously being made, the possibility of cyber-attacks, some of which may constitute cyber-terrorism, will continue to remain a significant risk within the Lehigh Valley.

4.3.27.5. Vulnerability Assessment

Cyber terrorism, involving the use of information technology to conduct attacks on digital infrastructure with the intent to disrupt, damage, or threaten a nation or organization, poses significant risks to communities like the Lehigh Valley. These attacks can target various sectors, including government networks, financial systems, utilities, and communication networks. The impacts of cyber terrorism on community lifelines are diverse and complex.

Table 101: Potential Vulnerabilities to Lifelines from Cyber-Terrorism

Lifelines	Impact Type	Description
Safety & Security		Cyber-attacks can compromise public safety systems, emergency communication channels, and law enforcement databases, hindering the ability to respond effectively to threats and maintain public order.
Health & Medical		Healthcare systems increasingly rely on digital technology. Cyber-attacks can disrupt hospital networks, access to patient records, and the functioning of medical equipment, impacting patient care and emergency services.
Housing & Building Infrastructure		Smart building systems and utilities management are vulnerable to cyber-attacks. Disruptions can lead to loss of heating, cooling, or electricity in residential and commercial buildings.
Utilities		Cyber terrorism can target critical infrastructure like power grids, water treatment facilities, and communication networks, leading to widespread service disruptions.

Lifelines	Impact Type	Description
Transportation Services		Modern transportation systems, including traffic control, public transit, and airport operations, rely heavily on digital technology. Cyber-attacks can cause significant disruptions, affecting the movement of people and goods.
Economic Stability		Cyber terrorism can have a profound impact on the economy, including financial markets, business operations, and consumer confidence. The cost of response and mitigation can be substantial.

Cyber-terrorism is a hazard that has the potential to significantly impact computer infrastructure and the systems and services that are provided to the public. Virtually all computers, networks, and similar informational technology in the Lehigh Valley are vulnerable to cyber-terrorism and cyber-attacks. Many critical facilities that are essential to daily operations are reliant upon computer networks to monitor and control critical functions. Larger cities like Allentown are considered more vulnerable to cyber-terrorism because of the higher concentrations of people, businesses, and critical infrastructure. However, smaller, rural areas should not be considered immune to such attacks, which often target smaller entities and local governments. The Lehigh Valley is also vulnerable to the effects cyber-terrorism even if the specific target is outside of both counties. Examples of this include acts of cyber-terrorism targeting nuclear power plants like Limerick Generation Station and Susquehanna Steam Electric Station. Additionally, attacks which manage to significantly disrupt statewide functions could result in subsequent impacts within the Lehigh Valley.

4.4 Hazard Vulnerability Summary

4.4.1 Methodology

A comprehensive range of natural and non-natural hazards that pose significant risk to the Lehigh Valley were selected and considered in this 2024 Plan. However, it is recognized that the communities in the Lehigh Valley have differing levels of exposure and vulnerability to each of these hazards. It is important for each community participating in this Plan to recognize those hazards that pose the greatest risk to their community and direct their attention and resources accordingly to most effectively and efficiently manage risk.

To this end, a relative hazard risk ranking process was conducted for the Lehigh Valley using the Risk Factor (RF) methodology identified in the Pennsylvania All-Hazard Mitigation Planning Standard Operating Guide (2020). The guidance states:

- The Risk Factor approach produces numerical values that allow identified hazards to be ranked against one another. The higher the Risk Factor value, the greater the hazard risk. Risk Factor values are obtained by assigning varying degrees of risk to five categories for each hazard: probability, impact, spatial extent, warning time and duration.
- To calculate the Risk Factor value for a given hazard, the assigned risk value for each category is multiplied by the weighting factor. The sum of all five categories equals the final Risk Factor value:
- Risk Factor Value = [(Probability x .30) + (Impact x .30) + (Spatial Extent x .20) + (Warning Time x .10) + (Duration x .10)]
- Hazards identified as “high risk” have Risk Factors greater than or equal to 2.5, with “moderate risk” hazards ranging from 2.0 to 2.4 and “low risk” hazards below 2.0.

The State Guide identifies five risk assessment categories, the criteria and associated risk level indices used to quantify their risk, and the weighting factor applied to each risk assessment category as shown in Table 102: Summary of Risk Factor (RF) Criteria.

In determining the hazard Risk Factors for Lehigh and Northampton counties, the objectives were to assess the main risk areas and their likely impact on the counties, including its people, natural areas, buildings and infrastructure. Each of the hazard risks was analyzed using the established criteria for the likelihood and consequences for the overall Risk Factor rating.

4.4.2 Ranking Results

Table 103 and Table 104 identify the region wide Risk Factor for each of the hazards profiled in the 2024 Plan. Based on the analysis, there are 15 high-risk hazards, seven moderate risk hazards and five low risk hazards.

A hazard risk assessment result for the entire Lehigh Valley does not mean that each municipality is at the same amount of risk for each hazard. Based on municipal input, an evaluation of the region wide Risk Factors was completed for each municipality to determine whether their risk is greater than (>), less than (<) or equal to (=) the Risk Factor assigned to the Lehigh Valley as a whole for each hazard.

Table 102: Summary of Risk Factor (RF) Criteria

Risk Assessment Category	Degree of Risk			Weight Value
	Level	Criteria	Index	
Probability: What is the likelihood of a hazard event occurring in a given year?	Unlikely	Less than 1% annual probability	1	30%
	Possible	Between 1% and 49.9% annual probability	2	
	Likely	Between 50% and 90% annual probability	3	
	Highly Likely	Greater than 90% annual probability	4	
Impact: In terms of injuries, damage, or death, would you anticipate impacts to be minor, limited, critical, or catastrophic when a significant hazard event occurs?	Minor	Very few injuries, if any. Only minor property damage and minimal disruption on quality of life. Temporary shutdown of critical facilities.	1	30%
	Limited	Minor injuries. More than 10% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one day.	2	
	Critical	Multiple deaths / injuries possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than a week.	3	
		High number of deaths / injuries possible. More than 50% of property in affected area damaged or destroyed.		

Risk Assessment Category	Degree of Risk				Weight Value
	Level	Criteria		Index	
	Catastrophic	Complete shutdown of critical facilities for 30 days or more.		4	
Spatial Extent: How large of an area could be impacted by a hazard event? Are impacts localized or regional?	Negligible Small Moderate Large	Less than 1% of area affected Between 1% and 10.9% of area affected Between 11% and 25% of area affected Greater than 25% of area affected		1 2 3 4	20%
Warning Time: Is there usually some lead-time associated with the hazard event? Have warning measures been implemented?	More than 24 hours 12 to 24 hours 6 to 12 hours Less than 6 hours	Self-Defined Self-Defined Self-Defined Self-Defined	Note: Levels of warning time and criteria that define them may be adjusted based on the hazard addressed.	1 2 3 4	10%
Duration: How long does the hazard event usually last?	Less than 6 hours Less than 24 hours Less than 1 week More than 1 week	Self-Defined Self-Defined Self-Defined Self-Defined	Note: Levels of warning time and criteria that define them may be adjusted based on the hazard addressed.	1 2 3 4	10%

Table 103: Lehigh Valley Hazard Risk Rankings for Natural Hazards

Hazard Risk	Natural Hazards	Probability	Impact	Extent	Warning	Duration	Risk Factor
HIGH	Pandemic & Infectious Disease	4	4	4	1	4	**3.7**
	Extreme Temperature	3	3	4	1	3	**3**
	Flood	4	2	3	3	3	**3**
	Winter Storm	3	2	4	1	2	**2.6**
	Windstorm/ Tornado	2	3	3	3	2	**2.6**
	Invasive Species	4	1	3	1	4	**2.6**
	Drought	2	2	4	1	4	**2.5**
	Subsidence / Sinkhole	4	1	1	4	4	**2.5**
MODERATE	Radon	4	1	2	1	4	**2.4**
	Wildfire	3	1	2	3	2	**2.1**
	Lightning	4	1	1	3	1	**2.1**
LOW	Earthquake	1	1	4	4	1	**1.9**
	Hailstorm	2	1	2	3	1	**1.7**
	Landslide	2	1	1	4	1	**1.6**

Table 104: Lehigh Valley Hazard Risk Rankings for Non-Natural Hazards

Hazard Risk	Non – Natural Hazards	Probability	Impact	Extent	Warning	Duration	Risk Factor
HIGH	Cyber-Terrorism	4	3	3	4	4	3.5
	Terrorism	3	4	4	4	2	3.5
	Drug Overdose Crisis	4	3	3	1	4	3.2
	Utility Interruption	4	2	3	3	3	3
	Environmental Hazards / Explosions	4	2	2	4	3	2.9
	Gas / Liquid Pipeline	4	2	2	4	2	2.8
	Fire (Urban / Structural)	4	2	1	4	2	2.6
MODERATE	Transportation Crash	4	1	1	4	1	2.2
	Civil Disturbance	4	1	1	3	2	2.2
	Dam Failure	1	3	2	4	1	2.1
	Levee Failure	1	3	2	4	1	2.1
LOW	Structural Collapse	2	2	1	4	1	1.9
	Nuclear Incident	1	1	2	4	2	1.6

4.4.2.1. FEMA NRI Risk Scores

The National Risk Index (NRI) is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards: Avalanche, Coastal Flooding, Cold Wave, Drought, Earthquake, Hail, Heat Wave, Hurricane, Ice Storm, Landslide, Lightning, Riverine Flooding, Strong Wind, Tornado, Tsunami, Volcanic Activity, Wildfire, and Winter Weather. Because not all hazards are applicable to the County, only those hazards with a defined risk to the Lehigh Valley are included. The National Risk Index is intended to fill gaps in available data and analyses to better inform federal, state, local, tribal, and territorial decision makers as they develop risk reduction strategies.

The National Risk Index's final rating is made by assessing the jurisdiction across three categories from each of the 18 hazard types:

- Social Vulnerability
- Community Resilience
- Expected Annual Loss

The National Risk Index score represents a community's relative level of risk as compared to all other communities at the same level across the United States (US). These measurements are calculated annually using average past conditions to develop a baseline risk measurement.[270]

4.4.2.2. Social Vulnerability

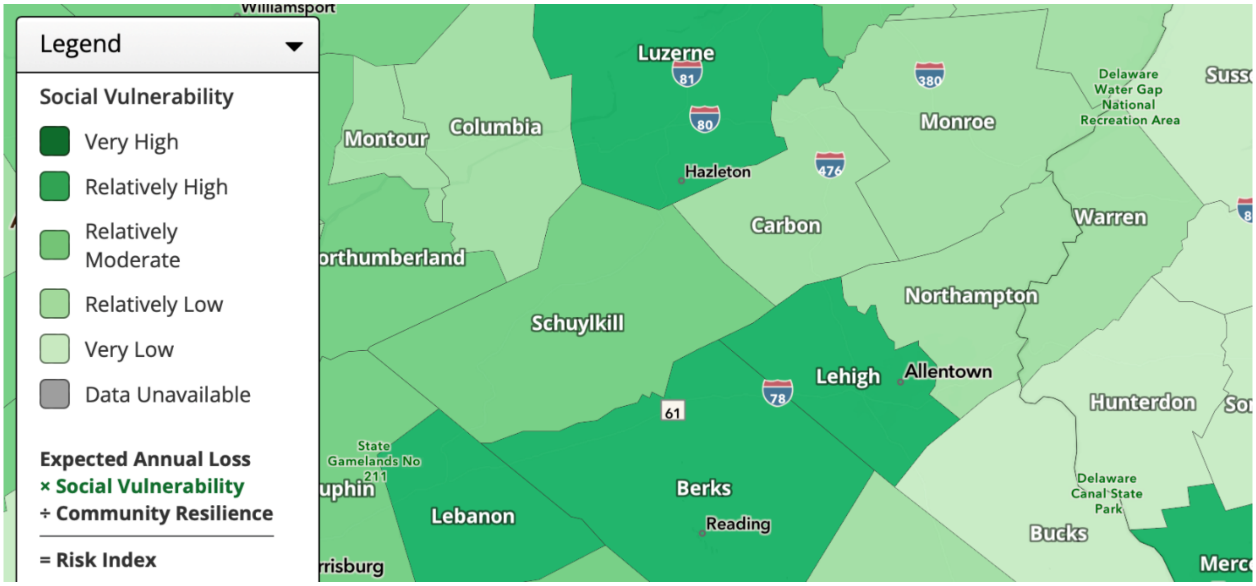
Social Vulnerability measures the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood. The table below compares Lehigh Valley amongst its neighboring counties with a Social Vulnerability Rating of "Relatively Moderate" and a Social Vulnerability Score of "54.50". The FEMA NRI Social Vulnerability (SoVi) Score and Rating represent the relative level of a community's social vulnerability compared to all other communities at the same level across the US.

Table 105: Social Vulnerability FEMA NRI Score

County	Social Vulnerability Score	Rating
Lehigh County	73.84	Relatively High
Northampton County	35.17	Relatively Low
Lehigh Valley Average	54.50	Relatively Moderate

[270] Federal Emergency Management Agency. "Learn More | National Risk Index." hazards.fema.gov. https://hazards.fema.gov/nri/learn-more.

Figure 37: Map of Region Depicting SVI Scores



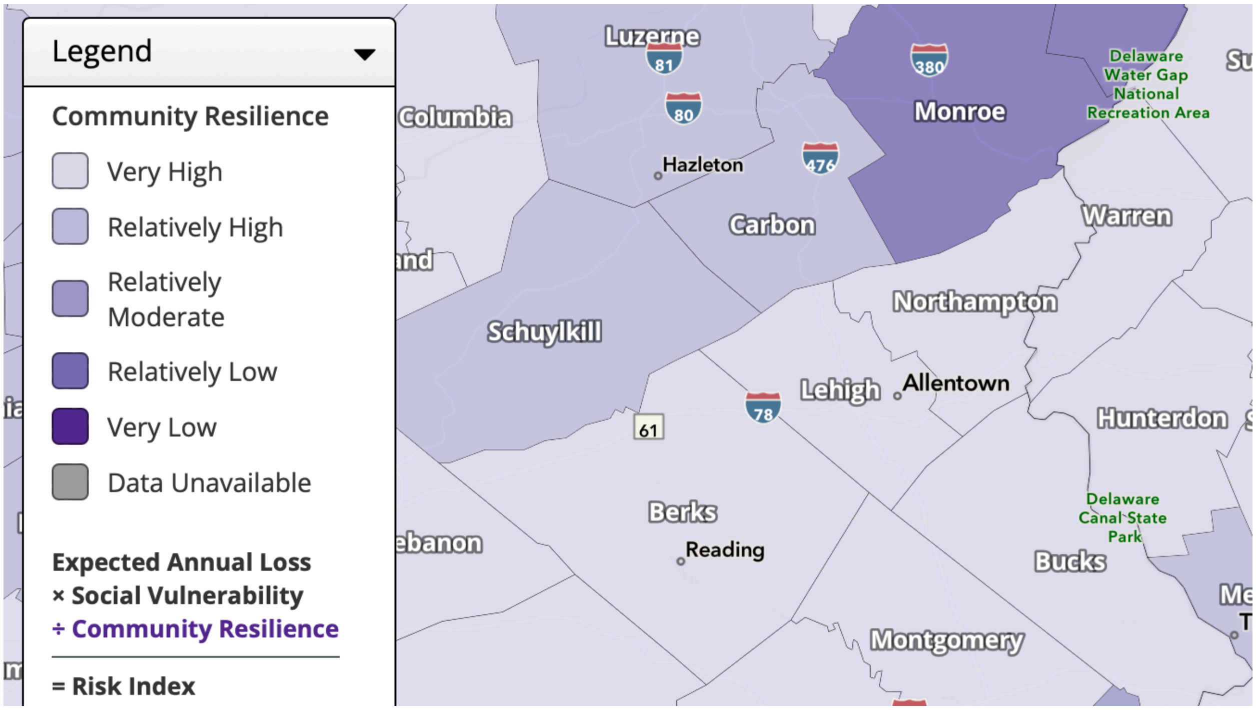
4.4.2.3. Community Resilience

Community Resilience measures a community's ability to prepare for anticipated natural hazards, adapt to changing conditions and withstand and recover rapidly from disruptions. The FEMA NRI Community Resilience is measured using the Baseline Resilience Indicators for Communities published by the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI). The table below illustrates Lehigh Valley's FEMA NRI Community Resilience score amongst its neighboring counties and ranks as the third highest. The FEMA NRI Community Resilience score for Lehigh Valley is "Very High" at a score of "81.38."

