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2024 HAZARD MITIGATION PLAN

MONTGOMERY COUNTY, MARYLAND
OFFICE OF EMERGENCY MANAGEMENT
AND HOMELAND SECURITY

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This Plan was developed in cooperation with:

Montgomery County

the participating jurisdictions of
The Maryland National Capital Park and Planning Commission
The Cities of Gaithersburg, Rockville, and Takoma Park
The Towns of Barnesville, Brookeville, Chevy Chase, Chevy Chase View, Garrett Park, Glen Echo, Kensington, Laytonsville, Poolesville, Somerset, and Washington Grove
and Villages of Chevy Chase, Chevy Chase Section 3, Chevy Chase Section 5, Martin's Additions, North Chevy Chase

Executive Summary

Hazard mitigation is often described as sustained actions taken to reduce or eliminate impacts of natural or human-made hazards including preventing loss of life and damage to property. It is a process that identifies and profiles hazards, analyzes people and facilities at risk because of these hazards, and develops mitigation actions to reduce or eliminate hazard risk and create a stronger, more resilient community.

The 2024 Montgomery County Hazard Mitigation Plan is designed to function as a roadmap for the coordination and execution of hazard mitigation policies and initiatives for jurisdictions within Montgomery County. It describes the characteristics of hazards which threaten the community, as well as mitigation goals, strategies, and associated actions to aid jurisdictions in reducing risks and minimizing damages by taking proactive steps before disaster strikes. This not only protects lives and properties but also reduces the social, economic, and environmental aftereffects which often follow hazardous events.

Prior to the implementation of any hazard mitigation strategies, it is necessary to understand the characteristics of both current and emerging hazards. To achieve this, a significant portion of time was allocated to researching past occurrences of hazards – both natural and human-made – that have impacted Montgomery County. To ensure no stone went unturned, the team parsed through a robust set of databases from government agencies including the National Weather Service, National Oceanic and Atmospheric Administration, National Centers for Environmental Information, Environmental Protection Agency, U.S. Fire Administration, Pipeline and Hazardous Materials Safety Administration, and more. Further information was obtained from Maryland and Montgomery County resources, when available.

There are 17 unique hazards detailed in this plan. Through a review of the available resources, some of which date into the 19th century, a picture of previous hazard occurrences within Montgomery County was formed. This illustrates how Montgomery County responded to previous events and also provides insight into trends and future conditions. The findings for each of the 17 hazards are presented in separate, dedicated sections within the Hazard Identification and Risk Assessment. Within these sections, the location and extent, range of magnitude, past occurrences, possible future occurrences, impacts due to climate change, and vulnerability assessment of each hazard is laid out. The vulnerability assessments specifically examine the consequences for people, systems, and natural, cultural, and historic assets.

Hazard mitigation is most effective when it serves the needs of the whole community. To achieve this, our planning process cast a wide net and engaged many participants and the public through a comprehensive virtual and in-person outreach process. The actions and

strategies which emerged are representative of the comprehensive and strategic improvements that the county is already targeting, as well as thoughtfully tailored actions from each of the engaged participants and stakeholders that call Montgomery County home.

Individual capability and strategy meetings were held with most of the County's incorporated communities. Through these calls the planning team was able to speak with community officials and discuss their individual concerns. These conversations provided insight about the local circumstances which likely would not have been attainable through other means. Although these communities are all within the same county, they often have different hazard exposure levels, needs, and response capabilities, and a mitigation strategy which works for one community may not be actionable for all.

After outlining the mitigation goals, objectives, and approaches, the 2024 Montgomery County Hazard Mitigation Plan delves into a comprehensive assessment of the capabilities of Montgomery County and its encompassing communities. This section begins with a review of administrative and technical capacities, such as the presence of in-house engineers, the utilization of geographic information systems (GIS), and so on, across different jurisdictions. It then transitions to a review of financial strengths, followed by an evaluation of policy-driven and programmatic capabilities. The legal powers vested in the communities across Montgomery County are also appraised. The section wraps up with a synthesis of the capabilities of each jurisdiction within the County, which is accompanied by a consequence analysis.

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I. Introduction

Emergency Management encompasses a comprehensive set of practices aimed at identifying, managing, mitigating, and responding to risks. It involves a proactive approach that entails preparing for disasters before they occur, offering support to affected populations during a crisis, and aiding in the recovery and reconstruction efforts that follow. The field of Emergency Management is dynamic, evolving as individuals, groups, and communities continually strive to manage hazards, reducing the potential impact of disasters.

At the heart of this proactive approach lies Hazard Mitigation Planning, a strategic method to prevent hazards from escalating into full-blown disasters. This planning process involves identifying essential policies, capabilities, activities, and tools necessary to effectively implement sustainable mitigation actions.

The concept of mitigation planning holds the promise of yielding long-term and recurring benefits by disrupting the repetitive cycle of disaster-related losses. A fundamental principle of hazard mitigation is that investments made before a disaster will significantly diminish the need for post-disaster emergency responses, repairs, recoveries, and reconstructions. By implementing mitigation practices, communities can bolster their resilience, enabling residents, businesses, and industries to recover swiftly in a post-disaster environment.

Yet, the advantages of mitigation planning extend beyond merely reducing vulnerability to hazards. They encompass 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 FEMA and States prioritize future grant funding, aligning resources with areas most in need of support and protection. Montgomery County completed its initial Hazard Mitigation Plan on February 2, 2007, and has updated it February 10, 2014, April 8, 2019, and most recently on March X, 2024.

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 Montgomery County's 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 that took effect on April 19, 2023, states that mitigation plans are the foundation for effective hazard mitigation. As such, 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.

This Plan update has been prepared to meet requirements set forth by FEMA and the Maryland Department of Emergency Management (MDEM) for Montgomery County to be eligible for funding and technical assistance from State and Federal hazard mitigation programs. On March XX, 2024, Montgomery County adopted the update to the Montgomery County Hazard Mitigation Plan in accordance with the authority granted to counties by the State of Maryland. This Plan was updated in accordance with current State and Federal rules and regulations governing Local Hazard Mitigation Plans. The Plan shall be monitored and updated on a routine basis to maintain compliance with the following legislation and guidance:

- Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C 5121, Section 322, Mitigation Planning, as enacted by Section 104 of the Disaster Mitigation Act of 2000 (P.L. 106-390) and by FEMA's Interim Final Rule published in the Federal Register on February 26, 2002, at Section 44 Code of Federal Regulations (CFR) Part 201. The Disaster Mitigation Act of 2000 added a new section to the law, Section 322, Mitigation Planning that requires local governments to prepare and adopt jurisdiction-wide Hazard Mitigation Plans for disasters declared after November 1, 2004, as a condition of receiving Hazard Mitigation Grant Program project grants and other non-disaster related mitigation grant assistance programs. Local governments must review and, if necessary, update their mitigation plans every five years from the original date of the plans in order to continue HMA program eligibility.
- The requirements for local mitigation plans are found in Section 44 CFR Section 201.6. FEMA's "Local Mitigation Planning Policy Guide" Effective April 19, 2023, provides updated FEMA interpretation and explanation of local plan mitigation regulations and FEMA's expectations for mitigation plan updates. In addition, MDEM and FEMA now use the 2023 Local Mitigation Plan Review Tool to ensure that a plan meets FEMA's regulatory requirements as well as additional requirements identified by the State of Maryland.
- The Maryland Code. The Emergency Management Policy was updated in July 2016 through Executive Order 01.01.1991.02 State of Maryland Emergency Management Policy. This policy authorizes the Maryland Department of Emergency Management

(MDEM) as the state agency with the primary responsibility for the planning and execution of disaster and emergency preparedness, response, and recovery including the coordination and development of hazard mitigation planning activities.

II. Planning Process

The Montgomery County Office of Emergency Management and Homeland Security (OEMHS) served as lead agency in the update of this Hazard Mitigation Plan. OEMHS and representatives for other County agencies served as a core Planning Team Steering Committee and worked closely with the Hazard Mitigation Planning Team (HMPT) to develop and review each section of the Mitigation Plan. The Steering Committee and HMPT participated in meetings throughout the process. Meeting agendas, meeting minutes, and sign in sheets were developed and maintained for each meeting and are detailed in Appendix B of this plan.

A. Local Methodology and Update Process

The Montgomery County Hazard Mitigation Plan 2024 update embraces a wholistic approach to hazard mitigation. In support of this, the Plan integrates input provided by a multitude of locales – including all 19 incorporated municipalities – in Montgomery County. It is also intended to support *all* residents, including individuals with access and functional needs, cultural minority and limited English-speaking populations, children, the elderly, and other vulnerable populations.

The content of this Plan is not limited to any single hazard, but applies to all hazards, including both natural and human caused disasters. For additional information on hazards that could impact Montgomery County, see the County's Threat and Hazards Identification Process (THIP), Emergency Operations Plan, and Section V Situation Overview.

This plan was completed in compliance with the Disaster Mitigation Act of 2000, 44 CFR § 201.3(d) and utilized the Local Hazard Mitigation Planning Policy Guide effective April 19, 2023. Development of the plan was a concerted effort on the part of Montgomery County and its municipalities. The Montgomery County OEMHS invited directors and staff from public agencies, private businesses and organizations, and community representatives to participate in the planning process. The HMPT validated that all information provided for incorporation in this plan update is correct, and that all agencies, organizations and the public's input were included as presented.

The Community Profile describes the general makeup of Montgomery County and its municipalities, including prevalent geographic, demographic, and economic characteristics. This baseline information provides a snapshot of the countywide planning area and thereby assists participating officials in recognizing those social, environmental, and economic factors that ultimately play a role in determining community vulnerability to natural hazards.