Table 106: Community Resilience FEMA NRI Score

County	Community Resilience Score	Rating
Lehigh County	81.44	Very High
Northampton County	81.32	Very High
Lehigh Valley Average	81.38	Very high

Figure 38: Map of Region Depicting Community Resilience Scores



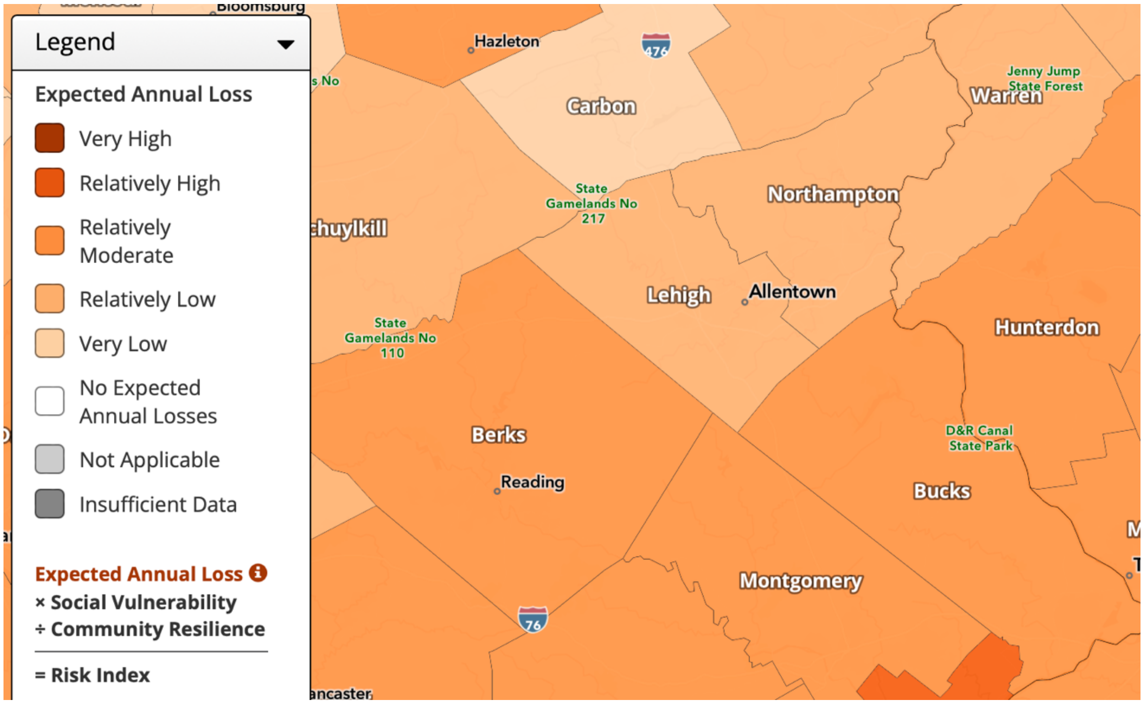
4.4.2.4. Expected Annual Loss

Expected Annual Loss (EAL) represents the average economic loss in dollars resulting from natural hazards each year. It is calculated for each hazard type and quantifies loss for relevant consequence types: buildings, people, and agriculture. The FEMA NRI EAL scores are calculated using an equation that combines values for exposure, annualized frequency, and historic loss ratios for the hazard types. Table 107 shows that the expected annual loss score for Lehigh Valley is the highest when compared to its neighboring counties. The EAL score for the Lehigh Valley is "82.59," which equates to a "Relatively Low" rating.

Table 107: Expected Annual Loss FEMA NRI Score

County	Expected Annual Loss Score	Rating
Lehigh County	83.23	Relatively Low
Northampton County	82.95	Relatively Low
Lehigh Valley Average	82.59	Relatively Low

Figure 39: Map of Region Depicting Expected Annual Loss Scores



4.4.2.5. Lehigh County NRI Summary

Lehigh County presents an interesting risk profile when analyzed through the National Risk Index[271]. This comprehensive assessment considers various factors to gauge the county's vulnerability to natural hazards, expected annual losses, social vulnerability, and community resilience. Let's delve deeper into each aspect of Lehigh County's risk index:

Risk Index: Lehigh County's overall Risk Index is scored at 83.1, which falls within the "Relatively Moderate" category when compared to the rest of the United States. This score reflects the county's susceptibility to various natural hazards and is influenced by factors such as expected annual loss, social vulnerability, and community resilience.

Expected Annual Loss: Lehigh County fares relatively well in terms of expected annual loss, with a score of 83.2, indicating that its anticipated losses due to natural hazards are comparatively low. This suggests that the county experiences fewer financial losses resulting from events like hurricanes, tornadoes, or wildfires when compared to other regions in the country.

[271] Federal Emergency Management Agency. "Learn More | National Risk Index." hazards.fema.gov. https://hazards.fema.gov/nri/learn-more.

Social Vulnerability: The county's social vulnerability score is 73.8, indicating that social groups within Lehigh County are relatively more susceptible to the adverse impacts of natural hazards. This is a significant consideration for disaster preparedness and response efforts, highlighting the need to address vulnerabilities within the community.

Community Resilience: Lehigh County boasts a remarkable score of 81.4 in terms of community resilience. This high rating signifies the county's ability to prepare for, adapt to, withstand, and recover rapidly from disruptions caused by natural hazards. This level of resilience is a critical asset in ensuring the safety and well-being of the community during and after adverse events.

It's essential to recognize that the overall low risk index for Lehigh County is a result of lower losses due to natural hazards, lower social vulnerability, and higher community resilience. These factors collectively contribute to the county's relatively moderate risk profile.

In comparison to the national and state percentiles, Lehigh County's risk index is noteworthy. For instance, 83% of U.S. counties have a lower Risk Index, indicating that Lehigh County is better equipped to handle the challenges posed by natural disasters. Similarly, the county's expected annual loss is lower than 83% of U.S. counties, indicating a commendable level of preparedness.

On the other hand, Lehigh County's social vulnerability score places it in the 98.50 percentile within Pennsylvania, which means that the county may need to focus on addressing specific social vulnerabilities to further enhance its resilience.

In terms of community resilience, Lehigh County is in the 64.20 percentile within Pennsylvania, demonstrating room for further improvement to bolster its capacity to manage and recover from natural hazards.

Overall, Lehigh County, showcases a balanced risk profile, with strengths in expected annual loss and community resilience, and an opportunity for continued enhancement in addressing social vulnerabilities.

4.4.2.6. Northampton County NRI Summary

Northampton County exhibits a relatively low risk profile when it comes to natural hazards.[272] This comprehensive risk assessment examines various critical factors, including the county's vulnerability to natural hazards, expected annual losses, social vulnerability, and community resilience. In-depth insights into each of these aspects provide a holistic view of Northampton County's preparedness and resilience in the face of potential disasters.

[272] Federal Emergency Management Agency. “Learn More | National Risk Index.” hazards.fema.gov. https://hazards.fema.gov/nri/learn-more.

Risk Index Analysis: Northampton County garners an impressive Risk Index score of 81.45, signifying its status as a "Relatively Low" risk area compared to the broader United States. This assessment considers multiple parameters, including expected annual losses, social vulnerability, and community resilience. Let's delve deeper into each of these components.

Risk Index Score: Northampton County's Risk Index score, which stands at 81.45, reflects its favorable risk profile. It outperforms 81% of U.S. counties and 84% of counties in Pennsylvania, indicating a well-managed risk landscape. This achievement underscores the county's commitment to disaster risk reduction.

Expected Annual Loss (EAL): Northampton County excels in terms of expected annual losses, boasting a score of 82.9. This indicates a relatively low level of projected financial losses stemming from natural hazards. In essence, the county's efficient disaster risk management strategies are geared toward mitigating the economic impact of events such as hurricanes, tornadoes, or wildfires.

Social vulnerability is a crucial aspect of risk assessment, and Northampton County stands out with a low vulnerability score of 35.2. This rating reflects the county's successful efforts in reducing the susceptibility of its social groups to the adverse impacts of natural hazards. The commitment to addressing vulnerabilities within the community has played a pivotal role in achieving this favorable rating.

Northampton County is distinguished by an impressive Community Resilience score of 81.3. This rating highlights the county's high capability to prepare for anticipated natural hazards, adapt to changing circumstances, and withstand and rapidly recover from disruptions. It underscores the county's dedication to disaster preparedness and response initiatives, ultimately ensuring the safety and well-being of its residents.

Northampton County's risk profile varies across different hazard types, with each type assessed individually. Some hazards, such as hurricanes and riverine flooding, exhibit relatively low risk, while others like tornadoes and ice storms fall into the moderate-risk category. While no hazard type is rated as "Very High" or "Very Low," this detailed analysis enables precise risk management strategies for specific hazards.

The Expected Annual Loss scores for various hazard types offer insights into the potential economic impact of each. Notable hazard types and their associated EAL values include hurricanes, riverine flooding, and tornadoes. Understanding these values aids in prioritizing resources and preparedness efforts.

The low social vulnerability score is a testament to Northampton County's commitment to ensuring that its social groups are well-prepared to face natural disasters. This is achieved through inclusive policies, community engagement, and targeted assistance programs.

Northampton County's high community resilience score is indicative of its proactive approach to disaster preparedness. The county's ability to adapt, respond, and recover rapidly from disruptions is a result of strategic planning, robust infrastructure, and effective coordination among various stakeholders.

Northampton County, boasts a commendable risk profile characterized by lower expected annual losses, diminished social vulnerability, and a notable level of community resilience.

4.4.3 Potential Loss Estimates

The risk assessment process used for the 2023 Plan is consistent with the process and steps presented in FEMA 386-2, State and Local Mitigation Planning How-to-Guide, Understanding Your Risks – Identifying Hazards and Estimating Losses (FEMA, 2001). This process identifies and profiles the hazards of concern and assesses the vulnerability of assets, such as population, structures, critical facilities and the economy at risk in the community.

To address the requirements of DMA 2000 and better understand potential vulnerability and losses associated with hazards of concern, the Lehigh Valley used standardized tools, combined with local, state and federal data and expertise to conduct the risk assessment. A summary of potential loss estimates is included in the hazard profiles for earthquake, flood, landslide, subsidence/sinkhole, windstorm / tornado, winter storm and wildfire.

4.4.3.1. Hazards US – Multi-Hazard (HAZUS-MH) Overview

HAZUS-MH is a Geographic Information System (GIS)- based software tool that applies engineering and scientific risk calculations that have been developed by hazard and information technology experts to provide defensible damage and loss estimates. These methodologies are accepted by FEMA and provide a consistent framework for assessing risk across a variety of hazards. The GIS framework also supports the evaluation of hazards and assessment of inventory and loss estimates for these hazards.

HAZUS-MH produces detailed maps and analytical reports that estimate a community's direct physical damage to building stock, critical facilities, transportation systems and utility systems. HAZUS-MH uses default HAZUS-MH provided data for inventory, vulnerability and hazards; this default data can be supplemented with local data to provide a more refined analysis. Damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements and economic impact) depending on the hazard and available local data. The guidance "Using HAZUS-MH for Risk Assessment: How-to Guide" (FEMA 433) was relied upon to support the application of HAZUS-MH for this risk assessment and plan (FEMA 2015). More information on HAZUS-MH is available at https://www.fema.gov/hazus.

In general, probabilistic analyses were performed to develop estimates of long-term average losses for the earthquake and wind hazards, as well as an expected/ estimated distribution of losses for the earthquake, flood and wind hazards. The probabilistic hazard analysis generates estimates of damage and loss for specified return periods. For annualized losses, HAZUS-MH 4.0 calculates the maximum potential annual dollar loss resulting from various return periods averaged on a "per year" basis. It is the summation of all HAZUS-supplied return periods (e.g., 10, 50, 100, 200, 500) multiplied by the return period probability, as a weighted calculation. In summary, the estimated cost of a hazard is calculated each year.

4.4.3.2. HAZUS-MH Analyses

Custom methodologies in HAZUS-MH 4.0 were used to assess potential exposure and losses associated with hazards of concern for the Lehigh Valley:

- Inventory: The default demographic data in HAZUS-MH 4.0, based on the 2010 US Census, was used for the HAZUS-MH analysis and hazard exposure analysis at the municipal level. The default building inventory in HAZUS-MH 4.0 was updated and replaced at the Census-block and Census-tract level with a custom-building inventory developed for the Lehigh Valley. The custom- building inventory was developed using building footprint data and detailed structure-specific assessor data provided by the Lehigh Valley Planning Commission and Lehigh and Northampton County GIS Departments. Structural and content replacement cost values were calculated for each building utilizing available assessor data and RSMeans 2018 values; a regional location factor for Lehigh Valley was applied (1.06) for all occupancy classes.

The occupancy classes available in HAZUS-MH 4.0 were condensed into the following categories (residential, commercial, industrial, agricultural, religious, governmental and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single-family dwellings.

An updated critical facility inventory was developed for the Lehigh Valley using the original critical facility inventory from the previous Plan and updated and expanded upon using spatial data provided by the Lehigh Valley Planning Commission. This updated inventory was incorporated into HAZUS- MH replacing the default critical facility (police, fire, schools, etc.) and utility inventories.

The 'locally-defined facilities' category includes all assets that the Lehigh Valley plan participants deemed critical to include in the inventory and that do not fit within a pre-defined HAZUS-MH facility category. These facilities include shelters, senior care facilities and municipal-owned buildings. The 'locally-defined facility' types are listed below:

- Agriculture and Food
- Boat Ramp
- Cemetery
- Commercial Parcels
- Community Organization
- County Building
- Day Care
- EMS

- Federal Building
- Funeral Home
- Golf Course
- Industrial
- Judicial Building
- Library
- Lodging
- Municipal Building
- Museum
- Post Office
- Print Media
- Prison
- Public Health
- Religious
- Rescue
- Senior
- Shelter
- State Building
- Storage and Preservation (Archive)
- Stream Gauge
- Veterinary

Earthquake

HAZUS-MH 4.0 was used to evaluate the Lehigh Valley's risk to the seismic hazard. A probabilistic assessment was performed to analyze the earthquake hazard losses (annualized losses and 100-, 500- and 2,500-year mean return period [MRP] losses). The probabilistic method uses information from historic earthquakes and inferred faults, locations and magnitudes, and computes the probable ground shaking levels that may be experienced during a recurrence period by Census tract.

As noted in the HAZUS-MH Earthquake User Manual, “Uncertainties are inherent in any loss estimation methodology. They arise in part from incomplete scientific knowledge concerning earthquakes and their effects upon buildings and facilities. They also result from the approximations and simplifications that are necessary for comprehensive analyses. Incomplete or inaccurate inventories of the built environment, demographics and economic parameters add to the uncertainty. These factors can result in a range of uncertainty in loss estimates produced by the HAZUS Earthquake Model, possibly at best by a factor of two or more”. However, HAZUS’ potential loss estimates are acceptable for the purposes of this 2024 Plan.

The National Earthquake Hazard Reduction Program (NEHRP) developed five soil classifications that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses. NEHRP soil classifications were not available for the Lehigh Valley at the time of this analysis. Soils were classified as NEHRP soil type D across the Lehigh Valley as a conservative approach to this risk assessment. Groundwater was set as at a depth of five-feet (default setting). Damages and loss due to liquefaction, landslide or surface fault rupture were not included in this analysis.

Default demographic and the updated general building stock and critical facility inventory data in HAZUS-MH 4.0 were used for the earthquake analysis.

Flood

The 1% and 0.2% chance flood events were examined to evaluate the Lehigh Valley’s risk and vulnerability to the riverine flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as the NFIP.

A Level 2 HAZUS-MH riverine flood analysis was performed for only the 1% chance flood event; the 0.2% annual chance flood event was not evaluated in HAZUS-MH for the 2024 Plan due to budgetary constraints. The Lehigh County FEMA Digital Flood Insurance Rate Maps (DFIRMs) dated July 2004 and the Northampton County effective DFIRMs dated 2014 were used to evaluate exposure and determine potential future losses. A FEMA Risk MAP product for the Schuylkill Watershed (9/30/2017) that encompasses a portion of Lynn Township in Lehigh County was also used.

A 3.2-foot resolution depth grid was developed for the 1% annual chance flood event for the Lehigh Valley. Using Geographic Information System (GIS) tools and the best available data including the DFIRM database for both counties and the 2008 3.2-foot Light Detection and Ranging (LiDAR) Bare Earth Digital Elevation Model (DEM) available from Pennsylvania Spatial Data Access – the Pennsylvania Geospatial Data Clearinghouse, a flood depth grid was generated and integrated into the HAZUS-MH riverine flood model.

To estimate exposure to the 1% and 0.2% annual chance flood events, the DFIRM flood boundaries, updated building and critical facility inventories and 2010 US Census population data were used.

The HAZUS-MH 4.0 riverine flood model was run to estimate potential losses for the Lehigh Valley for the 1% annual chance flood event. HAZUS-MH 4.0 calculated the estimated potential losses to the population (default 2010 US Census data) and potential damages to the updated general building stock and critical facility inventories based on the depth grid generated and the default HAZUS damage functions in the flood model.

To estimate the exposure to population, the DFIRM flood boundaries were also overlaid upon the updated building inventory. This is because Census blocks are not consistent with boundaries of the floodplain, and gross overestimate or underestimate of exposed population can occur via use of the centroid or intersect of the Census block with these zones. In an attempt to estimate population exposure more accurately, the number of structures located in the hazard areas was totaled and multiplied by the average household size for each County: Lehigh County 2.54; Northampton County 2.53. While this assumes that all structures in the floodplain are residential and single-household, it provides a reasonable estimate of population directly exposed to the flood risk. Limitations of these analyses are recognized, and thus results are used only to provide a general estimate for planning purposes.

To estimate debris generated by the 1% annual chance flood event, HAZUS-MH v4.2, which was released on January 29, 2018, was used instead of HAZUS-MH v4.0. This is because a FEMA-known error in v4.0 was detected, and the issue appears to have been resolved with the latest software release.

Hurricane/Wind

A HAZUS-MH 4.0 probabilistic analysis was performed to analyze the wind hazard losses for the Lehigh Valley. The probabilistic hurricane hazard 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 Lehigh Valley. HAZUS-MH contains data on historic hurricane events and wind speeds. It also includes surface roughness and tree coverage maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Annualized losses and the 100- and 500-year MRPs were examined for the wind/severe storm hazard. Default demographic and updated building and critical facility inventories in HAZUS-MH 4.0 were used for the analysis.

There is currently a FEMA-acknowledged issue with importing locally-defined facilities in HAZUS- MH v4.0 and v4.2. To estimate potential losses to locally-defined facilities identified by the Lehigh Valley, they were appended to the Emergency Operation Centers input in HAZUS-MH Comprehensive Data Management System (CDMS) and uploaded to the program. Due to the size of the two-county region in HAZUS-MH 4.0, the hurricane model was run at the Census Tract level to estimate potential losses using the same scenarios.

4.4.3.3. ESRI ArcGIS Analyses

For the following hazards, ArcGIS was used to assess potential exposure for hazards of concern with delineated hazard areas in Lehigh Valley. The defined hazard areas were overlaid upon the asset data (population, building stock, critical facilities) to estimate the exposure to each hazard. The limitations of these analyses are recognized, and as such the analyses are only used to provide a general estimate:

Environmental Hazards

The Federal Title III Superfund Amendments and Reauthorization Act (SARA), the Emergency Planning and Community Right to Know Act, and the Commonwealth of Pennsylvania set up requirements for producing, storing, and transporting hazardous materials. These hazardous materials may be released either at their storage facility location (fixed site) or in- transit. The Pennsylvania Department of Transportation State Roads layer (2011) was used to define the hazard area around major roadways. The hazard area was defined as a ¼ mile buffer around the major roadways where hazardous materials may be in transit to estimate areas that may be directly or indirectly impacted by a release. Additionally, a 0.5-mile buffer around the SARA Title III facilities for the Lehigh Valley and EPA Superfund sites was used to estimate potential exposure.

Landslide

The 2011 Landslide Incidence and Susceptibility geographic information system (GIS) layer from the US Geological Survey was used to coarsely define the general landslide susceptible area. According to Radbruch-Hall and others, the Landslide Incidence and Susceptibility GIS layer from National Atlas; and applies to the US Geological Survey layer as well: "…. was prepared by evaluating formations or groups of formations shown on the geologic map of the United States (King and Beikman 1974) and classifying them as having high, medium, or low landslide incidence (number of landslides) and being of high, medium, or low susceptibility to land sliding. Thus, those map units or parts of units with more than 15 percent of their area involved in land sliding were classified as having high incidence; those with 1.5 to 15 percent of their area involved in land sliding, as having medium incidence; and those with less than 1.5 percent of their area involved, as having low incidence." (Radbruch-Hall 1982).

Nuclear Incident

Population, building stock and critical facilities within the Ingestion Exposure Pathway Zone EPZ, which is a 50-mile radius around a nuclear facility, are susceptible to a nuclear incident. The Lehigh Valley is located within the Ingestion Exposure Pathway EPZs of the Susquehanna Steam Electric Station located in Luzerne County, PA and the Limerick Generating Station in Montgomery County, PA. The 50-mile EPZs were used to define the hazard area for a nuclear incident. The defined hazard area was overlaid upon the asset data (population, building and critical facilities) to estimate exposure to the nuclear incident hazard.

Subsidence and Sinkholes

To estimate the Lehigh Valley's vulnerability to the subsidence and sinkhole hazard, the portion of the region underlain by carbonate bedrock (limestone and dolomite) is considered exposed to natural subsidence. To determine exposure to this hazard, the asset spatial data was overlaid on the carbonate bedrock from the Pennsylvania Bureau of Topographic and Geologic Survey Geology (PBTGS) geology spatial layer. The limitations of this analysis are recognized and are only used to provide a general estimate of exposure.

Wildfire

The wildfire urban interface, known as WUI, obtained through the SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin-Madison was used to define the wildfire hazard areas. The University of Wisconsin Madison wildland fire hazard areas are based on the 2010 Census and 2006 National Land Cover Dataset and the Protected Areas Database. For the purposes of this risk assessment, the high-, medium- and low-density interface areas were combined and used as the 'interface' hazard area and the high-, medium- and low-density intermix areas were combined and used as the 'intermix' hazard areas. The defined hazard area was overlaid upon the asset data (population, building stock, critical facilities) to estimate the exposure to each hazard.

Winter Storm

The entire general building stock inventory in the Lehigh Valley is exposed and vulnerable to the winter storm hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. A percentage of the custom building stock structural replacement cost value was utilized to estimate damages that could result from winter storm conditions. Given professional knowledge and the currently available information, the potential losses for this hazard are considered to be overestimated; hence, providing a conservative estimate for losses associated with winter storm events.

4.4.3.4. Qualitative Analyses

For many of the hazards evaluated in this risk assessment, historic data are not adequate to model future losses at this time. Where GIS data are not available, a qualitative analysis was conducted for the following hazards using the best available data and professional judgment:

- Drought
- Extreme Temperature
- Hailstorm
- Lightning Strike
- Radon Exposure
- Structural Collapse
- Dam Failure
- Drug Overdose Crisis
- Fire (Urban/Structural)

- Invasive Species
- Levee Failure
- Civil Disturbance/Mass Gathering
- Pandemic and Infectious Disease
- Terrorism
- Transportation Crash
- Utility Interruption

4.4.3.5. Limitations

For this risk assessment, the 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 natural hazards and their effects on the built environment. Uncertainties also result from the following:

1. Approximations and simplifications necessary to conduct such a study
2. Incomplete or dated inventory, demographic or economic parameter data
3. The unique nature, geographic extent, and severity of each hazard
4. Mitigation measures already employed by the participating municipalities
5. The amount of advance notice residents have to prepare for a specific hazard event

These factors can result in a range of uncertainty in loss estimates, possibly by a factor of two or more. Therefore, potential exposure and loss estimates are approximate. These results do not predict precise results and should be used to understand relative risk. Over the long term, the Lehigh Valley will collect additional data to assist in developing refined estimates of vulnerabilities to natural and non-natural hazards.

4.4.4 Future Development & Vulnerability

Changes in population, growth and development may affect the future hazard vulnerability of a community. The Lehigh Valley's population is projected to increase 25.6% from 2010-2040, which is almost on par with the growth rate for the area from 1980-2010 (30%). With the exception of Chapman Borough, all municipalities are projected to see an increase in population through 2040. With the increase in population, these municipalities face increased vulnerability to hazards.

People are a community's most important asset and certain populations are more vulnerable than others are. Vulnerable populations can be more susceptible to hazard events based on a number of factors, including their physical and financial ability to react or respond during a hazard event. These populations include the elderly, disabled, those living below the poverty line, and those with limited English proficiency.

Since the Lehigh Valley's rebound from the 2008 recession, the region has seen a resurgence in development, including housing dominated by new apartment buildings and warehousing due to the rapid expansion of e-commerce. The three cities have been experiencing growth through redevelopment as revitalization efforts occur. Suburban townships adjacent to the cities have also experienced a significant amount of development as have rural townships. These trends are expected to continue, resulting in increased vulnerability to people and property. Known or anticipated future development, including known hazard risks and risk zones, was identified at the municipal level and documented in the municipal annexes.

The LVPC maintains a regional comprehensive plan, which at the time of this Plan is in the process of being updated, that recommends the preservation of farmland, natural resources, parks and open space in the Lehigh Valley. It also includes recommendations related to land use, transportation, community utilities, Stormwater management and housing, in an effort to improve community resiliency and sustainability. With farmland and prime land areas disappearing due to growth, more development may occur in less suitable areas that may result in increased vulnerability to hazards. The LVPC will be working with a number of municipalities in the region to develop multi-municipal comprehensive plans that can incorporate specific recommendations related to hazard mitigation planning to reduce future vulnerability.

Other conditions, such as climate change, may affect the future vulnerability of the region. Climate change in and of itself may not be a hazard, but it may change the characteristics of hazards of concern in the region. In May 2015, the Commonwealth prepared the Pennsylvania Climate Impacts Assessment Update, which reports on the potential impacts of climate change in the state. The report provides:

- Scientific predictions regarding changes in temperature and precipitation in Pennsylvania.
- Potential impact of climate change on human health, the economy and other sectors.
- Economic opportunities created by potential need for alternative sources of energy and climate related technologies.

The May 2015 report's main findings indicate it is very likely that Pennsylvania will experience increased temperatures and precipitation in the 21st century. An increase in the variability of temperature and precipitation may lead to increased frequency and severity of many of the hazards profiled in the Plan, including flooding, high winds, lightning, hailstorms and extreme temperatures. For example, an increase in extreme heat may lead to various human health impacts such as an increased formation of ground level ozone, which has been shown to be related to higher incidences of respiratory disease and death, higher concentrations of particulates, which have been shown to be related to higher incidence of respiratory and heart disease, and higher concentrations of airborne allergens, such as mold spores and pollen. Increased temperatures may correspond to an increase in water-based recreation, resulting in increased exposure to water-based disease.[273]

Increases in temperature will likely lead to increased evapotranspiration and thus an increase in soil-moisture- related droughts throughout late spring and early fall.

Pennsylvania's precipitation climate is projected to become more extreme in the future, with longer dry periods and greater intensity of precipitation. Most models indicate the maximum number of consecutive dry days in a year, a drought indicator, is projected to increase.

Warmer climates create a more favorable habitat for Emerald Ash Borer, Hemlock Woolly Adelgid, Gypsy Moths, Asian Tiger Mosquito and the Spotted Lanternfly, expanding the area that is warm enough for these insects. Warmer temperatures will also allow the insects to remain active longer. This could have devastating impacts to certain tree species (oak, ash, and hemlock) and garden and landscape plants. The Asian Tiger Mosquito, which is known for carrying and transmitting diseases, will also see an increase in its range, thus increasing the public health risk from these mosquitos.[274]

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[273] Lehigh Valley Planning Commission. "Climate + Energy Element." lvpc.org, 2014. https://www.lvpc.org/pdf/2014/climate%20and%20energy%20show%20FINAL.pdf.

[274] Benedict, Mark Q., Rebecca S. Levine, William A. Hawley, and L. Philip Lounibos. "Spread of The Tiger: Global Risk of Invasion by The Mosquito *Aedes Albopictus*." *Vector-Borne and Zoonotic Diseases* 7, no. 1 (March 2007): 76–85. https://doi.org/10.1089/vbz.2006.0562.

5. Capability Assessment

A capability assessment evaluates the capabilities and resources that are already in place at the municipal, county, state and federal levels to reduce hazard risk and identifies where improvements can be made to increase disaster resistance in a community.

5.1 Update Process Summary

The planning team spent considerable time validating and updating the Capability Assessment through four workshops held in-person between June 28 and 29, 2023. The Northampton County Emergency Operations Center (EOC) hosted two meetings on the 28th and Lehigh County hosted two matching sessions on June 29th at the Cetronia Ambulance Corps.

During the workshops participants:

- Revisited "Critical Facilities", "Community Lifelines", and "Community Assets".
- Validated assets pulled from Hazus and supplemented by data from both county GIS offices.
- Were asked to provide updates to development, populations, underserved communities, climate change, and municipal authority or policies.
- Reviewed the FEMA Region III Community Capability Assessment Worksheet.
- Updated the capability sections of the HMP annexes.
- Discussed opportunities for public and stakeholder outreach.

5.2 Capability Assessment Findings

The tables below summarize the participating communities' responses to the capability assessment worksheets.

Table 108 – Planning and Regulatory Resources

Capability	Northampton County		Lehigh County		Total	
	Number	Percent	Number	Percent	Number	Percent
Comprehensive Plan	28	74%	23	88%	51	80%
Capital Improvement Plan	8	21%	9	35%	17	27%
Economic Development Plan	2	5%	3	12%	5	8%
Continuity of Operations Plan	5	13%	6	23%	11	17%
Stormwater Management Plan / Ordinance	35	92%	21	81%	56	88%
Open Space Management Plan	25	66%	19	73%	44	69%
Natural Resources Protection Plan	8	21%	7	27%	15	23%
Transportation Plan	6	16%	2	8%	8	13%

Historic Preservation Plan	3	8%	7	27%	10	16%
Floodplain Management Plan	22	58%	14	54%	36	56%
Farmland Preservation	6	16%	9	35%	15	23%
Evacuation Plan	11	29%	7	27%	18	28%
Disaster Recovery Plan	9	24%	3	12%	12	19%
Hazard Mitigation Plan	38	100%	24	92%	62	97%
Emergency Operations Plan	35	92%	22	85%	57	89%
Zoning Regulations	35	92%	24	92%	59	92%
Floodplain Regulations	29	76%	22	85%	51	80%
NFIP Participation	24	63%	17	65%	41	64%
Building Code	31	82%	24	92%	55	86%
Fire Code	27	71%	17	65%	44	69%

Table 109 – Administrative and Technical Capability

Capability	Northampton County		Lehigh County		Total	
	Number	Percent	Number	Percent	Number	Percent
Planners w/ land use and land development knowledge	31	82%	21	81%	52	81%
Planners or engineers with natural and/or human-caused hazards knowledge	30	79%	22	85%	52	81%
Engineers or professionals trained in building and/or infrastructure construction practices	33	87%	22	85%	55	86%
Emergency Manager	35	92%	22	85%	57	89%
Floodplain administrator/manager	31	82%	20	77%	51	80%
Land Surveyors	24	63%	16	62%	40	63%
Staff familiar with the hazards of the community	33	87%	21	81%	54	84%
GIS/HAZUS personnel	23	61%	19	73%	42	66%
Grant writers or fiscal staff	25	66%	18	69%	43	67%

Table 110 – Fiscal Capability

Capability	Northampton County		Lehigh County		Total	
	Number	Percent	Number	Percent	Number	Percent
Capital improvement programming	19	50%	13	50%	32	50%
CDBG	21	55%	14	54%	35	55%
Special purpose taxes	14	37%	12	46%	26	41%
Gas/electric utility fees	4	11%	1	4%	5	8%
Water/sewer fees	17	45%	15	58%	32	50%
Stormwater utility fees	5	13%	4	15%	9	14%

Development impact fees	14	37%	11	42%	25	39%
General obligation, revenue, and/or special tax bonds	13	34%	13	50%	26	41%
Partnering arrangements or intergovernmental agreements	19	50%	19	73%	38	59%

Table 111 – Education and Outreach

Capability	Northampton County		Lehigh County		Total	
	Number	Percent	Number	Percent	Number	Percent
Firewise communities certification	2	5%	0	0%	2	3%
StormReady certification	0	0%	5	19%	5	8%
Natural disaster or safety-related school programs	3	8%	9	35%	12	19%
Ongoing public education or information programs such as, responsible water use, fire safety, household preparedness, and environmental education.	26	68%	23	88%	49	77%
Public-private partnership initiatives addressing disaster-related issues	3	8%	9	35%	12	19%
Local citizen groups or non-profit organizations focused on environmental protection, emergency preparedness, access and functional needs populations, etc.	12	32%	16	62%	28	44%

In addition to the inventory and analysis of specific local capabilities, the Capability Assessment Survey required each municipality to complete its own self-assessment of its capability for each of the four categories to effectively implement hazard mitigation actions. Respondents were required to identify their degree of capability as “Limited”, “Moderate” or “High”.