The Hazard Identification and Risk Assessment (HIRA) is presented as three different elements: Hazard Identification/Profile, Hazard Analysis, and a Vulnerability Assessment. Together, these

elements serve to identify, analyze, and assess Montgomery County's overall risk to natural hazards. The HIRA builds on available historical data from previous occurrences, establishes hazard-by-hazard profiles, and culminates in a hazard risk priority or 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. The HIRA is 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 serve as a basis for updating goals for this Plan update, each contributing to the development, adoption, and implementation of a meaningful Mitigation Strategy update that is based on accurate background information.

The Mitigation Strategy presents the plan goals and objectives as well as specific mitigation actions for each jurisdiction participating in the planning process. This updated strategy provides the foundation for Mitigation Action Plans that link jurisdictionally specific mitigation actions to locally assigned implementation mechanisms and target completion dates. Together, these sections are designed to make the Plan more strategic and functional through the identification of both long-term goals and near-term actions that will guide day-to-day decision-making and project implementation.

In addition to the identification and prioritization of possible mitigation projects, emphasis is placed on the use of program and policy alternatives to help make Montgomery County and participating municipalities less vulnerable to the damaging forces of nature while improving the economic, social, and environmental health of the community. The concept of multi-objective planning is emphasized throughout this Plan update, identifying ways to link hazard mitigation policies and programs with complimentary community goals that may be related to housing, economic development, community revitalization, recreational opportunities, transportation improvements, environmental quality, land development, and public health and safety. This Hazard Mitigation Plan update is a proactive document that represents a concerted effort to make Montgomery County and participating jurisdictions more livable communities.

The Plan Maintenance Procedures addresses how Montgomery County and participating jurisdictions will ensure the Plan's continuous long-term implementation. The procedures also include the manner in which the Plan will be regularly monitored, reported upon, evaluated, and updated to remain a current and meaningful planning document.

B. The Planning Team

The 2023 Montgomery County Hazard Mitigation Plan update was led by OEMHS staff and the Steering Committee that provided guidance and leadership for the overall project. OEMHS staff

assisted the HMPT through the planning process and dissemination of information and administrative tasks.

Table 1: 2023 Mitigation Planning Team

Name	Title & Department
Luke Hodgson	Director, Montgomery Co., OEMHS (January 2023)
Marianne Souders	Planning Division Chief, Montgomery Co., OEMHS
Kristina "Tina" Laboy	Emergency Management Specialist, Montgomery Co., OEMHS
Ehsan Bahador	Emergency Management Specialist, Montgomery Co., OEMHS
Adriana Hochberg	Department of Environmental Protection
Stan Edwards	Energy, Climate, and Compliance Division Manager, DEP
Laura Sivels	Climate Engagement Program Manager, Energy, Climate, and
Bill Musico	DPP Water Resources Plan Review, Department of Permitting Services
Carl Morgan	M-NCPPC, Planning
Robert Kronenberg	M-NCPPC, Planning
Tina Schneider	M-NCPPC, Planning
Miti Figueredo	M-NCPPC, Parks
Mike Riley	M-NCPPC, Parks
Adrienne Thomas	M-NCPPC
Tanya Brown	M-NCPPC
Michael Bolling	M-NCPPC

The following table documents the number of participants that participated in this planning process and includes their attendance during various Planning Team Meetings. Participants that that are included but did not attend meetings provided feedback via email or were consulted in coordination with data validation.

Table 2: 2023 Mitigation Planning Team and Meeting Participation

NAME	JURISDICTION, AGENCY	KICKOFF	HAZARDS	ACTIONS	ONE-ON-ONE	STRATEGY AND REVIEW
Luke Hodgson	Montgomery County OEMHS			X	X	
Marianne Souders	Montgomery County OEMHS	X			X	
Kristina "Tina" Laboy	Montgomery County OEMHS	X	X	X	X	
Ehsan Bahador	Montgomery County OEMHS			X		
Michelle Lloyd	Montgomery County OEMHS					
Adriana Hochberg	Montgomery County DEP					
Stan Edwards	Montgomery County DEP	X	X			

NAME	JURISDICTION, AGENCY	KICKOFF	HAZARDS	ACTIONS	ONE-ON-ONE	STRATEGY AND REVIEW
Laura Sivels	Montgomery County DEP	X	X			
Bill Musico	Montgomery County DPS	X	X			
Mara Parker	Montgomery County DEP			X		
Jamie Cooke	Montgomery County DGS			X		
Carl Morgan	M-NCPPC, Planning		X	X	X	
Christopher McGovern	M-NCPPC, Parks				X	
Robert Kronenberg	M-NCPPC, Planning					
Tina Schneider	M-NCPPC, Planning	X				
Miti Figueredo	M-NCPPC, Parks					
Mike Riley	M-NCPPC, Parks					
Adrienne Thomas	M-NCPPC			X		
Tanya Brown	M-NCPPC					
Michael Bolling	M-NCPPC			X		
Mildred Callear	Barnesville					
Cate McDonald	Brookeville				X	
John Loyd	Chevy Chase	X				
Jana Coe	Chevy Chase View	X			X	
Denise Hill	Chevy Chase View			X	X	
Jackie Parker	Chevy Chase Village	X	X	X	X	
Andy Leon Harney	Chevy Chase Village Section 3	X	X		X	
Ashley Kavanaugh	Chevy Chase Village Section 5				X	
Dave Fascinelli	Gaithersburg				X	
Kayla Buker	Garrett Park	X		X	X	
Barbara Matthews	Garrett Park				X	
Elizaeth Stickler	Glen Echo			X	X	
Dia Costello	Glen Echo					
Matt Hoffman	Kensington	X			X	

NAME	JURISDICTION, AGENCY	KICKOFF	HAZARDS	ACTIONS	ONE-ON-ONE	STRATEGY AND REVIEW
Jim Ruspi	Laytonsville				X	
Mary Burke	Laytonsville				X	
Amy Koral	Laytonsville			X		
Joy Jackson	Laytonsville				X	
Charles Hendricks	Laytonsville				X	
Michael Silliman	Martins Additions					
Wade Yost	Poolesville					
Niles Anderegg	Poolesville	X	X	X	X	
Mark Landahl	Rockville		X	X	X	
Abe Bruckman	Rockville			X		
Matt Trollinger	Somerset			X	X	
Ron Hardy	Takoma Park	X	X	X	X	
Susan Theis	The Village of North Chevy Chase	X			X	
Dave Lutter	Washington Grove	X	X		X	
John Compton	Washington Grove				X	
David Cosson	Washington Grove			X		

C. Planning Meetings and Documentation

Documentation prepared during the development of this plan is contained within Appendix B. This includes worksheets utilized during the 2018 update and modified for the 2023 process, the FEMA Region III Capabilities Worksheet, and presentation materials. Also included are the body of questions disseminated as part of the public participation process.

In October 2022, Montgomery County participated in a Steering Committee kickoff meeting to facilitate inter-departmental awareness and coordination. Municipalities were notified of the plan update in December 2022, and a second kick off meeting for the HMPT was held in January 2023. In May 2023, the HMPT met to review the hazard identification and mapping efforts. Individual jurisdiction meetings were held with each participating municipality between May and September 2023. The Town of Brooksville, Town of Chevy Chase, and Village of Martin's Additions were unable to attend these one-on-one coordination meetings.

On August 28, 2023, the Planning Team was invited to attend an in-person actions development and funding opportunities meeting, where representatives of utility providers from across the county were also invited to participate, though none attended. The plan was made available for planning team and public review on October 18, 2023, and a final Plan overview meeting was held on November 1, 2023, before submission to the state for review.

In all, the plan update process was conducted over the course of thirteen months, from October 2022 to November 2023.

D. Public Participation

An important component of Montgomery County's community-based mitigation planning process involves public, stakeholder, and jurisdiction participation. Individual citizen involvement provides a greater understanding of local concerns and ensures a higher degree of mitigation success by developing community "buy-in" from those directly affected by the planning decisions of public officials.

Public input was sought through virtual participation in two public surveys and through attendance at a "town hall" style Teams meeting advertised on the Montgomery County OEMHS project website during the planning process. On January 27, 2023, an initial survey requesting public feedback on hazards in Montgomery County went live. Unfortunately, it became apparent that the initial survey was targeted by a spam attack. While this spam attack muddied the overall picture of responses, there were moderately successful attempts to parse out useful data from the irrelevant information generated by the spam attack.

After an extensive process to exclude the spam results, there were 325 responses to the initial survey. Among these responses, the hazard perceived as most concerning was severe thunderstorms (55%), followed by flooding (38%) and high wind (35%). The hazard perceived as least concerning was dam failure (4%). When asked about the overall preparedness of Montgomery County, respondents most often assessed the County to be "somewhat prepared.". More than twice as many respondents selected "not at all prepared" than "extremely prepared."

Of note, many write in responses to this survey included reference to the actions and priorities outlined in the County's 2020 Climate Action Plan, indicating both strong support and awareness of both the plan and recommendations. Equally identified was a lack of community connection. Many people stated that they did not know or rely on neighbors; that they felt disconnected and alone. While some of the smaller municipalities identify their interconnectivity as a strength, these comments point to a larger community need for stronger ties and community connection. In the face of disaster, community resilience depends on these nuanced and individualized points of connection and support.

On July 19, 2023, a second survey was opened to the public to identify the specific community concerns and aid in action development. Like the initial survey, the second survey was hosted by the website SurveyMonkey so that community members could easily participate from any location with internet access. The survey included 31 questions identifying sectors of the community where hazard impacts are of most concern and identifying interest in potential

mitigation strategies.