Table 112 – Municipal Capacity Self-Assessment

Category	“Limited” Capacity Municipalities	“Moderate” Capacity Municipalities	“High” Capacity Municipalities
Planning and Regulatory Capability	21%	52%	27%
Administrative and Technical Capability	18%	55%	27%
Fiscal Capability	45%	35%	19%
Education and Outreach	42%	40%	18%

5.2.1 *Planning and Regulatory Capability*

While municipalities in Pennsylvania must comply with the minimum regulatory requirements established under the Pennsylvania Municipalities Planning Code (MPC)—Act 247 of 1968, as reauthorized and amended— they otherwise have considerable latitude in adopting ordinances, policies and programs that can support their ability to manage natural and non-natural hazard risk. Specifically, municipalities can manage these risks through comprehensive land use planning, zoning ordinances, subdivision and land development ordinances, hazard- specific ordinances (e.g., floodplain management, sinkholes, steep slopes), and building codes. It is noted that both counties, and many of the municipalities, have identified specific mitigation initiatives in the 2024 Plan to help build and enhance mitigation-related planning and regulatory capabilities in the Lehigh Valley.

5.2.1.1 Comprehensive Plans

Comprehensive plans promote sound land use and regional cooperation among local governments to address planning issues. A comprehensive plan is a policy document that states objectives and guides the future growth and physical development of a municipality. With regard to hazard mitigation planning, the MPC requires comprehensive plans to include a plan for land use, which, among other provisions, suggests that the plan give consideration to floodplains and other areas of special hazards. The MPC also requires comprehensive plans to include a plan for community facilities and services, and recommends giving consideration to storm drainage and floodplain management.

Pennsylvania's MPC requires counties to prepare and maintain a county comprehensive plan and to update it every ten years. While county governments are required by law to adopt a comprehensive plan, local municipalities (or groups of municipalities) may do so at their option. 80% of municipalities covered by this plan report having a comprehensive plan.

FutureLV is the region's Comprehensive Plan, and is closely integrated with the MoveLV Long-Range Transportation Plan. Additional studies and plans incorporated into the FutureLV plan and this plan include:

- **One Lehigh Valley (2014)** – Planning for the region's continued success, stability and resiliency, a 14-member regional alliance, the Lehigh Valley Sustainability Consortium, embarked on a nearly three- year effort to plan for a sustainable Lehigh Valley. The Consortium partners, including the LVPC, organized ten plans and projects around four themes: Economy, Environment, Transportation and Livable Communities. The LVPC assessed each of the Consortium partner's plans and projects and assembled a series of 31 goals intended to serve as an update to the regional comprehensive plan.
- **Climate and Energy Element (2014)** – The Climate and Energy Element was created as part of the One Lehigh Valley planning effort. The report identifies goals, policies and strategies to incorporate into the regional comprehensive plan update, including those to lessen the impacts of hazards. Public participation was an important component of preparing the report, with climate change and energy issues being the subject of public meetings June 19, 2014, in Easton, and June 26 and July 17, 2014 at the LVPC offices.

- **One Water (County Planning Directors Association of Pennsylvania 2016)** – The Pennsylvania MPC stipulates that comprehensive plans shall include a plan for the reliable supply of water, considering current and future water resources availability, uses and limitations, including provisions necessary to protect water supply sources. The County Planning Directors Association of Pennsylvania formed a task force to expand the understanding and implementation of Integrated Water Resources Management as a method for Pennsylvania counties and local governments to better address complex water resources and land planning issues. The Task Force reviewed an extensive body of information available from across the Commonwealth and the nation and prepared recommended actions to expand the implementation of Integrated Water Resources Management in Pennsylvania.
- **County Open Space Plans** – The LVPC, on behalf of Lehigh and Northampton counties, created open space plans for the two counties—Livable Landscapes an Open Space Plan for Northampton County (2016) and Livable Landscapes a Park, Recreation, Open Space, Agricultural and Historic Lands Plan for Lehigh County (2018). The LVPC will comment on open space issues identified in these plans during project reviews.
- **Lehigh Valley Return on Environment (2014)** – Prepared by the LVPC and the Wildlands Conservancy, this study identified a key trend—people's attachment to where they live and their quality of life positively impacts economic development. This study quantified the economic value of the benefits provided by open space and measured its impacts across four areas: Natural System Services ($355.5 million annual benefit), Air Quality ($54 million annual benefit), Outdoor Recreation ($795.7 million annual benefit) and Property Value ($1.8 billion total real estate premium attributed to living within ¼ mile of protected open space). Each of these areas generate the "natural capital" or economic value from the flow of goods and services supported by natural resources.
- **Lehigh Valley Greenways Plan (2007)** – A greenway is defined as a corridor of open space that may vary greatly in scale from narrow strips of green that run through urban, suburban and rural areas to wider corridors that incorporate diverse natural, cultural and scenic features. Greenways are a critical component of any landscape—protecting the environment, providing alternate routes of transportation, supplying recreational opportunities, and connecting natural and cultural areas to one another, thus providing a linear resource for a variety of users. Connectivity is the defining characteristic that distinguishes greenways from isolated paths and pockets of open space. While individual parks, preserved lands, undisturbed natural areas and waterways are valuable resources, their conservation and recreational value is magnified when they are linked together.
- **Natural Resources Plan** – This plan is a component of the regional comprehensive plan and identifies conservation priority areas based on steep slopes, stream quality, floodplains, wetlands, hydric soils, woodlands and important natural areas (identified in the Natural Heritage Inventory). The map shows areas considered very high, high and medium conservation priority. Very high priority areas are based on areas with the greatest combination of important natural resources. These areas should be given first consideration for public and private conservation acquisition or easement programs.
- **Natural Heritage Inventory** – The LVPC contracted with the Western Pennsylvania Conservancy (Pennsylvania Natural Heritage Program) to complete a study titled Natural Heritage Inventory of Lehigh and Northampton Counties Update 2013. This document updated the 2005 report (the

original study was completed in 1999) and identifies the plant and animal species of concern and outstanding natural communities in the Lehigh Valley.

Capital Improvement Plan

A capital improvement plan is a multiyear policy guide that identifies needed capital projects and is used to coordinate the financing and timing of public improvements. Capital improvements relate to streets, Stormwater systems, water distribution, sewage treatment and other major public facilities. A capital improvement plan should be prepared by the respective county or municipal governments and should include a budget with identified priorities.

27% of the municipalities participating in this plan have capital improvement plans.

Economic Development Plan

An economic development plan serves as a road map for economic development decision-making, based on the collection of statistical data, historical perspective and human potential. The plan:

- Defines realistic goals and objectives
- Establishes a defined time frame to implement goals and objectives
- Communicates those goals and objectives to the organization's constituents
- Ensures effective use of the organization's resources
- Provides a baseline from which progress can be measured
- Builds consensus around future goals and objectives. 8% of responding municipalities indicated they have an economic development plan.

Open Space Management Plan (Parks and Recreation or Greenways Plans)

An open space management plan is designed to preserve, protect and restore largely undeveloped lands in their natural state, and to expand or connect areas in the public domain such as parks, greenways and other outdoor recreation areas. In many instances open space management practices are consistent with the goals of reducing hazard losses, such as the preservation of wetlands or other flood-prone areas in their natural state in perpetuity. 60% of responding municipalities indicated they have open space plans.

Natural Resource Protection Plan

Natural resource protection plans are designed to protect woodlands, steep slopes, waterways, floodplains and wetlands by prohibiting or severely limiting development in these areas. Emergency managers and community planners have been made more aware of the benefits of protecting these areas as mitigation measures over the last few decades. 23% of municipalities in the Lehigh Valley indicated that they have a natural resource protection plan, however, many preserve natural resources through development restrictions in zoning or subdivision and land development regulations.

Historic Preservation Plan

This type of plan describes how the community will preserve the historic structures and areas within it. Since these structures pre-date building codes and modern community planning requirements, many of them are especially vulnerable to a variety of hazards. A historic preservation plan may include measures to retrofit or relocate historic treasures out of hazard impact areas. 16% of the municipalities that responded to the survey indicated that they have a historic preservation plan.

5.2.1.2 Guides/Model Regulations

The LVPC has released many guides and model regulations for the Lehigh Valley, including:

- **Floodplain Guide | Model Regulation (2014)** – The LVPC released an updated floodplain model regulation in March 2014. The guide and model regulation was funded in part by a grant from the Pennsylvania Department of Conservation and Natural Resources through the Delaware and Lehigh National Heritage Corridor. The new model regulation was in advance of Northampton County communities receiving new Flood Insurance Rate Maps (FIRMs) in July 2014, requiring each community to update their floodplain management ordinances. The current model regulation was written using the policies of the 2005 Regional Comprehensive Plan, the 2013 Regional Hazard Mitigation Plan, the updated 2012 DCED floodplain provisions and the 2013 NFIP Community Rating System Coordinator's Manual as guides.
- **Riparian and Wetland Buffers Guide / Model Regulation (2011)** - The US Environmental Protection Agency estimates that more than half of all stream pollution comes from land runoff, which can contain pollutants such as sediment, oil, fertilizers and pesticides. Increasing the amount of pavement in a watershed, or changing land use from forests to fields, can increase discharge to streams since both of these greatly reduce land permeability and soil storage. Streams in the Lehigh Valley are under pressure from the combined effects of farming uses and continued urbanization. Riparian buffers are a natural, effective means of protecting watercourses. The Commonwealth's Constitution, and more specifically the MPC, clearly authorizes local municipalities to adopt riparian buffer regulations.
- **Woodlands Guide / Model Regulation (2009)** - Two regulatory approaches to protect woodlands are to adopt tree protection requirements for new development and regulate the timber harvest on private property. Tree protection can include replacement of trees removed from a development site if the tree removed meets the size threshold and that it be replaced by a native tree with the same estimated maximum height and growth rate of the tree to be removed. Another technique is to protect tree roots in the area of land disturbance and establish a "tree protection zone" during construction around these trees. A timber harvest or forestry regulation does not prevent harvesting, but rather defines best management practices to apply during harvesting.
- **Steep Slopes Guide / Model Regulation (2008)** – This model regulation is designed as a section in a zoning ordinance. Applicants proposing development on steep slopes are required to obtain a conditional use permit. This process was chosen because it allows the governing body—not the zoning hearing board— the opportunity to thoroughly examine the proposal and impose any reasonable safeguards to protect the public's general welfare. The model regulation is

constructed as an overlay district, to apply a common set of standards to a designated area that may cut across several underlying zoning districts.

- **Conservation Subdivisions Model Ordinance (2015)** – Conservation subdivisions are residential developments in which a significant portion of the overall acreage of a property is set aside as undivided, permanently protected open space, while houses are clustered on the remainder of the property. The guide provides benefits and drawbacks of the approach, and an annotated model regulation and example worksheets for municipalities to use in writing their own regulations.

Zoning Ordinance

Zoning ordinances allow local communities to regulate the use of land to protect the interests and safety of the general public. Zoning ordinances can be designed to address unique conditions or concerns within a given community. They may be used to create buffers between structures and high-risk areas, limit the type or density of development, and/or require land development to consider specific hazard vulnerabilities. All municipalities in the Lehigh Valley, except the Boroughs of Chapman, East Bangor, and Roseto have zoning regulations (92%).

Building Code

Building codes regulate construction standards for new construction and substantially renovated buildings. Standards can be adopted that require resistant or resilient building design practices to address hazard impacts common to a given community. In 2003, the Commonwealth of Pennsylvania implemented Act 45 of 1999, the Uniform Construction Code (UCC), a comprehensive building code that establishes minimum regulations for most new construction, including additions and renovations to existing structures. Effective December 2009, the Commonwealth adopted regulations of the 2009 International Code Council’s codes. 82% of municipalities in the Lehigh Valley report having a building code in place.

Fire Code

Fire codes relate to both the construction and use of structures in terms of preventing fires from starting and minimizing their spread, and minimizing the injuries and deaths caused by a fire within a building. They govern such things as the following:

- building materials that may be used
- the presence and number/type of fire extinguishers
- means of egress
- hazardous materials storage and use.

69% of municipalities indicated that their community had a fire code in place.

Stormwater Management Plan / Ordinance

The proper management of storm water runoff can improve conditions and decrease the chance of flooding. The Pennsylvania legislature enacted the Stormwater Management Act (Act 167 of 1978), commonly called Act 167, requiring counties to develop Stormwater management plans for all watersheds. This planning effort results in sound engineering standards and criteria being incorporated into local codes and ordinances to manage storm water runoff from new development and redevelopment in a coordinated, watershed-wide approach.

Act 167 Stormwater Management Plans are intended to improve storm water management practices and mitigate potential negative impacts from future development or redevelopment. It is not the intent of the plans to solve existing flooding or runoff problems, but to identify them for future correction and assure that problems do not get worse. The plan does allow municipalities to establish a capital improvement program to correct storm drainage issues. Since flooding is the most significant natural hazard affecting the Lehigh Valley, the hazard mitigation plan provides a thorough understanding of the current capabilities to manage storm water and a clear action plan to mitigate future impacts.

88% of municipalities currently have a stormwater management plan in place. In addition to the Act 167 stormwater management plans in place, other related planning efforts include:

- **Green Infrastructure Guidelines (LVPC 2017)** – The Green Infrastructure Guidelines document was prepared in conjunction with the Monocacy Creek Watershed Act 167 Stormwater Management Plan Update, 2018. The Guidelines are important for reinforcing the message of the natural resources in the Lehigh Valley and their variety of essential services and benefits to residents and visitors, describing the best practices available for community and site design to preserve or enhance those resources, and defining improved stormwater management design practices to better mimic natural systems.
- **Recommended Procedures for Act 167 Drainage Plan Design (LVPC 2006)** – This document provides a step-by- step process for creating a drainage design to meet Act 167 Ordinance requirements.
- **Technical Best Management Practice Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed (LVPC 2002)** – The intent of this Best Management Practice design manual is to provide guidance for stormwater management systems to be developed in the rapidly developing Little Lehigh Creek Watershed. The manual was developed under the Act 167 Stormwater Management Program as administered by the Department of Environmental Protection and implemented by the LVPC.

5.2.1.3 Operational and Emergency Plans

Continuity of Operations Plan

Continuity of operations planning is the process of developing advanced arrangements and procedures that enable an organization to continue its essential functions, despite events that threaten to disrupt them. The continuity discipline aims to identify emergency or unconventional means to replace or work around those deficiencies in the short term until the organization can be reconstituted on a normal basis. 17% of responding municipalities indicated they have a continuity of operations plan.

Evacuation Plan

Evacuation is one of the most widely used methods of protecting the public from hazard impacts. The easiest way to minimize death and injury due to a hazard event is to remove as many people as possible from its path. Evacuation plans include descriptions of the area(s) being evacuated, the demographics and characteristics of people within those area(s), transportation routes to safe areas, and how the community will support those individuals who do not have access to their own transportation. Such plans address various evacuation situations, such as evacuation plans for dam safety, hazardous material spills and radiation releases. The counties, in cooperation with the American Red Cross of the Greater Lehigh Valley, have designated shelter locations. These shelters may be used during times of emergency and disasters. Both counties and 28% of the municipalities have an evacuation plan. Six municipalities have a plan under development.

Disaster Recovery Plan

A Disaster Recovery Plan is a comprehensive set of measures and procedures that ensure essential resources and infrastructure are maintained or backed up by alternatives during various stages of a disaster. It is another step to ensure the preparedness and ability to respond quickly and effectively to restore the community's essential services. The plan addresses the public sector's responsibilities, including temporary shelter, refuse disposal, overall damage assessment, restoration of utility services, reconstruction priorities, financial assistance, as well as dealing with emergency demands. 19% of the municipalities indicated that they have a disaster recovery plan.

5.2.2 *Administrative and Technical Capability*

Administrative and technical capability refers to the community's staff and their skills and tools that can be used for mitigation planning and to implement specific mitigation actions. It includes planners, engineers, emergency managers, floodplain administrators/managers, land surveyors, staff familiar with community hazards, personnel skilled in GIS, and grant writers. It also refers to the ability to access and coordinate these resources effectively. The degree of intergovernmental coordination among departments also affects administrative capability. Municipal responses to an administrative and technical capability survey can be found in their municipal annexes.

Municipalities are supported by county and regional administrative and technical capabilities, including Lehigh and Northampton counties, Lehigh Valley Planning Commission, Lehigh Valley Transportation Study, Lehigh Valley Regional Partnership, local environmental groups and watershed associations. Additional technical assistance is available for mitigation activities from a number of state and federal agencies, including:

- Pennsylvania Emergency Management Agency
- US Department of Agriculture
- Pennsylvania Department of Environmental Protection

- US Department of Housing and Urban Development
- Pennsylvania Department of Conservation and Natural Resources
- Economic Development Administration
- Pennsylvania Department of Transportation
- Emergency Management Institute
- Federal Emergency Management Agency
- US Environmental Protection Agency
- Small Business Administration
- US Army Corps of Engineers

It is noted that both counties, and many of the municipalities, have identified specific mitigation initiatives in the 2024 Plan to help build and enhance mitigation- related administrative and technical capabilities in the Lehigh Valley.

The Lehigh Valley is supported by strong regional and county-level emergency management capabilities provided by the Lehigh County Emergency Management Agency and Northampton County Emergency Management Services. Both Lehigh and Northampton counties continue to operate emergency 9-1-1 call centers and Emergency Operations Centers (EOCs) during emergencies in their counties. In addition, both counties continue to provide or support emergency service programs and measures, including emergency response, public alert and warning systems, emergency communications systems, hazard event monitoring systems, and public information and outreach programs.

5.2.2.4 National Flood Insurance Program Participation (Floodplain Management Plan / Floodplain Regulations)

When the US Congress passed the National Flood Insurance Act of 1968, it created the National Flood Insurance Program (NFIP). The program enables property owners in participating communities to purchase insurance as a protection against flood losses, in exchange for state and community floodplain management regulations that reduce future flood damages. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk to new construction and substantial improvements in floodplains, the federal government will make flood insurance available within the community as financial protection against flood losses.

In addition, the Pennsylvania Floodplain Management Act (Act 166 of 1978) mandates municipal participation in and compliance with the NFIP. It also establishes higher regulatory standards for new or substantially improved structures that are used for the production or storage of dangerous materials by prohibiting them in the floodway. Additionally, Act 166 establishes the requirement that a Special Permit be obtained prior to any construction or expansion of any manufactured home park, hospital, nursing home, jail and prison if the structure is located within a special flood hazard area. The Pennsylvania Department of Community and Economic Development (DCED) provides communities with a suggested ordinance document to assist municipalities in meeting the minimum requirements of the NFIP along with Act 166. The model ordinance contains provisions for municipal consideration that are more restrictive than state and federal requirements.

Through administration of floodplain ordinances, municipalities can ensure that all new construction or substantial improvements to existing structures in the 1% annual chance floodplain are engineered to minimize the impact of flooding and are better able to withstand the forces of a flood event.

All municipalities in the Lehigh Valley participate in and enforce the NFIP. All municipalities have adopted a Floodplain Ordinance and are required to update the ordinance whenever the regulatory NFIP flood mapping is officially updated. NFIP- participating communities are required to make current regulatory NFIP mapping available to their residents for review and provide mapping assistance. Typically, this mapping is available at the municipal offices in each community.

The National Flood Insurance Program's Community Rating System (CRS) was established in 1990 to encourage local governments to increase their standards for floodplain development. The goal of this program is to encourage communities, through flood insurance rate adjustments, to implement standards above and beyond the minimum requirements.

The CRS is a voluntary program designed to reward participating communities for their efforts to create more disaster-resistant communities using the principles of sustainable development and management. By enrolling in the program, municipalities can leverage greater flood protection while receiving flood insurance discounts, ranging from 5% up to 45%.

Currently within the Lehigh Valley, no municipalities participate in the CRS program. Increased participation in the Lehigh Valley will be supported by both counties as identified in their updated mitigation actions. Further, certain communities in the Lehigh Valley have identified in their updated mitigation actions that they plan to apply to the CRS program.

5.2.3 Financial Capability

Financial capabilities are the resources that a municipality has access to or is eligible for to fund mitigation actions and include capital improvement programming; Community Development Block Grants; special purpose taxes; gas/electric utility fees; water/sewer fees; storm water utility fees; development impact fees; general obligation, revenue, and/or special tax bonds; and partnering arrangements or inter- governmental agreements. The costs associated with implementing mitigation activities vary. Some mitigation actions such as outreach and education efforts require little to no costs other than staff time and existing operating budgets. Other actions such as acquisition of flood-prone properties could be largely or entirely dependent on available funding. As such, it is critical to identify all available sources of funding at the local, county, regional, state and federal level to support implementation of the mitigation actions identified in the 2024 Plan. Municipalities fund mitigation projects through existing local budgets, local appropriations (including referendums and bonding), and through a variety of federal and state loan and grant programs.

Municipal responses to the financial capabilities survey can be found in their municipal annexes. While most of the identified financial capabilities are available to all of the municipalities in the Lehigh Valley, the extent to which communities have leveraged these funding sources varies widely. It is logical to expect that communities that are familiar with accessing specific grant programs will continue to consider and pursue those sources.

5.2.3.1 FEMA Grant Programs

Hazard Mitigation Grant Program (HMGP)

The HMGP is a post-disaster mitigation program. It is made available to states by FEMA after each federal disaster declaration. The HMGP can provide up to 75% funding for hazard mitigation measures. The HMGP can be used to fund cost-effective projects that will protect public or private property in an area covered by a federal disaster declaration or that will reduce the likely damage from future disasters. Examples of projects include acquisition and demolition of structures in hazard prone areas, flood proofing or elevation to reduce future damage, minor structural improvements and development of state or local standards. Projects must fit into an overall mitigation strategy for the area identified as part of a local planning effort. All applicants must have a FEMA- approved Hazard Mitigation Plan. Applicants who are eligible for the HMGP are state and local governments, certain nonprofit organizations or institutions that perform essential government services, and Indian tribes and authorized tribal organizations. Individuals or homeowners cannot apply directly for the HMGP; a local government must apply on their behalf. Applications are submitted to PEMA and placed in rank order for available funding and submitted to FEMA for final approval.

Flood Mitigation Assistance (FMA)

FMA provides funding to assist states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP. The FMA is funded annually; no federal disaster declaration is required. Only NFIP-insured homes and businesses are eligible for mitigation in this program. Funding for FMA is very limited and, as with the HMGP, individuals cannot apply directly for the program. Applications must come from local governments or other eligible organizations. The federal cost share for an FMA project is 75%. At least 25% of the total eligible costs must be provided by a non-federal source. Of this 25%, no more than half can be provided as in-kind contributions from third parties. At minimum, a FEMA-approved local flood mitigation plan is required before a project can be approved. FMA funds are distributed from FEMA to the state. PEMA serves as the grantee and program administrator for FMA.

During the planning period, the FMA program launched a disaster initiative called Swift Current. The intent for the Swift Current Initiative is to explore how to make flood mitigation assistance available within the disaster recovery timeframe, for repetitively flooded and substantially damaged buildings insured under the NFIP in advance of the annual grant process. In March 2022, FEMA offered participation in the Swift Current initiative to four states impacted by Hurricane Ida in 2021, including Pennsylvania, that had the highest severe repetitive loss and repetitive loss of NFIP-insured unmitigated properties and total claims (by count) within their respective FEMA regions. FEMA has made $5 million in funding available to Pennsylvania under this initiative, for which subrecipients had not yet been selected as of October 2024. Subapplications included one acquisition, seven elevations, and on mitigation reconstruction project consisting of 10 residences in four communities.

5.2.4 Education and Outreach

This type of capability refers to education and outreach programs and methods already in place in a community that could be used to implement mitigation activities and communicate hazard-related information to the public, including Firewise Communities certification, StormReady certification, natural disaster or safety- related school programs, ongoing public education / information program, public-private partnership initiatives, and local citizen groups of nonprofit organizations. The Firewise Communities program is a national program that emphasizes community involvement and provides information for residents to reduce the risk of wildland fire igniting homes. The National Weather Service StormReady program encourages communities to take a proactive approach to improving local hazardous weather operations and public awareness. Municipal responses to the education and outreach survey can be found in their municipal annexes.

Lehigh County Emergency Management Agency and Northampton County Emergency Services have the following education and outreach capabilities:

- Outreach Projects
    - **Are You Ready?** – An in-depth program for citizen Preparedness (individual, family and community preparedness). Provides a step- by-step approach to disaster preparedness by walking the student through how to get informed about local emergency plans, how to identify hazards that affect their area, and how to develop and maintain an emergency communications plan and disaster supply kit. Hazard-specific information is also covered.
    - **Ready…Pack…Go –** This Lehigh County program is to encourage community members and their families to be self-sufficient for at least 72 hours. The theme of "Ready…Pack…Go" is to be "ready" to have a plan for you and your family; "pack" to have pre-packed food, water and supplies; and "go" to a safe location based on the type of disaster. What if there was an emergency today? Are you ready? Learn how to protect yourself, your family and your pets!
    - **Red E. Fox Children's 9-1-1 Program** – Northampton County participates in the Red E. Fox program. The mission and purpose of this program is to teach children how to save lives and property through the proper use of 9-1-1, the nation's universal emergency telephone number. Red E. Fox delivers this message and teaches children when to use 9-1-1 and when not to, how to place a 9-1-1 call, and what to say to the dispatcher during a police, fire, or medical emergency. Red E. Fox was created as a 9-1-1 Public Safety icon in the tradition of Smokey Bear and McGruff the Crime Dog.
    - **SERVPA** - SERVPA is a secure, confidential volunteer registry site. Volunteers that register through SERVPA are open to the idea of volunteering in case of an emergency. The registration provides a little about their background, preferences and constraints. It does not guarantee that they will be called upon, nor does it mean that they must participate if called. If a volunteer is called to assist in an event or emergency, they will have the opportunity to learn more about the specific event and the commitment required. Lehigh County has utilized this system for the past 10 years to call out

volunteers during emergencies, announce training opportunities, provide call down drill notifications and announce outreach events.

  - **Community Emergency Response Teams (CERT)** – Training to educate citizens about disaster preparedness and training in basic disaster response skills, such as fire suppression, disaster medical operations, light search and rescue, team organization, disaster psychology, and terrorism awareness. The goal of this program is for emergency personnel to train members of neighborhoods, community organizations, or workplaces in basic response skills. If a disastrous event overwhelms or delays the community's professional response, CERT members can assist others by applying the basic response and organizational skills that they learned during training. These skills can help save and sustain lives following a disaster until help arrives.
  - **Citizen Corps Council** – The mission of Citizen Corps is to harness the power of every individual through education, training, and volunteer service to make communities safer, stronger, and better prepared to respond to the threats of terrorism, crime, public health issues and disasters of all kinds.
  - Emergency Management courses are provided through the county EMA offices to the local coordinators and elected officials. The following courses are provided:
    - Duties and Responsibilities of the Local Emergency Management Coordinator (LEMC),
    - Elected Officials Seminar,
    - Initial Damage Assessment,
    - Safe Schools Training,
    - National Incident Management System,
    - Work Environment of the LEMC and
    - Numerous FEMA Independent Study Courses.
  - Local Emergency Planning Committee (LEPC) – The LEPC works closely with the business community to form a safety net around the chemical industry to protect the general population from the possible outcome of hazardous material incidents. The LEPC has a minimum of seven members and includes at least one representative from each of the following groups:
    - Elected Official representing local governments within the county
    - Law enforcement, first aid, health, local environmental, hospital and transportation personnel
    - Firefighting personnel
    - Civil Defense and emergency management personnel
    - Broadcast and print media
    - Community groups not affiliated with emergency service groups
    - Owners and Operators of facilities subject to the requirements of SARA Title III
- Technical Assistance – The county EMA offices can support local, public and private entities as needed through coordination and provision of information and equipment resources. These include both existing county capabilities, such as County Hazardous Materials Response Team and Technical Rescue Teams, and predetermined private and public resources.
  - The Lehigh County Special Operations Team is/has:

        - Greater than 30 active members trained to Operations and Technician level in compliance with OSHA 1910.120.
        - Personal Protective Equipment (PPE) for all levels of HazMat entry. Level A, B, C.
        - Self-contained breathing apparatus for 22 team members with in-suit communications. Dedicated radio frequencies.
        - Monitoring equipment for Radiation, Chemical & Biological Warfare, Mercury and Industrial Toxics available at any time.
        - Spill Containment and Mitigation supplies for spills, large and small.
        - Specialized equipment for tanker and rail car emergencies.
        - Certifications in the following: Confined Space Rescue Technician, Trench Rescue Technician, Low and High Angle Rope Rescue, Structural Collapse, and Incident Command.
        - Medically trained members in CPR, AED, EMT and Paramedic, Nurse and Doctors.
        - Paramedics and Doctors trained in Rescue Medicine to aid in the care of Technical Rescue Patients.
        - Drone program used for damage assessments and active incidents.
    - Northampton County Emergency Management Services provides IMT: Incident Management Teams and support, and supplements the contractual Hazardous Materials Response Team of Lehigh County Special Operations during HazMat incidents through trained staff, support equipment and assets.
        - Lehigh County provides contractual Hazardous Materials Response Team coverage to Northampton County.
    - Northampton County has specialized equipment and apparatus to support incidents, such as:
        - Command Post
        - Mobile Communication
        - Chemical, Biological, Radiological, Nuclear and Explosives (CBRNE) support truck
        - Carries specialized equipment for decontamination and air monitoring
        - Equipment to support HazMat operations
        - Radiological and air monitoring equipment
        - HazMat support trailers
        - Equipment for mass decontamination
        - Firefighting Foam trailers
        - Vapor suppression and/or firefighting for use with Hazardous materials incidents.

To protect the assets of both counties, the capabilities listed are a brief description of equipment and services provided within the two counties and any contiguous counties.

Lehigh and Northampton counties have already taken several steps to take control of the drug overdose epidemic. Northampton County created the Heroin and Opioid Overdose Task Force that secured a $103,000 state grant in 2017 to provide communities with Naloxone and to fund the Angel program, which enables addicts to turn in their drugs at any police station, without fear of arrest, in exchange for help in finding treatment. Lehigh County has instituted the Blue Guardian program, in which police and a recovery specialist, within a few days, visit the home of anyone who has been saved by Naloxone to help them seek treatment. Both counties have joined court actions seeking monetary damages from Opioid manufacturing companies to help fund more programs to control the crisis.

The LVPC also has a variety of informational resources available to the public. Many of the publications discussed previously are available for review by the public at the LVPC office or on the LVPC website. The LVPC also provides or hosts a variety of educational workshops for the public. The Lehigh Valley Government Academy has sponsored seminars related to storm water management, floodplain issues, model environmental ordinances, Growing Greener-Conservation by Design, and basic courses in subdivision and land development review, zoning and community planning. The LVPC, in partnership with PennDOT, hosts the Local Technical Assistance Program, providing free technical information and proven technologies dealing with roadway maintenance and safety methods. The LVPC's popular Planning and Pizza series included recent sessions on the regional Hazard Mitigation Plan, regional Comprehensive Plan, Monocacy Creek Act 167 Plan, Lehigh County Parks and Agriculture Planning and the Transportation Improvement Program. Copies of the floodplain mapping and flood studies prepared by FEMA for Lehigh County are available for public review at the LVPC office. The floodplain mapping currently in effect in Lehigh County is dated July 16, 2004. Paper copies of the Northampton County flood maps and studies, effective July 16, 2014, are not available at the LVPC, however, the LVPC responds to floodplain information requests from the public related to the mapping and studies.

5.2.5 Plan Integration

Plan integration is the process by which communities look critically at their existing planning framework and align efforts with the goal of building a safer, smarter community. Plan integration involves a two-way exchange of information, incorporation of ideas and concepts between hazard mitigation plans (state and local), and other community plans. Specifically, plan integration involves the incorporation of hazard mitigation principles and actions into community plans and community planning mechanisms into hazard mitigation plans. In the Lehigh Valley, there are many existing plans and programs that support hazard risk management, and so it is critical that the 2024 Plan continue to integrate and coordinate with, and complement, those mechanisms.

Numerous existing plans, studies, reports and technical information were reviewed and incorporated into the 2024 Plan. The use of this information is cited in the various sections where it is used. An all-inclusive list of resources used to prepare the Plan is located in Appendix A.

The Community Profile section was prepared using existing LVPC plans and data, including the Comprehensive Plan the Lehigh Valley…2030 (2005), BuildLV: Lehigh Valley Annual Development Report (2017), MoveLV: Long Range Transportation Plan (2017) and The People (2017). Data incorporated into this section included environmental information, Lehigh Valley population and employment projections through 2040, development trends and transportation infrastructure. The LVPC also provided GIS mapping using existing layers. The US Census Bureau American Community Survey provided demographic and housing data.