As of October 3, 2023, there were 89 responses to the second survey. The communities of Takoma Park and Garrett Park were particularly active, accounting for nearly 80% of all survey responses. It is encouraging to see these two communities show interest in the process, although ideally we would see additional participation from individuals living in unincorporated County.

When asked about the frequency with which they think about or worry about natural disasters, more than 75% of respondents answered either "very often" or "several times a year" which were the two most frequent options available as responses. These responses are encouraging as they indicate that most individuals in Montgomery County are, at a minimum, giving thought to the consequences of natural disasters multiple times per year. Unfortunately, it appears that there is still ample room for improvement regarding community awareness, as a majority of respondents selected "no" when asked if they knew where they would go in the event of an emergency evacuation.

Respondents were asked to select from the following 8 multiple choice options when answering questions about specific concerns regarding individual hazards:

- None of the Above
- Home/Property
- Utilities (loss of power, water, cable/internet, etc)
- Cultural or historic locations
- Personal Safety
- Roads/Transportation
- Natural resources
- Other (please specify)

Across more than a dozen specific hazards, concerns about damage to homes/property, utilities, and personal safety were most common. Interestingly, the only hazards for which personal safety was the number one concern were pandemics and uncontrolled releases of hazardous materials.

Demographics were also collected. These questions, when compared to overall county demographics, help us identify whether there are any populations underrepresented or absent in the survey results. Based on the answers provided by respondents, it does appear that there are a few slices of the population which were underrepresented. One of the clearest examples of this is the low number of responses from unincorporated parts of the County. A majority of the County's population resides outside of incorporated communities, but only 7% of the responses came from these individuals. Future outreach activities should strive to garner more proportional participation.

One other apparent gap between the survey respondents and the overall population in Montgomery County is the overall level of education attained. While Montgomery County has a higher than average educated population, a disproportionate almost 80% of survey respondents indicated they had attained a master's degree or higher. This could be attributed to several factors:

- **Education & Participation Bias**: People with higher educational backgrounds might be more inclined to participate in surveys due to a greater understanding of its importance,

or perhaps they are more regularly engaged in civic or community activities which make them more likely to encounter and respond to such surveys.

- **Access to Survey**: Depending on the medium or platform used to administer the survey, there might have been inadvertent barriers to participation. For example, if it was an online survey, those without regular internet access or digital literacy skills—a group which often correlates with lower educational attainment—might have been underrepresented.
- **Perceived Relevance**: People with advanced degrees might have felt that the survey topics or questions were particularly relevant or important to their personal or professional lives, thus motivating higher participation rates among this group.

An action has been added to the Mitigation Strategy that addresses the need for additional whole-community participation in future planning efforts.

III. Community Profile and Coordination

For over two centuries, Montgomery County has woven a rich tapestry of local communities, a testament to its historical roots as a collection of rural enclaves surrounding the nation's capital. These municipalities, towns, and neighborhoods have consistently joined forces to enhance their collective well-being, each playing a unique role in shaping Montgomery County into a vibrant and thriving place to call home, work, and savor leisure time.

The county's communities, while diverse and distinctive in their own right, often share common traits that contribute to the overall charm of Montgomery County. Bethesda, Silver Spring, Kensington, and Wheaton exemplify the advantages that urban settings offer, bustling with activity and opportunities. Conversely, Olney, Poolesville, and Laytonsville beckon with small-town allure set against a tranquil rural backdrop. Some communities, like Brookeville, Barnesville, and Washington Grove, boast significant properties designated within their historic districts, preserving a cherished heritage.

Notably, Rockville, as the county's seat, showcases an inviting residential historic district that seamlessly melds with its burgeoning business hub. Similarly, Gaithersburg boasts both a captivating residential historic district and enriching museums nestled within its commercial precincts.

This diverse tapestry of communities, each with its unique character and contributions, embodies the collective spirit of Montgomery County, making it an exceptional place that celebrates unity in diversity.

A. Community Profile, Land Use and Development Trends

Montgomery County's hazard mitigation efforts are intricately influenced by a range of factors and circumstances intrinsic to its unique profile. These critical elements have been diligently considered throughout the entire hazard identification, risk analysis, and vulnerability assessment process.

Given Montgomery County's pivotal role as a partner within the National Capital Region and its status as home to numerous federal agencies, the repercussions of a hazardous event extend far beyond its borders. These consequences have the potential to disrupt not only the county but also the entire region and the nation. Therefore, it is imperative that all aspects of the community profile are thoroughly examined and integrated into every phase of the mitigation process, aligning seamlessly with mitigation measures.

This section serves as a concise summary of Montgomery County's geographical and physical attributes, demographic composition, housing characteristics, interrelationships between municipalities, and its collaborative ties with neighboring jurisdictions.

1. Geography and Physical Environment

Montgomery County, Maryland, positioned immediately north-northwest of the District of Columbia, comprises many municipalities that serve as suburbs and “bedroom communities” for DC workers. The Potomac River marks its western border, while to the north and east, it shares borders with the Maryland Counties of Frederick, Howard, and Prince George’s.

Spanning 507 square miles, Montgomery County ranks as the 12th largest county by area among Maryland's 23 counties. Notably, it stands as the state's most populous county, boasting 1,062,061 residents according to the 2020 Census.

Since the 2020 COVID-19 pandemic-related shutdown, numerous jurisdictions, including Montgomery County, have observed a significant surge in workers adopting a work-from-home model. This shift, with ramifications spanning from the necessity for consistent power to changes in traffic patterns, modifications in disaster modeling, and shifts in commercial space utilization, has yet to be comprehensively assessed. The evolving dynamics of Montgomery County's workforce and residential patterns, in light of these changes, underscore the importance of understanding and adapting to these new paradigms.

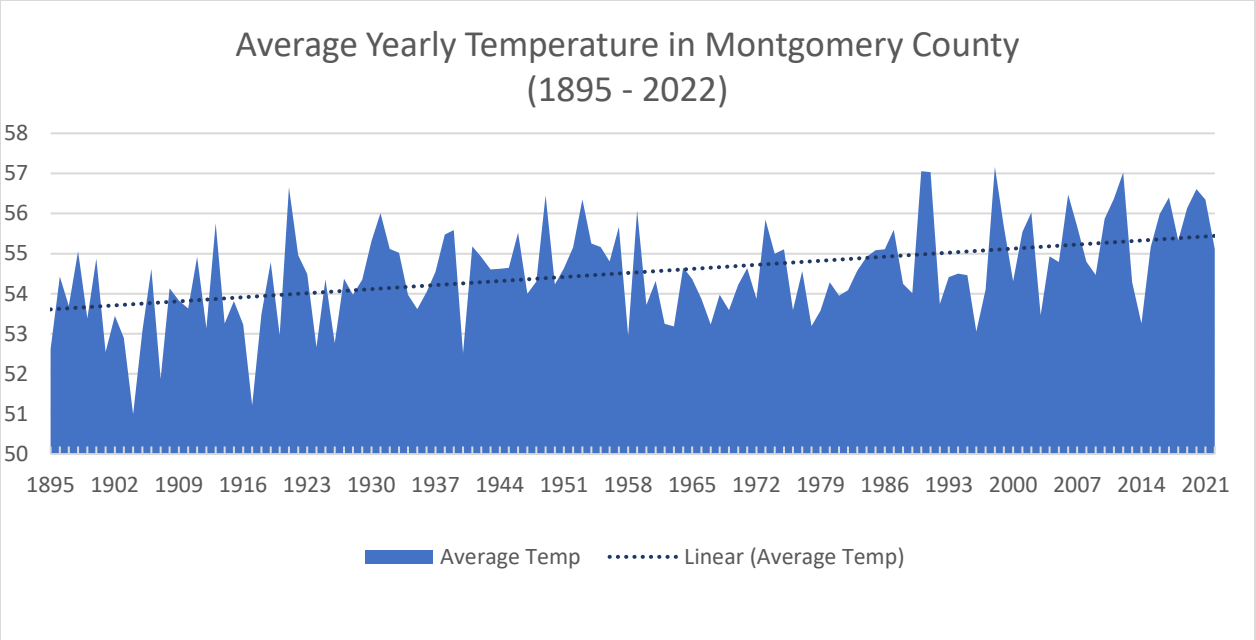
2. Climate

Montgomery County experiences four distinct seasons, and the county receives an average of 42 inches of precipitation per year.[1] Montgomery County has an annual average of 76 days with 0.1 inches or more of precipitation. While precipitation in the County is relatively consistent month-to-month, Spring is usually the wettest season for both the County and the State of Maryland. The average yearly snowfall total in Montgomery County is 18.71 inches, which is slightly less than the yearly average of 20.61 inches for the whole state. The hottest month in Montgomery County is July, with an average temperature of 75.8 Fahrenheit, and the coldest month is January, with an average temperature of 32.2 Fahrenheit.

The table below displays the average yearly temperatures throughout Montgomery County as documented over the last 127 years. Included is the trend line showing the impact of climate change on average temperatures. This impact is described further in later chapters.

Figure 1: Average Yearly Temperatures Graph

[1] Maryland Department of the Environment. "Normal Precipitation by Month." mde.maryland.gov. Accessed August 1, 2023. https://mde.maryland.gov/programs/water/waterconservation/Pages/default.aspx.



One of the more notable aspects of Montgomery County's climate is the average wind speed. Data from nearly 15,000 stations between 1980 and 2010 shows that wind in Montgomery County moves at an average of 34.50 mph, which is far higher than the average windspeeds across Maryland (19.74 mph) and the nation (16.93 mph). Interestingly, the windspeed in Montgomery County is near or less than the state and national averages from June – September, but dramatically higher from October – May. The highest average windspeed occurs during the month of January when speeds reach an average of 61.6 mph.[2] Impacts related to high wind is described further in later chapters.

3. Topography

Montgomery County is composed of small rolling hills. The elevation ranges from 52 feet above sea level near the Washington D.C. line to 850 feet above sea level in the north, near the town of Damascus.

[2] USA.com. "Montgomery County, MD Weather." Accessed August 3, 2023. http://www.usa.com/montgomery-county-md-weather.htm.

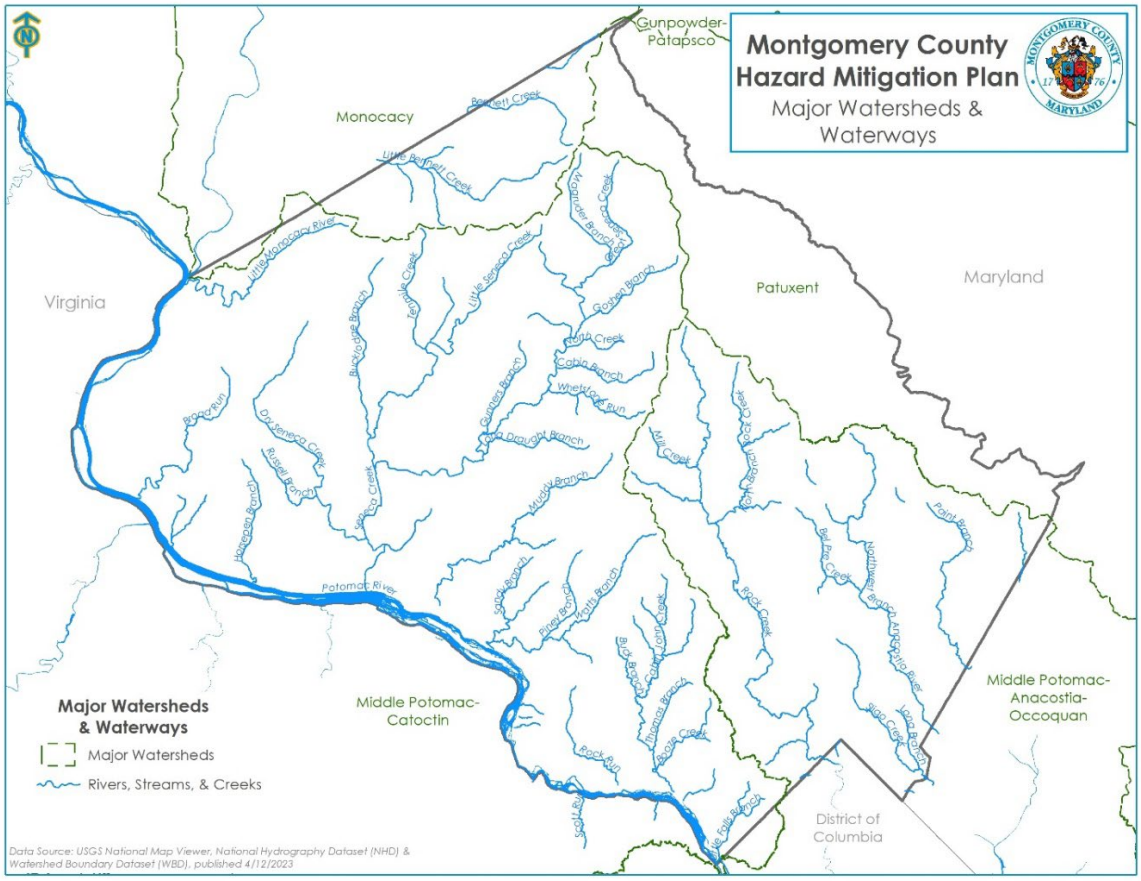
4. Open Space

Montgomery County has a land-use policy that promotes open spaces and agricultural preservation in coordination with controlled growth. This promotes planning for more efficient water, sewer, and public facilities. According to the Maryland-National Capital Park and Planning Commission, approximately one-third of Montgomery County's land is protected within the County's Agricultural Reserve, which supports more than 500 working farms. There are another 37,100 acres of parkland distributed across 421 parks including 5 regional parks, 22 urban parks, and 96 neighborhood parks.[3] These parks contain approximately 490 miles of streams, with more than 1,400 miles of stream overall. These streams all eventually reach Chesapeake Bay, and some of them contribute to the public water supply in Montgomery County and neighboring Prince George's County.

The figure below shows the number and boundaries of watersheds within the County.

Figure 2: Major Watersheds and Waterways Map

[3] Conservation Montgomery. "What's At Stake – Conservation Montgomery." conservationmontgomery.org, 2022. https://conservationmontgomery.org/whats-at-stake-2/.



5. Demographics

While Montgomery County is the most populous county in Maryland, with a population of 1,062,061 according to the 2020 census, the population is also growing. With a 9.3% increase since the 2010 census, this is more than the overall growth experienced by the state during the same period, 7.0%. The County's population is mostly concentrated within the I-495 beltway and along the major traffic corridors like I-270.

Figure 3: Population Change in Montgomery County, MD

YEAR	POPULATION	GAIN FROM PREV. CENSUS	% INCREASE OF COUNTY POP	COUNTY GROWTH AS % OF STATE'S OVERALL GROWTH
1990[4]	757,027	177,974	30.74%	32.52%

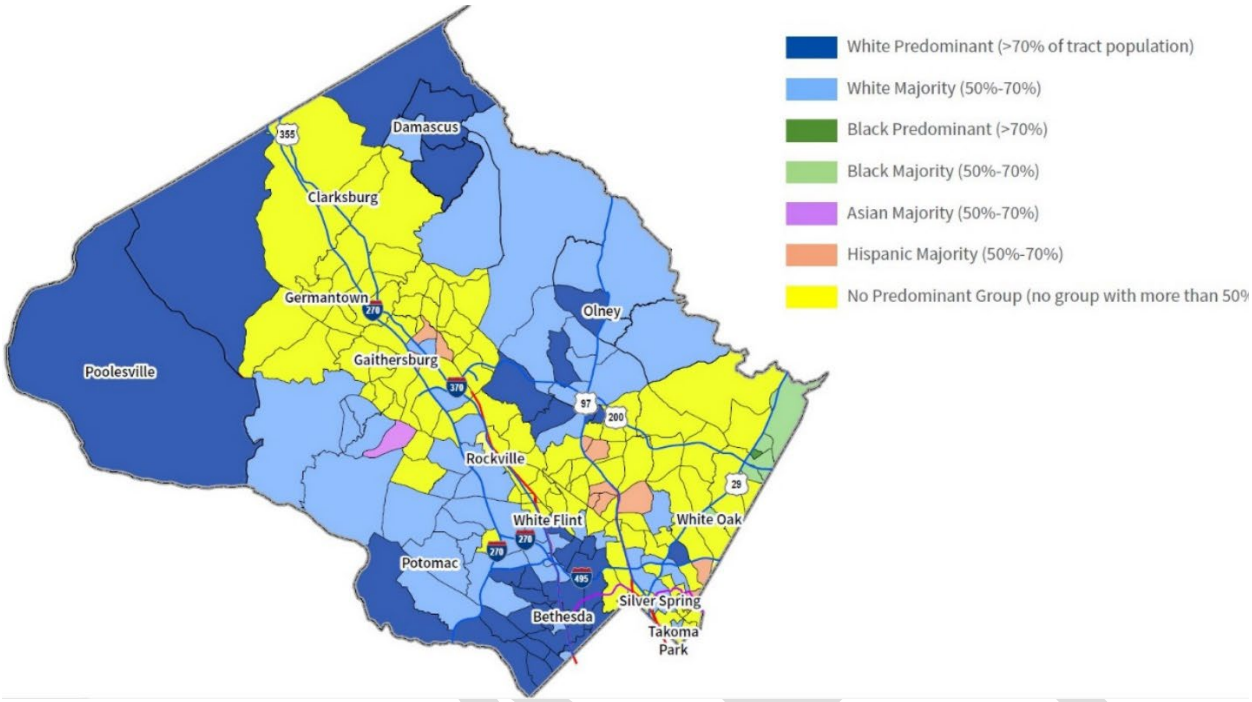
[4] U.S. Census Bureau. "Profile of General Demographic Characteristics." planning.maryland.gov. Accessed October 2, 2023. https://planning.maryland.gov/MSDC/Documents/census/historical_census/SF1_80-00/mdst80-00.pdf.

YEAR	POPULATION	GAIN FROM PREV. CENSUS	% INCREASE OF COUNTY POP	COUNTY GROWTH AS % OF STATE'S OVERALL GROWTH
2000[5]	873,341	116,314	15.37%	22.58%
2010[6]	971,777	98,436	11.27%	20.63%
2020[7]	1,062,061	90,284	9.29%	22.37%

Of the 1,062,061 people living in Montgomery County in 2020, nearly 60% of the county's population identify as non-white or a combination of two or more races. This level of diversity can also be found at the state level, as Maryland is one of the 6 minority-majority states in 2023.[8] The other 5 minority-majority states are Texas, Hawaii, California, Nevada, and New Mexico. This also makes Maryland the only minority-majority state east of the Mississippi River.