An extensive list of data sources, vital to the identification of historical disaster events and their impacts on the region, was reviewed and incorporated into the Risk Assessment section, including the Comprehensive Plan the Lehigh Valley…2030 (2005), National Climatic Data Center, Lehigh and Northampton County Knowledge Center databases, Pennsylvania 2013 Standard State All-Hazard Mitigation Plan, among others. Federal Emergency Management Agency data related to Presidential Disaster Declarations, repetitive property losses and National Flood Insurance Program policies and claims were also incorporated into the 2024 Plan. Existing GIS layers were used in conjunction with existing Lehigh and Northampton County tax parcel data for the hazard vulnerability assessments. FEMA floodplain mapping for Northampton County, which became effective in July 2014, was incorporated into the Flood profile.

It is the intention of this 2024 Plan that the municipalities continue to incorporate the findings and recommendations into future local planning efforts and into the overall execution of their land use planning process. Some of the most important planning and regulatory capabilities for hazard mitigation integration include comprehensive plans, zoning and subdivision / land development ordinances, emergency operations plans and building codes. Further, the sample adoption resolutions in Appendix I includes a resolution item stating the intent of the local governing body to incorporate mitigation planning as an integral component of government and partner operations. The Administrative Planning Team will work with local government officials to integrate hazard mitigation goals and actions into the general operations of government and partner organizations.

The two counties and municipalities in the Lehigh Valley recognize that the findings and recommendations of the 2024 Plan need to be incorporated into their emergency planning, preparedness, response and recovery programs and operations. Specifics about response and recovery programs and efforts in the Lehigh Valley have led to county and local mitigation actions to improve regional emergency management coordination and build related risk management capabilities. Public education and outreach to improve personal preparedness and promote an awareness of mitigation opportunities and personal protection through risk insurance have also been incorporated in county and local mitigation actions.

6. Mitigation Strategy

6.1. Update Process Summary

The 2024 Plan focuses on improving the county and local mitigation strategies from the 2018 Plan. Throughout the planning process, both counties and all municipalities were encouraged to thoroughly consider their natural and non-natural hazard risks and vulnerabilities, and to identify appropriate actions to mitigate those risks. This strategy articulates goals, objectives, and actions for risk reduction in Northampton and Lehigh counties over the next five years. A mitigation technique matrix was completed to identify and evaluate possible mitigation actions for each hazard. Municipal actions were categorized and prioritized on a regional basis. National Flood Insurance Program-related actions are identified.

6.1.1 Review of Existing Mitigation Plan Goals and Objectives

Hazard mitigation goals are general guidelines that explain what you want to achieve in your community. They represent broad policy statements and are usually long-term and represent global visions. Hazard mitigation objectives define strategies or implementation steps to attain the identified goals but are not as specific as mitigation actions. Unlike goals, objectives are specific, measurable, and may have a defined completion date.

For the 2024 Plan, the eight existing goals and 23 existing objectives from the 2018 Lehigh Valley Plan were reviewed with the Planning Team, stakeholders and the public. The public was provided opportunities to comment on the existing goals during the draft plan's public comment period. All of the goals were confirmed and carried over to the 2024 Plan and one goal was added (related to reducing high-hazard dam risk). Additionally, the 2024 Plan examines two hazards which were not previously profiled: gas/liquid pipelines and cyber-terrorism. The Planning Team concurred with the proposed revisions to the goals.

In developing this strategy, the planning team considered the goals of the FutureLV comprehensive plan, which was developed after the 2018 plan was completed, as outlined in Section 2.4 – Land Use and Development. The planning team considered changes to community priorities, which included increased concern related to sinkholes after recent occurrences, and concerns about increased potential for structural fire due to the increase in warehousing and commercial industry in the region. The Commonwealth of Pennsylvania 2023 State Hazard Mitigation Plan was also reviewed to ensure that the 2024 Plan goals complement and support the five state goals identified below:

- Protect lives, property, environmental quality, and resources of the Commonwealth, including Repetitive Loss (RL) and Severe Repetitive Loss (SRL) properties.
- Enhance consistent coordination, collaboration, and communications among stakeholders.
- Provide a framework for active hazard mitigation planning and implementation.
- Build legislative support and secure funding for mitigation efforts.

- Increase awareness, understanding, and preparedness across all sectors.

Goal and Objective Review Worksheets were provided to all participants and were completed by 14 of the participating communities. The goals and objectives were also discussed in the Strategy Meeting on January 19, 2024. Table 113 summarizes the collected information and resulting changes. Goals and objectives that relate to a community's continued compliance with the National Flood Insurance Program are noted with (NFIP).

Table 113 Summary of Goals and Objectives Review

Goal		Objective		Discussion or Comments	Resulting Change
1	**To minimize the risk to human life associated with natural and non-natural hazards (NFIP)**	A	Create a better understanding among the public and local governments of the benefits and opportunities associated with hazard mitigation planning and actions (NFIP)	The planning team noted that a better strategic outreach plan would be of benefit to the community. Participants also noted that CRS participation may support this goal.	No Change
		B	Continuously promote and maintain better early warning and emergency communications.	No comments received.	No Change
		C	Provide added protection for vulnerable populations. (NFIP)	The planning team noted challenges first responders have faced when attempting to access homeless people living in remote areas to provide assistance.	No Change
2	**To promote hazard avoidance, especially in**	A	Minimize future risks of losses associated with structures, including repetitive loss structures. (NFIP)	No comments received.	No Change

	floodplains (NFIP)	B	Reduce flooding potential through planning, training and outreach. (NFIP)	No comments received.	No Change
		C	Encourage and facilitate the development or revision of comprehensive plans and zoning/land use ordinances to limit development in high-hazard areas.	No comments received.	No Change
3	**To reduce the damages and functional loss from natural and non- natural hazards to existing and future public and private assets, including structures, critical facilities and infrastructure (NFIP).**	A	. Identify the current risks of critical facilities and infrastructure from hazards, and determine actions to lessen those risks in the future. (NFIP)	No comments received.	No Change
		B	Encourage and/or perform regular maintenance and upgrades of existing drainage systems potentially impacting critical facilities.	No comments received.	No Change
		C	Encourage and/or provide backup power resources (generators) for critical facilities	No comments received.	No Change
4	**To preserve and enhance the effectiveness of natural resources,**	A	Encourage and/or provide maintenance and restoration of streams and rivers and associated floodplains to naturally provide flood mitigation.	No comments received.	No Change

	including woodlands, streams, rivers, wetlands, floodplains and riparian buffers to provide resiliency benefits (NFIP).	B	Encourage regulation of and/or regulate development in priority conservation areas, including floodplains, to minimize flood damage. (NFIP)	No comments received.	No Change
5	**To develop, prioritize and implement cost effective, long-term actions that will reduce the impacts of natural and non-natural hazards (NFIP).**	A	Thoroughly assess the community, established capabilities, and identify specific cost-effective actions for improvement, relative to existing and future hazard risks. (NFIP)	No comments received.	No Change
		B	Establish mitigation action priorities, encourage, and track progress. (NFIP)	No comments received.	No Change
6	**To improve local regulations to reduce the impacts of natural and non- natural hazards (NFIP).**	A	Better, integrate hazard mitigation planning with comprehensive planning and land use regulations. (NFIP)	No comments received.	No Change
		B	Identify and promote “best practices” for municipal regulation of land use in zoning and subdivision ordinances and official maps	No comments received.	No Change
		C	Encourage proactive planning for potential hazard events and	No comments received.	No Change

			potential related property damage. (NFIP)		
		D	Incorporate hazard mitigation planning into existing municipal policy.	No comments received.	No Change
7	**To enhance planning and emergency response efforts among federal, state, county and local emergency management personnel to protect public health and safety.**	A	Continually improve communication capabilities, training and coordination for hazard events.	No comments received.	No Change
		B	Continually improve the planning for shelters, evacuation routes and disaster recovery.	No comments received.	No Change
		C	Continue the promotion of disaster resiliency in the business community.	No comments received.	No Change
		D	Maintain and/or upgrade emergency response equipment and resources.	No comments received.	No Change
8	**To promote public awareness on both the potential impacts of natural and non-natural hazards and actions to reduce those impacts (NFIP).**	A	Encourage and/or provide education and outreach to increase awareness of hazards and opportunities for mitigation. (NFIP)	No comments received.	No Change
		B	Encourage and/or provide public education programs for businesses, households and individuals on mitigation, safety measures and preparedness.	No comments received.	No Change

6.1.2 Review of Existing Mitigation Action Plan

The 2018 Lehigh Valley Plan identified 1,161 actions to mitigate the impact of hazards. These actions were categorized into 28 regional action categories. Since the 2018 plan was adopted, participating municipalities have conducted annual reviews of their annexes, including progress towards identified goals, and the status of individual municipal actions are described in the relevant annexes. Table 114 provides a high-level summary of the Mitigation Action Plan Review Worksheets completed by members of the planning team as part of the review process. More detail is available in Appendix C, Meeting and Other Participation Documents. Actions that support to a community's continued compliance with the National Flood Insurance Program are noted with (NFIP).

Table 114 - Status of 2018 Mitigation Plan Actions

2018 Regional Action Number	Action Category	Number of Municipalities	Action Status (Complete, In Progress, Continuous, or Discontinued)	Discussion or Comments (If complete, describe success. If in progress, what percent complete, and what remains to be done? If continuous, how often? If discontinued, why?)	Carried Forward into New Plan (Y/N)
1	Retrofit structures in flood-prone areas, with repetitive and severe repetitive loss properties as a priority	48	Continuous	See individual community annex for progress made towards completing actions in this category.	Yes
2	Purchase or relocate structures in hazard prone areas	47	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
3	Maintain compliance with the National Flood Insurance Program, including enforcement of floodplain management requirements, floodplain identification and mapping, and flood insurance outreach (NFIP)	57*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
4	Conduct and facilitate community and public outreach for residents and businesses to promote and	59*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes

2018 Regional Action Number	Action Category	Number of Municipalities	Action Status (Complete, In Progress, Continuous, or Discontinued)	Discussion or Comments (If complete, describe success. If in progress, what percent complete, and what remains to be done? If continuous, how often? If discontinued, why?)	Carried Forward into New Plan (Y/N)
	effect hazard risk reduction (NFIP)				
5	Begin and/or continue the process to adopt higher regulation of floodplains and carbonate bedrock areas (NFIP)	47*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
6	Determine if CAV or CAC visit is needed and schedule (NFIP)	46	Discontinued	Due to the technical expertise required, this action was not feasible at the municipal level.	No
7	Have designated Floodplain Administrator certified and/or pursue continuing education training (NFIP)	46	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
8	Participate in the Community Rating System (NFIP)	45*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
9	Obtain/archive elevation certificates (NFIP)	47	Continuous	See individual community annex for progress made towards completing actions in this category	Yes

2018 Regional Action Number	Action Category	Number of Municipalities	Action Status (Complete, In Progress, Continuous, or Discontinued)	Discussion or Comments (If complete, describe success. If in progress, what percent complete, and what remains to be done? If continuous, how often? If discontinued, why?)	Carried Forward into New Plan (Y/N)
10	Continue to support implementation, monitoring, maintenance and updating of the plan	61*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
11	Develop/enhance Comprehensive Emergency Management Plans	62*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
12	Create/enhance/maintain mutual aid agreements with neighboring communities for continuity of operations	56*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
13	Improve post-disaster capabilities, including processing FEMA/PEMA paperwork and qualified damage assessment personnel	55	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
14	Work with regional agencies to develop damage assessment capabilities through training programs, certification of qualified	61*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes

2018 Regional Action Number	Action Category	Number of Municipalities	Action Status (Complete, In Progress, Continuous, or Discontinued)	Discussion or Comments (If complete, describe success. If in progress, what percent complete, and what remains to be done? If continuous, how often? If discontinued, why?)	Carried Forward into New Plan (Y/N)
	individuals such as floodplain managers (NFIP)				
15	General storm drainage/flooding projects	8	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
16	Specific storm drainage/flooding projects (non-critical facilities)	22	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
17	Critical facilities - storm drainage/flooding projects or relocation	3	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
18	Critical facilities - back-up power projects	11	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
19	Critical facilities - other projects	16*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
20	Emergency notifications/ communication/traffic control	4*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes

2018 Regional Action Number	Action Category	Number of Municipalities	Action Status (Complete, In Progress, Continuous, or Discontinued)	Discussion or Comments (If complete, describe success. If in progress, what percent complete, and what remains to be done? If continuous, how often? If discontinued, why?)	Carried Forward into New Plan (Y/N)
21	Stream or floodplain restoration/stabilization projects	8	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
22	Work to minimize tree/electric line conflicts	9*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
23	Geotechnical/sinkhole evaluation (adopt construction standards, remediation)	3	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
24	Hazardous materials inventory/emergency planning, education, certification	4	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
25	Dam/levee projects	3	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
26	Specific bridge replacement or retrofits	8*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes

2018 Regional Action Number	Action Category	Number of Municipalities	Action Status (Complete, In Progress, Continuous, or Discontinued)	Discussion or Comments (If complete, describe success. If in progress, what percent complete, and what remains to be done? If continuous, how often? If discontinued, why?)	Carried Forward into New Plan (Y/N)
27	Wildfire mitigation	1	Continuous	See individual community annex for progress made towards completing actions in this category	Yes
28	Integrate hazard mitigation into local plans and ordinances	4*	Continuous	See individual community annex for progress made towards completing actions in this category	Yes

6.2. Mitigation Goals and Objectives

6.2.1 Changes to Risk and Capability

To ensure the goals reflect updated conditions, the goal evaluation process included a review of the updated capability assessment and risk assessment, which included two new hazard profiles (Gas / Liquid Pipelines and Cyber-Terrorism). Based on this review, the Planning Team determined that the revised goals reflect the region's current vision for a disaster-resilient Lehigh Valley.

Additionally, the Pennsylvania Hazard Mitigation Plan Standard Operating Guidance (SOG) presents several questions which are intended to aid the Planning Team in formulating goals and objectives. In conjunction with the latest capability assessments and risk assessments, the following questions from the SOG were utilized to inform the Planning Team's decisions:

- *Do the goals and objectives identified in the previously approved plan reflect the updated risk assessment?*
- *Did the goals and objectives identified in the previously approved plan lead to mitigation projects and/or changes in policy that helped the jurisdiction(s) reduce vulnerability?*
- *Do the goals and objectives identified in the previously approved plan support changes in mitigation priorities?*
- *Do the goals identified in the updated plan reflect current state goals?*
- *Do the goals and objectives include hazard mitigation considerations for community historic and cultural resources?*

Updated capability assessments and risk assessments revealed several changes since 2018. Some of the key changes include:

- An increased awareness of pandemic and human disease-related risk
- Increased risk of structural fires due to the increase in warehouse spaces in the region
- Recognition of the importance of reducing risk related to high-hazard potential dams.

6.2.2 2024 Mitigation Goals and Objectives

For the 2024 Plan, objectives were created for each of the eight goals for a total of 24 objectives. The Planning Team reviewed and concurred with the objectives. Goals and objectives that relate to a community's continued compliance with the National Flood Insurance Program are noted with (NFIP). Public participation involved in the development of mitigation goals and objectives is described in Section 3.3, and meeting documentation is included in Appendix C.

Goal 1: To minimize the risk to human life associated with natural and non- natural hazards (NFIP).
OBJECTIVES:

1. Create a better understanding among the public and local governments of the benefits and opportunities associated with hazard mitigation planning and actions. (NFIP)
2. Continuously promote and maintain better early warning and emergency communications.

3. Provide added protection for vulnerable populations. (NFIP)

Goal 2: To promote hazard avoidance, especially in floodplains (NFIP).

OBJECTIVES:

1. Minimize future risks of losses associated with structures, including repetitive loss structures. (NFIP)
2. Reduce flooding potential through planning, training and outreach. (NFIP)
3. Encourage and facilitate the development or revision of comprehensive plans and zoning/land use ordinances to limit development in high-hazard areas.

Goal 3: To reduce the damages and functional loss from natural and non- natural hazards to existing and future public and private assets, including structures, critical facilities and infrastructure (NFIP).

OBJECTIVES:

1. Identify the current risks of critical facilities and infrastructure from hazards, and determine actions to lessen those risks in the future. (NFIP)
2. Encourage and/or perform regular maintenance and upgrades of existing drainage systems potentially impacting critical facilities.
3. Encourage and/or provide backup power resources (generators) for critical facilities.
4. Encourage and/or perform maintenance and upgrades to reduce long-term vulnerability to high hazard potential dams.

Goal 4: To preserve and enhance the effectiveness of natural resources, including woodlands, streams, rivers, wetlands, floodplains and riparian buffers to provide resiliency benefits (NFIP).