Figure 4:: **Predominant Race or Ethnic Group by Census Track, 2020**

[5] U.S. Census Bureau. "DP1: Profile of General Demographic Characteristics: 2000." data.census.gov. Accessed October 2, 2023. https://data.census.gov/table/DECENNIALDPSF42000.DP1?g=050XX00US24031&y=2000.
[6] U.S. Census Bureau. "P1: RACE - Census Bureau Table." data.census.gov. Accessed October 2, 2023. https://data.census.gov/table/DECENNIALPL2010.P1?g=010XX00US_040XX00US24_050XX00US24031&y=2010&d=DEC+Redistricting+Data+(PL+94-171).
[7] U.S. Census Bureau. "P1: RACE - Census Bureau Table." data.census.gov. Accessed October 2, 2023. https://data.census.gov/table/DECENNIALPL2020.P1?g=010XX00US_050XX00US24031.
[8] Santos, Richard Z. "Texas Is Now a Majority-Minority State. Why Haven't Our Politics Changed?" Texas Monthly, July 18, 2023. https://www.texasmonthly.com/news-politics/texas-majority-minority-state-political-implications/.



Montgomery County benefits from its proximity to the nation's capital, which draws highly skilled, educated, and motivated people from all corners of the world. The County has wisely leaned into this asset, and American Community Survey estimates that within the County, nearly 436,000 individuals 25 years and older have attained a Bachelor's degree. This is notable as it accounts for more than 50% of all individuals 25 years and older in the County. For comparison, 42% of individuals 25 and older in Maryland have attained a Bachelor's degree.[9]

Montgomery County is in the 99th percentile of all counties in the United States in terms of household income, household net worth and educational attainment, and the county's gross economic output exceeds $81 billion a year, which is more than 13 states.[10] These statistics, however, do not tell the whole story. Job growth over the past two decades has been slow and household incomes have been flat. The total number of jobs in the county grew by five percent from 2004 to 2019, while 20 similarly sized counties across the country grew by an average of

[9] U.S. Census Bureau American Community Survey 2017-2021. "S1501 Educational Attainment." data.census.gov, 2021. https://data.census.gov/table?q=education&tid=ACSST5Y2021.S1501.
[10] Maryland-National Capital Park and Planning Commission. "Thrive Montgomery 2050." montgomeryplanning.org, October 2022. https://montgomeryplanning.org/wp-content/uploads/2023/06/THRIVE-Approved-Adopted-Final.pdf.

21%.[11] In addition, household income growth in the county has lagged the national average and was the slowest in the region during this period. Montgomery County added jobs, albeit slowly, but growth came largely in lower-wage sectors of the economy.

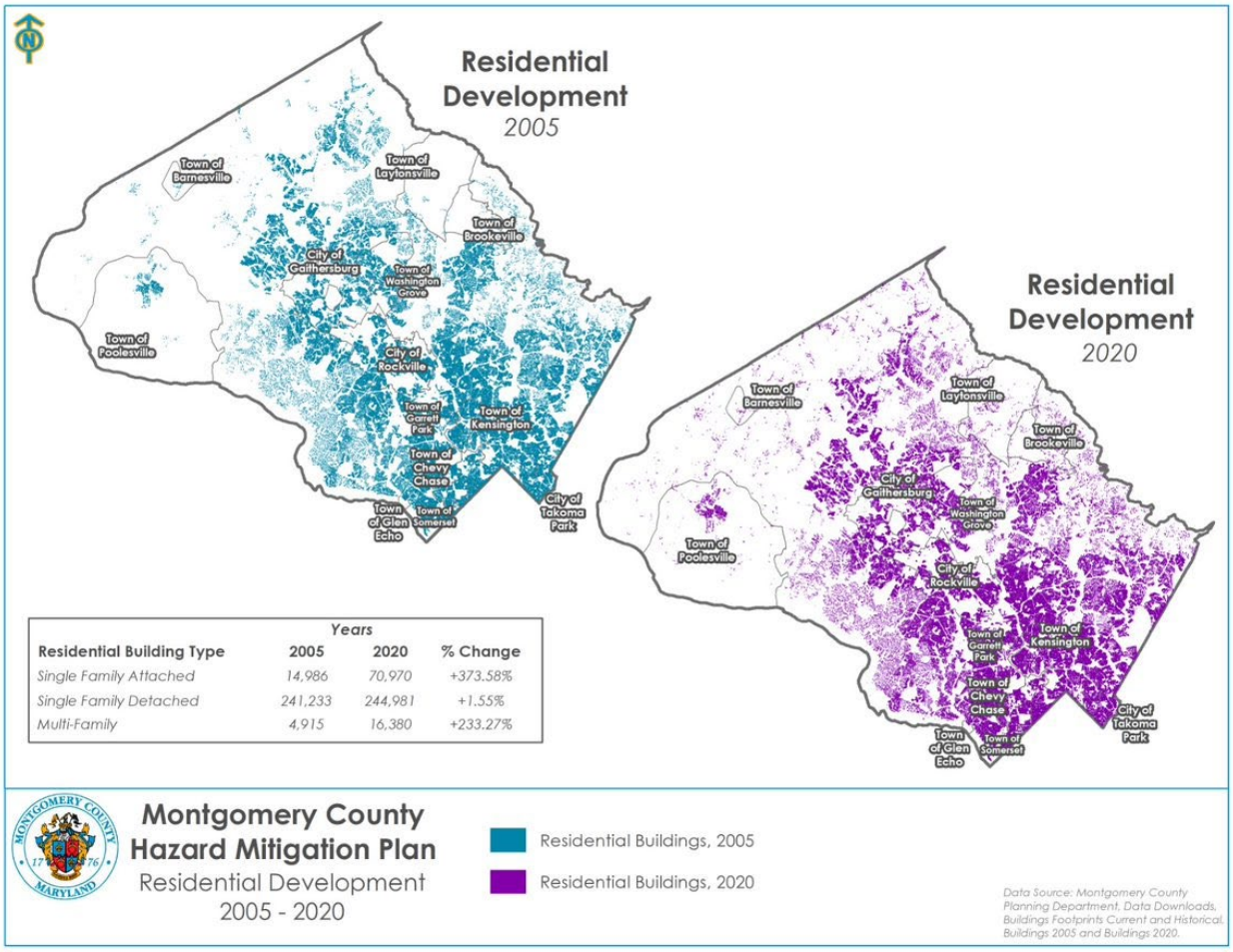
Looking ahead, the population in Montgomery County is expected to continue to grow through at least 2045. The Thrive Montgomery 2050 plan, which was approved and adopted in October 2022, projects that the County's population will grow to 1.2 million by 2045. This is an increase of about 208,000 people, or 21% gain over 30 years. In the near term, the County is forecasted to gain 72,000 people at a rate of 20 people per day to reach 1,087,000 people in 2025.[12]

6. Changes in Development

Overall development in Montgomery County has followed a similar trend to the County's population, experiencing significant growth over the previous decades. The Montgomery County Planning Department estimates that from 2005 to 2020, single family attached and multi-family buildings have increased by 374% and 233% respectively. However, maintaining this boom in development is becoming increasingly difficult as the County's undeveloped land dwindles. Approximately 85% of the land in Montgomery County is already developed or otherwise constrained, and the Thrive Montgomery 2050 plan acknowledges that accommodating the projected growth through 2045 will be a challenge even if new construction is compact.[13] Traffic concerns and impacts associated with population increases are a pressing concern for many jurisdictions in the southern part of the county.

Figure 5 Commercial Development in 2005 and 2020

[11] Maryland-National Capital Park and Planning Commission. "Thrive Montgomery 2050." montgomeryplanning.org, October 2022. https://montgomeryplanning.org/wp-content/uploads/2023/06/THRIVE-Approved-Adopted-Final.pdf.
[12] Maryland-National Capital Park and Planning Commission. "Thrive Montgomery 2050." montgomeryplanning.org, October 2022. https://montgomeryplanning.org/wp-content/uploads/2023/06/THRIVE-Approved-Adopted-Final.pdf.
[13] Maryland-National Capital Park and Planning Commission. "Thrive Montgomery 2050." montgomeryplanning.org, October 2022. https://montgomeryplanning.org/wp-content/uploads/2023/06/THRIVE-Approved-Adopted-Final.pdf.

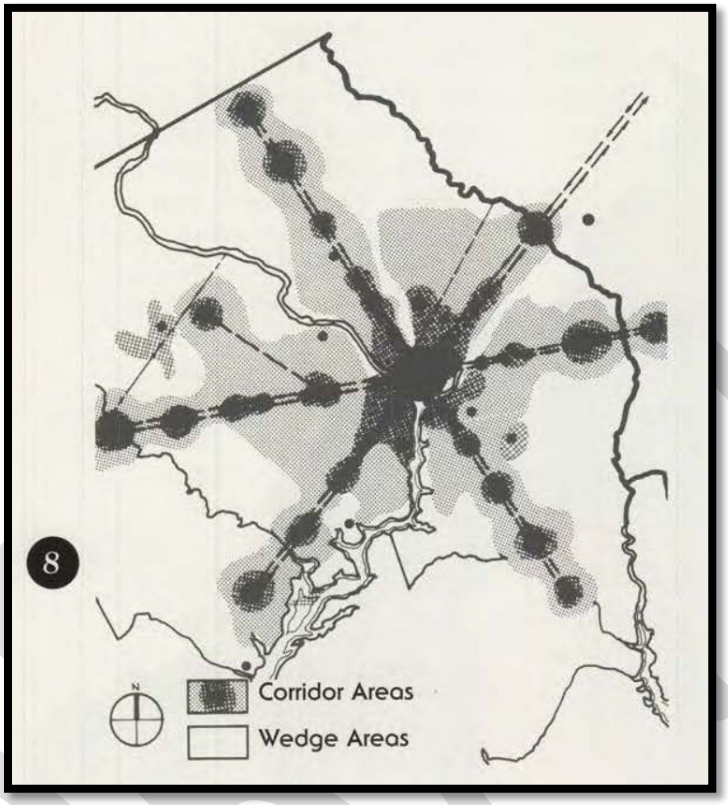


Development in Montgomery County has not always been consistent across its entire jurisdiction. The 1993 General Plan Refinement of the Goals & Objectives for Montgomery County refined the concept of "wedges and corridors", which was first put forward in the 1964 Montgomery County general plan. Conceived in 1961, the wedges and corridors concept was first proposed for the entire National Capital Region by the National Capital Planning Commission's Policies Plan for the Year 2000. In summary, the concept called for six corridors of urban development radiating out from Washington D.C. like spokes of a wheel, and these corridors would be separated by wedges of low-density development and parkland.[14] However, only Montgomery County and Prince George's County officially adopted the wedges and corridors concept. Since then, Montgomery County has found that the concept has partially

[14] Maryland-National Capital Park and Planning Commission. "Thrive Montgomery 2050." montgomeryplanning.org, October 2022. https://montgomeryplanning.org/wp-content/uploads/2023/06/THRIVE-Approved-Adopted-Final.pdf.

discouraged public and private investment in certain regions of the County. In recognition of this, the Thrive Montgomery 2050 plan advocates for new land use strategies which build upon the previous concepts of wedges and corridors but will hopefully be beneficial for *all* of Montgomery County.

Figure 6. 1993 Diagram of Wedges and Corridors Concept radiating out from Washington D.C.



One of the strategies advocated for in the Thrive Montgomery 2050 plan is applying the principles of urbanism to future development. Broadly, the concept of urbanism draws on the lessons of thousands of years of experimentation and evolution in the design and development of villages, towns, and cities to apply the ideas that have emerged as the foundation for adaptable and resilient communities everywhere. An urbanism-focused approach to the development of land and related infrastructure - such as roadways, transit systems, and parks - emphasizes the value of:

- compact form of development
- diverse uses and building types
- transportation networks that complement these two land use strategies, at all densities and scales

The Thrive Montgomery 2050 plan is also in favor of implementing the concept of "15-minute living" in the densest urban areas of the County. Generally speaking, 15-minute living is the idea that basic components of an urban setting - such as schools, grocery stores, emergency services, and parks - should be within a 15-minute walk (or bike ride in some instances) of residents. When applied correctly, the concept has the potential to offer numerous benefits, including reducing road traffic, increasing community resiliency, and enhancing neighborhood identities. To advance 15-minute living, Montgomery County will need to prioritize development which de-emphasizes a car-centric lifestyle. This type of development can take different forms, but some common traits include fewer parking surfaces, wider bike and foot paths, and easy access to public transit.

Transition to "15-minute living" will take time and focused development. Changes that do not meet existing logistic needs. In addition, it may not be feasible or reasonable for some sectors of the community - people with mobility issues may not be capable of walking to and from services, for instance.

7. Relationship Between County and Municipalities

The relationships between the County and each municipality are highly nuanced and adapted to fit individual needs. In many cases, the County has and continues to provide basic services like schools, fire, EMS, police, permit reviews, and stormwater management, while in other cases functional operations have been taken over by the municipalities.

The State of Maryland outlines 14 individual process steps for Municipalities to seek full legal and fiscal authority[15], starting with achieving a minimum population of 300 and concluding with the adoption of a community Comprehensive Land Use Plan. Of the 19 participating jurisdictions in the Hazard Mitigation Planning Team, seven have completed every step in this process - Barnesville, Brooksville, Gaithersburg, Laytonsville, Poolesville, Rockville, and Washington Grove. Of note, both Barnesville and Brooksville no longer meet the population minimum requirement but achieved full municipal status prior to the implementation of the state code. Takoma Park has the authority to complete Comprehensive Land Use Plan but has opted to cede authority to the Maryland-National Capital Park and Planning Commission due to feasibility and the interconnected nature of the entities. In September 2023, MNCPP concluded

[15] Code of Maryland | Subtitle 2 - INCORPORATION OF MUNICIPALITIES | Casetext

the update of portions of the 2000 Takoma Park Master Plan with the Takoma Park Minor Master Plan Amendment.

Although these municipal process steps exist, certain municipalities are barred from completing them due to restrictions around zoning authority. The MNCPP retains full zoning authority for all of the Chevy Chase towns, villages, and sections, as well as Martin's Additions, Glen Echo, Somerset, Garrett Park, and Kensington. In addition, the County maintains certain authorities over permitting, codes, and stormwater management. Stormwater management can be an area of contention. All of the communities experience stormwater flooding to some degree, as described in more detail in later chapters, and in many cases functional maintenance is a responsibility that has been passed back and forth between municipality and County as needs and capacity changed.

Montgomery County's new zoning code, effective on October 30, 2014, is effective throughout the entire County except for seven municipalities identified above that control their own zoning. The cities of Gaithersburg and Rockville have permitting authority for building permits where the County Code, Chapter 8, does not apply.

8. Land Use Planning Authority

Montgomery County also has several land use regulations that limit development in hazard areas. County land use and administrative regulations are described and present in Chapter 50 and COMCOR 50.00.01. Information related to development in hazard areas is described below.

- Purpose of Chapter 50 (Subdivision Regulations) of the Montgomery County Code: Chapter 50 provides for the legal division and subsequent transfer of land. It requires the coordination of new transportation facilities with other existing and planned facilities, a determination of adequate public facilities, and land for public use. The intent of this Chapter is to protect natural resources and sensitive environmental features; promote the health, safety, and welfare of the present and future inhabitants of the Maryland-Washington Regional District within Montgomery County under the General Plan; and any other purpose enumerated in the Land Use Article.

- COMCOR 50.00.01 Administrative Procedures for Subdivision Plan Review: On March 2, 2017, the Planning Board approved release of proposed administrative regulations for the recently enacted rewrite of Chapter 50. The proposed regulations replace the previously adopted 2007 "Manual of Development Review Procedures" that contains Planning Department practices related to the review and processing of development applications that are acted upon by the Planning Board or Planning Director under

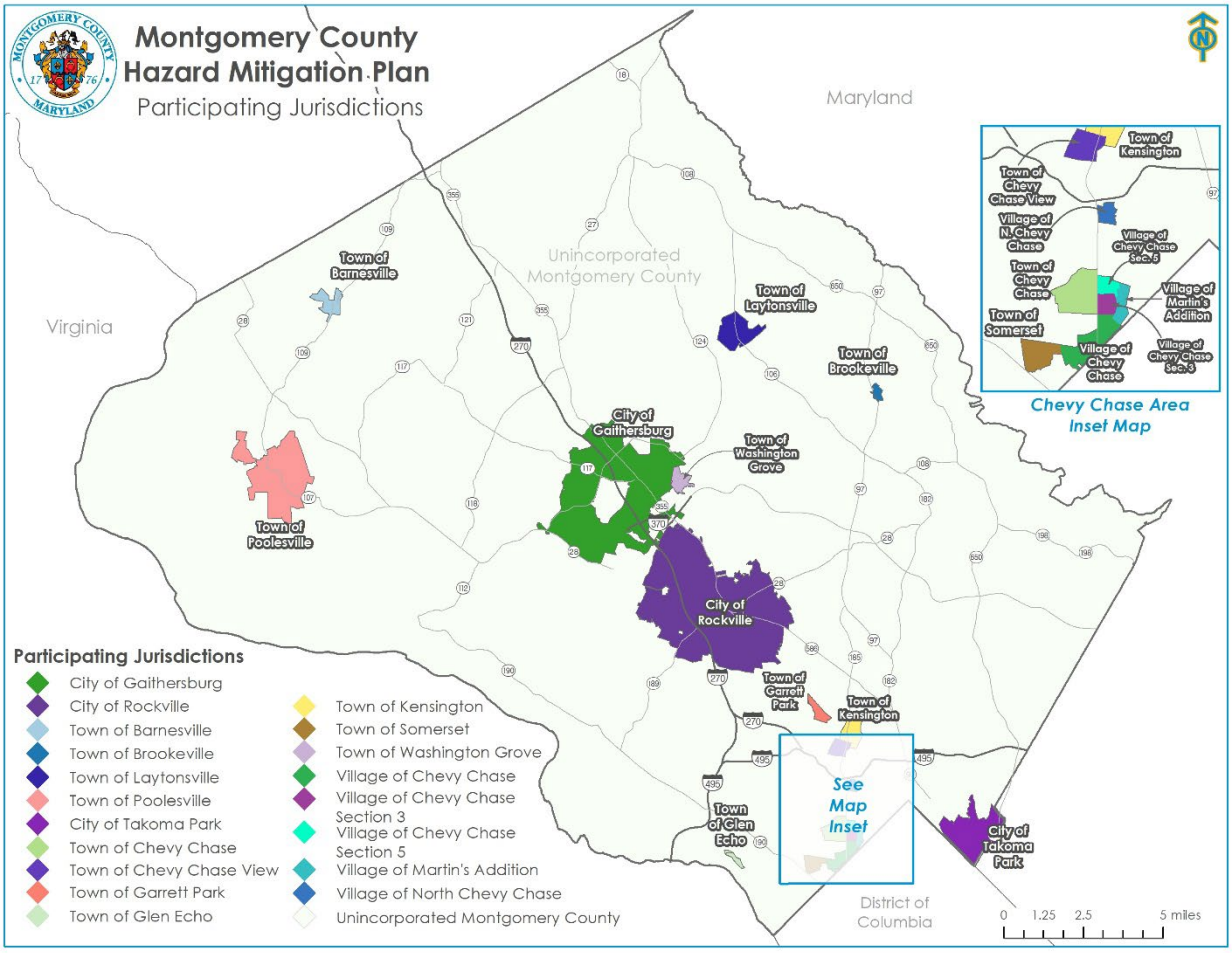
Chapter 50 and Chapter 59 of the County Code. When Chapter 59 was rewritten in 2014, these practices were changed and codified as part of new provisions for Administration and Procedures (Article 59-7). Similar updates were needed as part of the recent rewrite of Chapter 50. The purpose of the original manual and the proposed regulations continues are to:

- Clearly explain the Planning Department's overall regulatory review process for applicants, staff, residents and other interested parties.
- Clarify standards and procedures for submission of timely and relevant information by applicants.
- Provide for timely participation by public agencies in the review of applications.
- Provide for participation by interested parties so their views can be known by staff and the Planning Board before action is taken.