OBJECTIVES:

1. Encourage and/or provide maintenance and restoration of streams and rivers and associated floodplains to naturally provide flood mitigation.
2. Encourage regulation of and/or regulate development in priority conservation areas, including floodplains, to minimize flood damage. (NFIP)

Goal 5: To develop, prioritize and implement cost-effective, long-term actions that will reduce the impacts of natural and non-natural hazards (NFIP).

OBJECTIVES:

1. Thoroughly assess the community, established capabilities, and identify specific cost-effective actions for improvement, relative to existing and future hazard risks. (NFIP)
2. Establish mitigation action priorities, encourage, and track progress. (NFIP)

Goal 6: To improve local regulations to reduce the impacts of natural and non- natural hazards (NFIP).

OBJECTIVES:

1. Better integrate hazard mitigation planning with comprehensive planning and land use regulations. (NFIP)
2. Identify and promote "best practices" for municipal regulation of land use in zoning and subdivision ordinances and official maps.
3. Encourage proactive planning for potential hazard events and potential related property damage. (NFIP)
4. Incorporate hazard mitigation planning into existing municipal policy.

Goal 7: To enhance planning and emergency response efforts among federal, state, county and local emergency management personnel to protect public health and safety.

OBJECTIVES:

1. Continually improve communication capabilities, training and coordination for hazard events.
2. Continually improve the planning for shelters, evacuation routes and disaster recovery.
3. Continue the promotion of disaster resiliency in the business community.
4. Maintain and/or upgrade emergency response equipment and resources.

Goal 8: To promote public awareness on both the potential impacts of natural and non-natural hazards and actions to reduce those impacts (NFIP).

OBJECTIVES:

1. Encourage and/or provide education and outreach to increase awareness of hazards and opportunities for mitigation. (NFIP)
2. Encourage and/or provide public education programs for businesses, households and individuals on mitigation, safety measures and preparedness.

6.3. Identification and Analysis of Mitigation Techniques

44 CFR Requirement Part 201.6(c)(3)(ii): The mitigation strategy shall include a section that identifies] a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

The 2024 Plan mitigation strategy includes an analysis of a comprehensive range of mitigation actions with an emphasis on existing and new buildings. The Commonwealth of Pennsylvania All-Hazard Mitigation Planning Standard Operating Guide, 2020, identifies four types of actions or techniques for consideration in developing the mitigation action plan:

1. **Local Plans and Regulations**: These actions include government authorities, policies, or codes that influence the way land and buildings are developed and built.
2. **Structure and Infrastructure:** These actions involve modifying existing structures and infrastructure or constructing new structures to reduce hazard vulnerability.
3. **Natural Systems Protection:** These actions minimize damage and losses and also preserve or restore the functions of natural systems.
4. **Education and Awareness:** These actions inform and educate citizens, elected officials, and property owners about hazards and potential ways to mitigate them and may also include participation in national programs.

It is important to note that emergency services actions can reduce the impacts of a hazard event on people and property but typically are not considered mitigation techniques as they do not meet the hazard mitigation definition of reducing or eliminating “long-term” risks cause by hazards. Mitigation techniques for each hazard are shown in Table 115.

Table 115: Mitigation Technique Categories

Mitigation Technique Categories				
Hazard	Local Plans and Regulations	Structure and Infrastructure	Natural Systems Protection	Education and Awareness
Natural Hazards				
Drought	X	X	X	X
Earthquake	X	X		X
Extreme Temperature	X	X	X	X
Flood, Flash Flood, Ice Jam	X	X	X	X
Hailstorm		X		X
Invasive Species	X		X	X
Landslide	X	X	X	X
Lightning Strike	X	X		X
Pandemic and Infectious Disease				X
Radon Exposure				X
Subsidence/Sinkhole	X	X	X	X
Wildfire	X	X	X	X
Windstorm/Tornado	X	X		X

Winter Storm		X		X
Non-Natural Hazards				
Civil Disturbance / Mass Gathering		X		X
Dam Failure	X	X		X
Drug Overdose Crisis				X
Environmental Hazards / Explosion	X	X		X
Fire (Urban / Structural)	X	X		X
Levee Failure	X	X		X
Nuclear Incident	X	X		X
Structural Collapse	X	X		X
Terrorism	X	X		X
Transportation Crash	X	X		X
Utility Interruption		X		X
Gas/Liquid Pipelines	X	X		X
Cyber-Terrorism		X		X

6.4 Mitigation Action Plan

44 CFR Requirements

Part 201.6(c)(3)(ii): [The mitigation strategy shall include a section that analyses] a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

Part 201.6(c)(3)(ii): [The mitigation strategy] must also address the jurisdiction's participation in the NFIP, and continued compliance with NFIP requirements, as appropriate.

Part 201.6(c)(3)(iii): [The mitigation strategy section shall include] an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

The Planning Team reviewed mitigation strategy ideas at a hybrid virtual/in-person strategy meeting on January 18, 2024. During the planning process, participants consulted the updated risk assessment, updated capability assessment, updated goals and objectives, and the progress made to actions from the 2018 plan. Municipalities were encouraged to identify mitigation actions, focusing on identifying well-defined, implementable projects with a careful consideration of available capabilities, risk reduction, losses avoided, costs and possible funding sources, including mitigation grant programs. Municipalities were also encouraged to identify mitigation actions that specifically protect historic and cultural resources. Throughout the planning process, the public, through surveys and other means, was given the opportunity to identify potential mitigation actions to be included in the Plan. Public participation involved in the development of mitigation actions is described in Section 3.3, and meeting documentation is included in Appendix C.

With the completion of the evaluation of 2018 Plan mitigation actions, those actions identified as "Complete" were removed from the 2024 mitigation actions unless they were part of a larger, ongoing action. Two examples of this are 1) multi-part projects where one or more parts were completed but other parts remain, and 2) continuous actions such as maintaining compliance with the NFIP, where a completed action since 2018 was adopting an updated floodplain ordinance. 2018 actions identified as "Discontinued" have been removed from this Plan. The 2018 actions identified as "No Progress/Unknown", "In Progress/Not Yet Complete" or "Continuous" have been carried forward in the 2024 Plan.

Each municipality has identified more than one mitigation action, with at least one that relates to continued NFIP compliance. For the 2024 Plan, 1,109 actions covering all participating municipalities are included in the municipal annexes, and county-level actions are identified for the 2024 Plan in the county annexes. More than one related action is provided for each hazard in the 2024 Plan.

With all municipal 2024 actions identified, actions were categorized into 27 regional action headings in Table 116. Specific 2024 actions for each community are identified in the municipal annexes. For each regional action listed, the number of municipalities that include that action in their municipal annex is provided. Actions related to continued NFIP compliance are also identified in the action plan summary. Mitigation action numbers that apply to each municipality are also documented in Table 117.

Table 116: Municipal 2024 Action Plan Summary

2024 Regional Action Number	Action Category	Number of Municipalities	Hazards Addressed	Mitigation Technique Category	Applies to New or Existing Structures	Applies to Cultural or Historic Resources	Goal-Objective Number	Priority
1	Retrofit structures in flood-prone areas, with repetitive and severe repetitive loss properties as a priority	47	Flood	Structures and Infrastructure	Existing	Yes	2-1	**High**
2	Purchase or relocate structures in hazard prone areas	47	Flood, Landslide, Subsidence / Sinkhole, Dam Failure, Levee Failure	Structures and Infrastructure	Existing	Yes	2-1	**High**
3	Maintain compliance with the National Flood Insurance Program, including enforcement of floodplain management requirements, floodplain identification and mapping, and flood insurance outreach (NFIP)	57	Flood	Local Plans and Regulations	Existing	Yes	2-1; 2-2; 2-3; 3-1; 4-2	**High**
4	Conduct and facilitate community and public outreach for residents and businesses to promote and	57	All	Education and Awareness	Both	Yes	1-1; 2-2; 7-3; 8-1; 8-2	**High**

*County-level mitigation actions are also associated with these categories, noting that for actions that are specifically a municipal responsibility, such as maintaining National Flood Insurance Program compliance, the county actions include encouraging and supporting municipal efforts.

2024 Regional Action Number	Action Category	Number of Municipalities	Hazards Addressed	Mitigation Technique Category	Applies to New or Existing Structures	Applies to Cultural or Historic Resources	Goal-Objective Number	Priority
	effect hazard risk reduction (NFIP)							
5	Begin and/or continue the process to adopt higher regulation of floodplains and carbonate bedrock areas (NFIP)	46	Flood, Subsidence/ Sinkhole	Local Plans and Regulations	N/A	No	2-1; 2-3; 6-1; 6-4	**High**
6	Have designated Floodplain Administrator certified and/or pursue continuing education training (NFIP)	46	Flood	Local Plans and Regulations	N/A	No	2-2	**Medium**
7	Participate in the Community Rating System (NFIP)	45	Flood	Local Plans and Regulations	N/A	No	2-2; 4-2	**High**
8	Obtain/archive elevation certificates (NFIP)	47	Flood	Local Plans and Regulations	N/A	No	2-2; 3-1	**Low**
9	Continue to support implementation, monitoring, maintenance and updating of the plan	61	All	All	Both	No	1-1; 3-1; 5-1; 5-2	**High**

*County-level mitigation actions are also associated with these categories, noting that for actions that are specifically a municipal responsibility, such as maintaining National Flood Insurance Program compliance, the county actions include encouraging and supporting municipal efforts.

2024 Regional Action Number	Action Category	Number of Municipalities	Hazards Addressed	Mitigation Technique Category	Applies to New or Existing Structures	Applies to Cultural or Historic Resources	Goal-Objective Number	Priority
10	Develop/enhance Comprehensive Emergency Management Plans	60	All	Local Plans and Regulations	Both	No	1-3; 6-3; 7-1; 7-2	**Medium**
11	Create/enhance/maintain mutual aid agreements with neighboring communities for continuity of operations	58	All	All	Both	No	6-3; 7-1; 7-2	**Medium**
12	Improve post-disaster capabilities, including processing FEMA/PEMA paperwork and qualified damage assessment personnel	56	All	Education and Awareness	N/A	No	1-3; 2-2; 6-3; 7-1; 7-2; 7-4	**Low**
13	Work with regional agencies to develop damage assessment capabilities through training programs, certification of qualified individuals such as floodplain managers (NFIP)	56	All	Education and Awareness	N/A	No	2-2; 7-1; 7-2	**Medium**

*County-level mitigation actions are also associated with these categories, noting that for actions that are specifically a municipal responsibility, such as maintaining National Flood Insurance Program compliance, the county actions include encouraging and supporting municipal efforts.

2024 Regional Action Number	Action Category	Number of Municipalities	Hazards Addressed	Mitigation Technique Category	Applies to New or Existing Structures	Applies to Cultural or Historic Resources	Goal-Objective Number	Priority
14	General storm drainage/flooding projects	15	Flood	Structures and Infrastructure	Existing	Yes	3-2	**Medium**
15	Specific storm drainage/flooding projects (non-critical facilities)	18	Flood	Structures and Infrastructure	Existing	Yes	2-1	**Medium**
16	Critical facilities - storm drainage/flooding projects or relocation	7	Flood	Structures and Infrastructure	Existing	Yes	2-1; 3-2	**High**
17	Critical facilities - back-up power projects	16	All	Structures and Infrastructure	Both	Yes	3-3; 7-4	**High**
18	Critical facilities - other projects	2	All	Structures and Infrastructure	Existing	Yes	2-1	**High**
19	Emergency notifications/ communication/traffic control	13	All	Education and Awareness	Existing	No	1-2; 6-3; 7-1; 7-4; 8-1	**High**

*County-level mitigation actions are also associated with these categories, noting that for actions that are specifically a municipal responsibility, such as maintaining National Flood Insurance Program compliance, the county actions include encouraging and supporting municipal efforts.

2024 Regional Action Number	Action Category	Number of Municipalities	Hazards Addressed	Mitigation Technique Category	Applies to New or Existing Structures	Applies to Cultural or Historic Resources	Goal-Objective Number	Priority
20	Stream or floodplain restoration/stabilization projects	5	Flood	Natural Systems Protection	Existing	No	4-1	**Medium**
21	Work to minimize tree/electric line conflicts	10	Windstorm / Tornado, Winter Storm	Structures and Infrastructure	Existing	No	2-1	**High**
22	Geotechnical/sinkhole evaluation (adopt construction standards, remediation)	3	Subsidence / Sinkhole	Local Plans and Regulations	Both	Yes	2-1	**High**
23	Hazardous materials inventory/emergency planning, education, certification	6	Environmental Hazards / Explosion	Education and Awareness	Both	Yes	2-2; 3-1; 8-1	**High**
24	Dam/levee projects	5	Flood, Earthquake	Structures and Infrastructure	Existing	Yes	2-1; 3-4	**Medium**
25	Specific bridge replacement or retrofits	4	Flood	Structures and Infrastructure	Existing	Yes	2-1	**Medium**

*County-level mitigation actions are also associated with these categories, noting that for actions that are specifically a municipal responsibility, such as maintaining National Flood Insurance Program compliance, the county actions include encouraging and supporting municipal efforts.

2024 Regional Action Number	Action Category	Number of Municipalities	Hazards Addressed	Mitigation Technique Category	Applies to New or Existing Structures	Applies to Cultural or Historic Resources	Goal-Objective Number	Priority
26	Wildfire mitigation	1	Wildfire	All	Existing	Yes	2-1	**Medium**
27	Integrate hazard mitigation into local plans and ordinances	25	All	Local Plans and Regulations	Both	No	4-2; 6-1; 6-2; 6-4	**High**

*County-level mitigation actions are also associated with these categories, noting that for actions that are specifically a municipal responsibility, such as maintaining National Flood Insurance Program compliance, the county actions include encouraging and supporting municipal efforts.

Table 117: Municipal Action Matrix

Lehigh County	Regional Action Numbers	Northampton County	Regional Action Numbers
Alburtis Borough	**4, 9, 10, 11, 13, 19, 21, 23, 27**	Allen Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**
Allentown City	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 16**	Bangor Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**
Catasauqua Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 19, 20, 22, 23, 24, 27**	Bath Borough	**1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 21**
Coopersburg Borough	**4, 9, 10, 11, 12, 14, 19, 27**	Bethlehem Township	**3, 4, 9, 10, 11, 12, 13, 14, 15, 23**
Coplay Borough	**3, 4, 5, 9, 10, 11, 12, 13, 17, 19**	Bushkill Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**
Emmaus Borough	**1, 2, 3, 4, 8, 9, 10, 13, 14, 19, 21**	Chapman Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15**
Fountain Hill Borough	**3, 4, 9, 10, 11, 12, 13, 14, 27**	East Allen Township	**3, 11, 12, 14, 15, 23, 27**
Hanover Township	**3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 27**	East Bangor Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 21**

Lehigh County	Regional Action Numbers	Northampton County	Regional Action Numbers
Heidelberg Township	**9, 10, 11, 13, 15, 17, 19, 21**	Easton City	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 24, 25, 27**
Lower Macungie Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 25**	Forks Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 27**
Lower Milford Township	**3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16**	Freemansburg Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 27**
Lowhill Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**	Glendon Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**
Lynn Township	**3, 4, 9, 10, 11, 12, 13, 14, 17**	Hanover Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 27**
Macungie Borough	**1, 2, 3, 4, 9, 10, 11, 12, 13, 15, 20**	Hellertown Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 23, 27**
North Whitehall Township	**3, 4, 9, 10, 11, 12, 13, 19**	Lehigh Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 19, 21**
Salisbury Township	**3, 4, 5, 9, 10, 11, 12, 13, 27**	Lower Mount Bethel Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 27**

Lehigh County	Regional Action Numbers	Northampton County	Regional Action Numbers
Slatington Borough	**9, 10, 13, 19, 21**	Lower Nazareth	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 27**
South Whitehall Township	**1, 2, 3, 4, 9, 10, 11, 12, 13, 15, 16, 17, 27**	Lower Saucon Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 27**
Upper Macungie Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**	Moore Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 27**
Upper Milford Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 19, 21**	Nazareth Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17**
Upper Saucon Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 23, 25, 27**	Northampton Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 20, 22**
Washington Township	**9, 10, 13, 19, 21**	North Catasauqua Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**
Weisenberg Township	**3, 4, 9, 10, 11, 12, 13, 19**	Palmer Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 17, 22**
Whitehall Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 16, 17, 18 24, 25**	Pen Argyl Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 27**

Lehigh County	Regional Action Numbers	Northampton County	Regional Action Numbers
Lehigh Valley Authority		Plainfield Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 17, 26**
Lehigh-Northampton Airport Authority		Portland Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 27**
		Roseto Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 27**
		Stockertown Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 19**
		Tatamy Borough	**1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 17, 20, 27**
		Upper Mount Bethel Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 21, 27**
		Upper Nazareth Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**
		Walnutport Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**

Lehigh County	Regional Action Numbers	Northampton County	Regional Action Numbers
		Washington Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 20**
		West Easton Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 27**
		Williams Township	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14**
		Wilson Borough	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**
		Wind Gap Borough	**1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 17**
		Bethlehem City	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 24**

The regional actions were prioritized against one another on a Lehigh Valley-wide basis by applying the PEMA Multi-Objective Mitigation Action Prioritization criteria. The weighted criteria include:

- Effectiveness (20% of score) – The extent to which an action reduces the vulnerability of people and property.
- Efficiency (30% of score) – The extent to which time, effort and cost is used as a means of reducing vulnerability.
- Multi-Hazard Mitigation (20% of score) – How much the action reduces vulnerability for more than one hazard.
- Addresses High Risk Hazard (15% of score) – How the action reduces vulnerability for people and property from a hazard(s) identified as high risk.
- Addresses Critical Communications/Critical Infrastructure (15% of score) – How the action pertains to the maintenance of critical functions and structures such as transportation, supply chain management, data circuits, etc.