B. Incorporated Municipalities

There are 19 incorporated municipalities within Montgomery County, housing more than 175,000 individuals. Two chartered municipalities, Friendship Heights and Oakmont, cede additional authority and are fully reliant on County support, similar to Drummond, a village and special taxing district located within the County.

Figure 7. Local Jurisdiction Map



In most municipalities, additional housing developments are not expected due to lack of available parcels. Most identified 1 to 3 possible future developments, mainly subdivision of existing parcels or, at most, a single multi-family development. The modest growth in population reflects this lack of additional space while the county, conversely, is experiencing significant development and population increases.

It should be noted that population and demographic information contained bellow are pulled from reports that either align with the jurisdictional boundaries of each municipality, or with the closest US Census tract. Small discrepancies in total population number may be present as census tracks are not precisely aligned with legal jurisdictional boundaries.

Table 3: Population Changes in Montgomery County 2010 - 2020

Municipality	2010 Population	2020 Population	Percent Change
Barnesville	172	144	-19.44%
Brookeville	134	166	19.28%

Municipality	2010 Population	2020 Population	Percent Change
Chevy Chase	2,824	2,904	2.75%
Chevy Chase Section Five	658	672	2.08%
Chevy Chase Section Three	760	802	5.24%
Chevy Chase View	920	1,005	8.46%
Chevy Chase Village	1,953	2,049	4.69%
Gaithersburg	59,933	69,657	13.96%
Garrett Park	992	996	0.40%
Glen Echo	255	279	8.60%
Kensington	2,213	2,122	-4.29%
Laytonsville	353	572	38.29%
Martin's Additions	933	946	1.37%
North Chevy Chase	519	682	23.90%
Poolesville	4,883	5,742	14.96%
Rockville	61,209	67,117	8.80%
Somerset	1,216	1,187	-2.44%
Takoma Park	16,715	17,629	5.18%
Washington Grove	555	505	-9.90%

The demographic disparities between the county and its individual municipalities are notably pronounced. Data on age and race, sourced from the 2020 census, were utilized to identify underserved populations in each area. Some communities skew older, placing a higher emphasis on mobility, access to technology, and transportation. In contrast, other areas have seen a significant demographic shift. As older residents have sold their properties to younger families, there's been a marked increase in the percentage of individuals under the age of 18, as reflected in the 2020 census data.

Table 4: Age of Population in Montgomery County

Location	Total Population	Under 18 years	Percent under 18	60 years and over	Percent over 60
Montgomery County	**1,047,661**	**243,489**	**23.2%**	**226,452**	**21.6%**
Barnesville	163	64	39.3%	50	30.7%
Brookeville	151	23	15.2%	43	28.5%
Chevy Chase	2,979	772	25.9%	843	28.3%
Chevy Chase Section Five	757	220	29.1%	152	20.1%
Chevy Chase Section Three	900	309	34.3%	195	21.7%

Location	Total Population	Under 18 years	Percent under 18	60 years and over	Percent over 60
Chevy Chase View	1,151	381	33.1%	253	22.0%
Chevy Chase Village	1,871	442	23.6%	730	39.0%
Gaithersburg	67,878	14,947	22.0%	12,544	18.5%
Garrett Park	840	190	22.6%	323	38.5%
Glen Echo	323	83	25.7%	84	26.0%
Kensington	2,212	638	28.8%	484	21.9%
Laytonsville	480	129	26.9%	113	23.5%
Martin's Additions	1,089	262	24.1%	331	30.4%
North Chevy Chase	555	153	27.6%	160	28.8%
Poolesville	5,228	1,241	23.7%	952	18.2%
Rockville	68,155	14,454	21.2%	15,745	23.1%
Somerset town	952	246	25.8%	317	33.3%
Takoma Park	17,703	4,661	26.3%	3,531	19.9%
Washington Grove	710	127	17.9%	226	31.8%

Of the 19 municipalities, only Gaithersburg, Rockville, and Takoma Park have diversity rates comparable to the county. Each are larger, more urban communities, as when compared with the primarily residential neighborhood-scale municipalities.

Table 5: Race by Selected Location in Montgomery County

Location	Total	Asian	Black	Hispanic	White	Percent White
Montgomery County	**1,062,061**	**162,472**	**192,714**	**217,409**	**430,980**	**40.6%**
Barnesville	144	1	0	9	126	87.5%
Brookeville	166	4	1	6	150	90.4%
Chevy Chase	2,904	160	25	150	2,360	81.3%
Chevy Chase Section Five	672	18	7	22	586	87.2%
Chevy Chase Section Three	802	27	10	54	660	82.3%
Chevy Chase View	1,005	23	18	74	843	83.9%
Chevy Chase Village	2,049	45	4	99	1,790	87.4%
Gaithersburg	69,657	13,202	11,193	19,834	21,970	**31.5%**
Garrett Park	996	47	9	69	818	82.1%
Glen Echo	279	11	2	18	236	84.6%

Location	Total	Asian	Black	Hispanic	White	Percent White
Kensington	2,122	142	143	324	1,402	66.1%
Laytonsville	572	67	80	78	319	55.8%
Martin's Additions	946	32	17	32	834	88.2%
North Chevy Chase	682	52	38	53	497	72.9%
Poolesville	5,742	400	292	569	4,081	71.1%
Rockville	67,117	14,381	7,119	11,334	30,227	**45.0%**
Somerset	1,187	43	19	94	963	81.1%
Takoma Park	17,629	805	5,539	2,764	7,364	**41.8%**
Washington Grove	505	17	25	46	385	76.2%

1. Barnesville

a) Open Space

Barnesville sits at the top of a ridge with views of Sugarloaf Mountain to the north and the Catoctin Mountain and Blue Ridge ranges to the west. They are a relatively rural community with the smallest municipal population in the county.

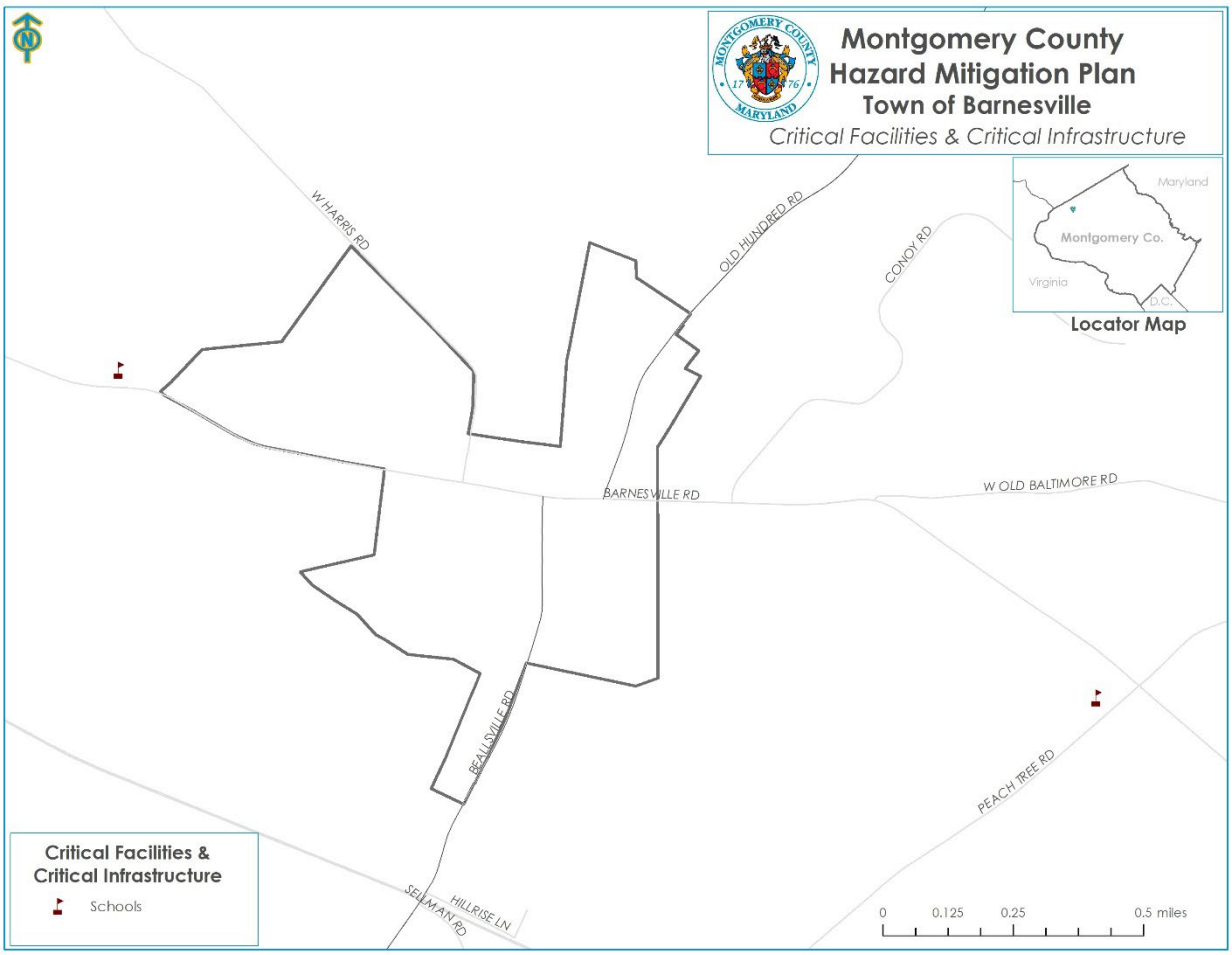
b) Demographics

As of 2020, the community of Barnesville had a population of 144, which makes it the smallest population of all incorporated communities in Montgomery County. The population of Barnesville also decreased by 19.4% between 2010 and 2020, going from 172 to 144.

c) Changes in Development

Barnesville has seen a proportionally huge decrease in population since the 2010 survey, through an equally large portion of that population is made currently made up by children under the age of 18. These changes can be attributed to homes sales to younger families, or to overall family growth.