These scores were used to assign each regional actions an overall level of priority, based on the following scale:

- High: 2.5-3
- Medium: 1.9-2.4
- Low: 0-1.8

Error! Reference source not found. provides detail about how each regional action scored in each criteria, and their overall prioritization scores.

Table 118: Mitigation Action Prioritization

Mitigation Actions		Multi-Objective Mitigation Action Prioritization Criteria						
2024 Regional Action Number	Action	Effectiveness	Efficiency	Multi-Hazard Mitigation	Addresses High Risk Hazard	Addresses Critical Communications/ Critical Infrastructure	Total Score	Priority
1	Retrofit structures in flood-prone areas, with repetitive and severe repetitive loss properties as a priority	3	3	1	3	2	**2.5**	**High**
2	Purchase or relocate structures in hazard prone areas	3	3	3	3	2	**2.9**	**High**
3	Maintain compliance with the National Flood Insurance Program, including enforcement of floodplain management requirements, floodplain identification and mapping, and flood insurance outreach (NFIP)	3	3	1	3	3	**2.6**	**High**
4	Conduct and facilitate community and public outreach for residents and businesses to promote	3	2	3	3	2	**2.6**	**High**

Mitigation Actions		Multi-Objective Mitigation Action Prioritization Criteria						
2024 Regional Action Number	Action	Effectiveness	Efficiency	Multi-Hazard Mitigation	Addresses High Risk Hazard	Addresses Critical Communications/ Critical Infrastructure	Total Score	Priority
	and effect hazard risk reduction (NFIP)							
5	Begin and/or continue the process to adopt higher regulation of floodplains and carbonate bedrock areas (NFIP)	3	3	2	3	2	**2.7**	**High**
6	Have designated Floodplain Administrator certified and/or pursue continuing education training (NFIP)	2	3	1	3	1	**2.1**	**Medium**
7	Participate in the Community Rating System (NFIP)	3	3	1	3	2	**2.5**	**High**
8	Obtain/archive elevation certificates (NFIP)	1	2	1	3	1	**1.6**	**Low**
9	Continue to support implementation,	3	2	3	3	2	**2.6**	**High**

Mitigation Actions		Multi-Objective Mitigation Action Prioritization Criteria						
2024 Regional Action Number	Action	Effectiveness	Efficiency	Multi-Hazard Mitigation	Addresses High Risk Hazard	Addresses Critical Communications/ Critical Infrastructure	Total Score	Priority
	monitoring, maintenance and updating of the plan							
10	Develop/enhance Comprehensive Emergency Management Plans	2	2	3	3	2	**2.4**	**Medium**
11	Create/enhance/maintain mutual aid agreements with neighboring communities for continuity of operations	1	2	3	3	2	**2.2**	**Medium**
12	Improve post-disaster capabilities, including processing FEMA/PEMA paperwork and qualified damage assessment personnel	1	1	3	1	1	**1.4**	**Low**
13	Work with regional agencies to develop damage assessment capabilities through	1	2	3	3	1	**2.0**	**Medium**

Mitigation Actions		Multi-Objective Mitigation Action Prioritization Criteria						
2024 Regional Action Number	**Action**	**Effectiveness**	**Efficiency**	**Multi-Hazard Mitigation**	**Addresses High Risk Hazard**	**Addresses Critical Communications/ Critical Infrastructure**	**Total Score**	**Priority**
	training programs, certification of qualified individuals such as floodplain managers (NFIP)							
14	General storm drainage/flooding projects	3	2	1	3	1	**2.0**	**Medium**
15	Specific storm drainage/flooding projects (non-critical facilities)	3	2	1	3	3	**2.0**	**Medium**
16	Critical facilities - storm drainage/flooding projects or relocation	3	3	1	3	3	**2.6**	**High**
17	Critical facilities - back-up power projects	3	3	3	3	3	**3.0**	**High**
18	Critical facilities - other projects	3	3	3	3	3	**3.0**	**High**

Mitigation Actions		Multi-Objective Mitigation Action Prioritization Criteria						
2024 Regional Action Number	Action	Effectiveness	Efficiency	Multi-Hazard Mitigation	Addresses High Risk Hazard	Addresses Critical Communications/ Critical Infrastructure	Total Score	Priority
19	Emergency notifications/ communication/traffic control	3	2	3	3	3	**2.7**	**High**
20	Stream or floodplain restoration/stabilization projects	3	2	1	2	1	**1.9**	**Medium**
21	Work to minimize tree/electric line conflicts	3	3	2	3	3	**2.8**	**High**
22	Geotechnical/sinkhole evaluation (adopt construction standards, remediation)	3	3	3	2	2	**2.7**	**High**
23	Hazardous materials inventory/emergency planning, education, certification	3	3	1	3	2	**2.5**	**High**
24	Dam/levee projects	3	2	2	2	3	**2.4**	**Medium**

Mitigation Actions		Multi-Objective Mitigation Action Prioritization Criteria						
2024 Regional Action Number	**Action**	**Effectiveness**	**Efficiency**	**Multi-Hazard Mitigation**	**Addresses High Risk Hazard**	**Addresses Critical Communications/ Critical Infrastructure**	**Total Score**	**Priority**
25	Specific bridge replacement or retrofits	2	2	1	3	3	**2.1**	**Medium**
26	Wildfire mitigation	3	2	1	2	1	**1.9**	**Medium**
27	Integrate hazard mitigation into local plans and ordinances	3	3	3	3	1	**2.7**	**High**

7. Plan Maintenance

7.1 Update Process Summary

Monitoring, evaluating and updating the Lehigh Valley Hazard Mitigation Plan is critical for it to be usable and valuable. Following through on the actions laid out in the Plan is important to maintaining the momentum created by the municipal, county, state, federal and community partners who worked together to build it.

For the 2024 Plan, the Administrative Planning Team is committed to meeting annually, preparing progress reports for incorporation in the next plan update and meeting after significant hazard events that may require changes to the Plan. The following table describes the actions taken by the planning team over the previous 5 years in advance of the publication of the 2024 hazard mitigation plan.

Table 119: Summary of Plan Maintenance Tasks Since Previous Update

Date	Maintenance Conducted	Changes Made to Plan	Municipal Participants	Municipal Worksheets submitted
August 15, 2019	In person annual review meeting, municipal questionnaire handed out during meeting	Yes – Submitted to PEMA December 2019	14	23
October 2020	Virtual questionnaire via email	Yes – Submitted to PEMA March 2021	-	32
September 2021	Virtual questionnaire via email	Yes – Submitted to PEMA February March 2022	-	20
November 4, 2022	In person annual review Meeting, asked municipalities to update annexes	Yes – Submitted to PEMA December 2022	18	20

The 2024 Plan identifies the positions responsible to lead the maintenance effort. A list of the members of the Planning Team is provided in Table 4. Plan maintenance is now the joint responsibility of both counties.

The Capability Assessment section discusses the way existing programs will be utilized to support the implementation of the Plan.

7.2 Monitoring, Evaluating, and Updating the Plan

The Lehigh Valley Hazard Mitigation Administrative Planning Team will remain intact as the group responsible for monitoring, evaluating and updating the 2024 Lehigh Valley Hazard Mitigation Plan.

The Administrative Planning Team will be co-chaired by the Lehigh County Director of Emergency Management Agency or their designee and the Northampton County Director of Emergency Management Services or their designee. Each participating municipality in the Lehigh Valley is expected to maintain a Planning Team point of contact, and the Administrative Planning Team co-chairs are responsible for maintaining an updated list of municipal points of contact who will assist in keeping the plan current. Municipal points of contact for the 2024 Plan are identified in the municipal annexes. It shall be the responsibility of each municipality to inform the Administrative Planning Team co-chairs of any changes in their municipal representation.

If any member of the Administrative Planning Team can no longer fulfill their duties to the team, it is the responsibility of the co-chairs to choose their replacement.

The co-chairs will call the annual meetings of the Administrative Planning Team and Planning Team to evaluate the Plan's progress and effectiveness. The meetings should be held in August, to allow municipal participants sufficient time to review their action plans and prepare any questions or inquiries they may have regarding their specific plan/annex. This will also provide conversation with attending participants regarding annual FEMA Hazard Mitigation Assistance Program announcements that typically come out in early August, annually. Forms of Hazard Mitigation Grant Programs are also available immediately after any Presidential Declared disaster event.

The responsibilities of the Administrative Planning Team co-chairs shall include:

- Encouraging each municipality to adopt the 2024 Plan within one year of its passage.
- Contacting each municipal point of contact on an annual basis (at minimum) to request information regarding the status of mitigation actions and whether any new actions should be added due to changing conditions.
- Compiling the updated information and public outreach completed in an annual progress report, to be posted on the Hazard Mitigation webpage at http://ncem-pa.org/hazard-mitigation/.
- Convening the Administrative Planning Team and the Planning Team for annual meetings. Ability to convene Administrative Planning Team and Planning Team for meetings whenever necessary outside of the annual meetings.
- Providing FEMA and PEMA with all annual progress reports.
- Ensuring annual progress reports are incorporated in the five-year update.
- Providing opportunities for public input.

During the annual plan review process, the Administrative Planning Team will review the plan for effectiveness. The plan will be considered to be effective if (1) the data or goals included herein are able to be incorporated into other planning mechanisms, and (2) if the actions proposed in the plan are able to be implemented. This effectiveness review will include considering:

- Participating jurisdictions' success in incorporating elements of the HMP into other mechanisms
- The number / percentage of mitigation actions proposed in the plan that have been implemented, or for which communities are seeking funding
- The success of grant applications for these actions in competitive funding processes
- The degree to which political, administrative, or financial support for these actions is available.

Each participating municipality, the counties or any other ancillary organization are responsible for implementing their mitigation actions and informing the Administrative Planning Team annually of any progress made. This includes incorporating those actions into other planning documents, such as comprehensive plans, zoning ordinances, capital improvement plans and budgets, as necessary.

Each participating municipality or county's representative on the Administrative Planning Team will also be responsible for incorporating the goals, actions, and data from this plan into the following planning mechanisms, if they have them:

- Comprehensive plan
- Capital improvement plan
- Economic development plan
- Open space management plan, Parks and Recreation Plan, or Greenway Plan
- Natural Resource Protection Plan
- Historic Preservation Plan

Each participant's individual process for integrating information from the mitigation strategy into these planning mechanisms will vary, as a majority of these documents are not developed, maintained, or updated by the jurisdiction's representative on the Administrative Planning Team. However, all team members will make every effort to participate in updates of these documents when they occur, and will provide copies of the final plan to the agencies or individuals who are responsible for these planning mechanisms for their review and awareness.

It will remain the responsibility of the Lehigh and Northampton County Emergency Management Agencies to monitor grant opportunities to help the counties and municipalities fund their mitigation actions and inform the municipal points of contact of those opportunities. To give the region enough time to perform the next five-year update, the counties will apply for Hazard Mitigation Planning grant funding well in advance of the next plan update process.

The plan and annexes will be updated annually during routine reviews as new information is received. However, the co-chairs will consider seeking funding for a full plan update starting three years from its expiration, with a goal of beginning the plan update in earnest two years before expiration, and submitting to PEMA for review at least 6 months before expiration.

7.3 Continued Public Involvement

The public has had a continued opportunity to provide input and feedback regarding hazard mitigation since the 2018 Plan was adopted.

Public involvement that extends beyond the Plan's adoption is a priority for both counties and the LVPC. To promote continued involvement, the 2024 Lehigh Valley Hazard Mitigation Plan, including municipal annexes, will be posted online to give stakeholders and the public 24-hour access. The website shall include an email link that allows stakeholders and/or public to provide feedback and/or comment, and social media will be used as part of a continued outreach effort as well. Any media reports and public meeting notices will be posted online, as well as any progress reports and updates of the Plan.

Annual progress reports or any proposed updates to the Plan will be open for public review online and during at least one public meeting each year. The co-chairs will handle the scheduling of public meetings when deemed necessary and will inform all other Administrative and Planning Team members when this occurs.

Responses to the public outreach worksheet are included in the municipal annexes. Over the next five years, municipal participation will continue to include assisting and promoting outreach to their community.

In addition, copies of the 2024 Lehigh Valley Hazard Mitigation Plan will be made available for public access at each participating municipal building and at:

Lehigh County Emergency Management Agency
640 W. Hamilton Street
Allentown, PA 18101

Northampton County Emergency Management Services
100 Gracedale Avenue
Nazareth, PA 18064

8. Plan Adoption

Adoption of the Lehigh Valley Hazard Mitigation Plan by Lehigh and Northampton counties and each participating municipality is a critical step for ensuring implementation of its goals, objectives and actions.

Adoption by the local governing bodies demonstrates the commitment of Lehigh and Northampton counties and each participating municipality to fulfill the mitigation goals and objectives outlined in the Plan. Adoption formalizes the Plan and authorizes responsible agencies to execute their responsibilities. For this multi-jurisdictional plan to be approved, each jurisdiction included in the Plan must have its governing body adopt the Plan upon notification of approval pending adoption by the Federal Emergency Management Agency (FEMA).

Following adoption or formal action on the Plan, each participating jurisdiction must submit a copy of the resolution or other legal instrument showing formal adoption (acceptance) of the Plan to their respective county emergency management agency for this Plan. These will then be submitted to PEMA and forwarded to FEMA. Upon final FEMA approval, each municipality must submit a copy of the FEMA approval letter to their respective county emergency management agency.

In addition to being required by the Disaster Mitigation Act of 2000, adoption of the plan is necessary because:

- It lends authority to the plan to serve as a guiding document for all local and state government officials;
- It gives legal status to the plan in the event it is challenged in court;
- It certifies to program and grant administrators that the plan's recommendations have been properly considered and approved by the governing authority and jurisdictions' citizens; and
- It helps ensure the continuity of mitigation programs and policies over time because elected officials, staff and other community decision- makers can refer to the official document when making decisions about the community's future.

Table 120 lists the jurisdictions which have adopted the 2024 Plan as well as the dates of the jurisdictions' adoption.

Table 120: Date of Plan Adoption by Jurisdiction

Jurisdiction	Date of Plan Adoption
Northampton County	
Allen Township	
Bangor Borough	
Bath Borough	
Bethlehem Township	
Bushkill Township	
Chapman Borough	

East Allen Township	
East Bangor Borough	
Easton City	
Forks Township	
Freemansburg Borough	
Glendon Borough	
Hanover Township	
Hellertown Borough	
Lehigh Township	
Lower Mount Bethel Township	
Lower Nazareth	
Lower Saucon Township	
Moore Township	
Nazareth Borough	
Northampton Borough	
North Catasaqua Borough	
Palmer Township	
Pen Argyl Township	
Plainfield Township	
Portland Borough	
Roseto Borough	
Stockertown Borough	
Tatamy Borough	
Upper Mount Bethel Township	
Upper Nazareth Township	
Walnutport Borough	
Washington Township	
West Easton Borough	
Williams Township	
Wilson Borough	
Wind Gap Borough	
Bethlehem City	
Lehigh County	
Alburtis Borough	
Allentown City	
Catasauqua Borough	
Coopersburg Borough	
Coplay Borough	
Emmaus Borough	
Fountain Hill Borough	
Hanover Township	
Heidelberg Township	
Lower Macungie Township	
Lower Milford Township	
Lowhill Township	
Lynn Township	
Macungie Borough	
North Whitehall Township	
Salisbury Township	
Slatington Borough	

South Whitehall Township	
Upper Macungie Township	
Upper Milford Township	
Upper Saucon Township	
Washington Township	
Weisenberg Township	
Whitehall Township	
Lehigh Valley Authority	
Lehigh-Northampton Airport Authority	