Figure 8. Barnesville Critical Facilities Map



2. Brookeville

a) Open Space

The Town of Brookville is a relatively small residential area located to the north of the more densely populated D.C. suburbs. Every plot located within the municipality has been built to the maximum capacity within compliance with municipal zoning, with the exception of two 1-acre plots. Any maintained green space within the municipality is residential.

b) Demographics

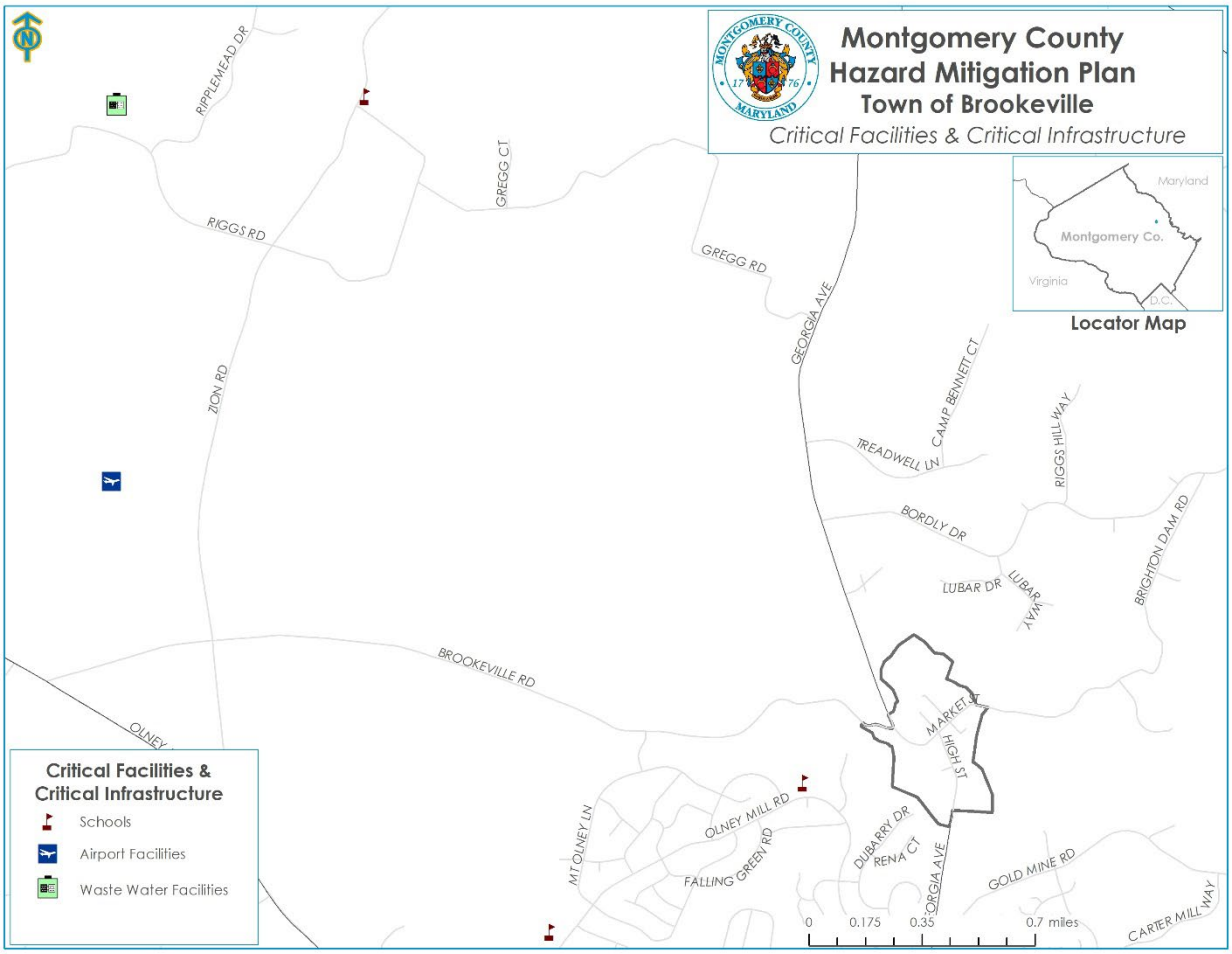
The population of Brookeville in 2020 was 166 individuals, making it the second smallest municipality by population in Montgomery County. Though small, the population has recently experienced significant growth. As of the 2020 Census, more than a quarter of the population in Brookeville was 60 years or older, but property sales an influx of younger families has

contributed to an increase of nearly 20% from 2010 to 2020. Approximately 10% of Brookville's population identified as Black, Asian, or Hispanic/Latino in 2020.

c) Changes in Development

Brookeville is the oldest municipality in Montgomery County, having incorporated in 1794. As of 2023, the community is nearly built out, with only two properties available to provide additional housing space within Brookeville's jurisdiction. These properties could be subdivided to support a maximum of four new homes. Sub-division of these plots are neither planned nor expected within the next 5-years. As an incorporated town for more than two centuries, Brookeville has multiple listings on the National Parks Service's National Register of Historic Places. Sites on this list have unique development-related restrictions intended to help protect their historic value.

Figure 9. Brookeville Critical Facilities Map and Surrounding Area



3. Town of Chevy Chase

a) Open Space

Primarily a residential suburb, Chevy Chase adjoins Friendship Heights, a popular shopping district and is boarded by Rock Creek to the East. The community includes two recreational green spaces, the Elm Street Urban Park and the Jane E. Lawton Community Recreation Center, and two Private country clubs.

b) Demographics

The population in the Town of Chevy Chase has seen relative maintenance and consistency, with a slight 2.75% rise between 2010 and 2020. The Town has relatively older population with 18.3% over the age of 60 compared to the county's 21.6%.

c) Changes in Development

The Town has seen relatively few changes in population movement, aside from a slight increase as community members age in place.

4. Chevy Chase View

a) Open Space

Every plot located within the municipality has been built to the maximum capacity within compliance with municipal zoning. Any maintained green space within the municipality is residential, aside from trees within the right-of way. Municipal tree maintenance occurs quarterly.

b) Demographics

From 2010 to 2020, Chevy Chase View experienced a population surge from 920 to 1,005 residents, marking an 8.5% increase. This growth rate surpassed that of other Chevy Chase communities over the decade. Furthermore, Chevy Chase View boasts a notably youthful demographic, with one in every three residents being below the age of 18. In the context of Montgomery County's 19 incorporated municipalities, only Barnesville and Chevy Chase Village Section 3 have a greater proportion of their populations under 18. A breakdown of the community's racial and ethnic composition in 2020 reveals 23 Asian, 18 Black, 74 Hispanic, and 843 White residents.

c) Changes in Development

As of summer 2023, Chevy Chase View is home to 309 single-family residences and three churches. Notably, the community is witnessing a considerable shift in its demography: nearly one-third (91) of these homes have changed hands over the past five years. Community leaders attribute this turnover to an influx of younger families replacing the outgoing older residents,

leading to a more youthful population. Additionally, Chevy Chase View is actively investigating opportunities in gray/green infrastructure, with findings from this research expected by December 2023.

5. Chevy Chase Village

a) Open Space

Every plot located within the municipality has been built to the maximum capacity within compliance with municipal zoning. Any maintained green space within the municipality is residential. However, Chevy Chase Village has received a Tree City USA designation for growth in the public right-of way, and tree maintenance in the community occurs every 4-8 weeks.

b) Demographics

Chevy Chase Village is a community made entirely of single-family residential homes. In the last 5 years they have seen many older residents moving out, though the population continues to increase. Nearly 40% of the residents within the Village are 60 or older. Continued changes in the makeup of the community are likely over the next 5 years.

c) Changes in Development

Chevy Chase Village is completely built out with 720 homes and no room for new development. There are no commercial buildings within in the jurisdictional boundary. The only non-residential structure is a church. Chevy Chase Village is considering projects to add bike paths in the area, similar those targeted by the Town of Kensington, although additional funding is needed to support the project and additional stakeholders would be needed to facilitate transit between multiple jurisdictions and across state and county maintained roads.

6. Chevy Chase Village Section 3

a) Open Space

Every plot located within the municipality has been built to the maximum capacity within compliance with municipal zoning. Any maintained green space within the municipality is residential, aside from trees within the right-of way. Municipal tree maintenance is robust. Community leaders inspect frequently and reports are issued for both municipal and private concerns.

b) Demographics

Between 2010 and 2020 the population in Chevy Chase Village Section 3 grew from 760 to 802, which is an increase of 5.2%. While its total population is less than 1000, Chevy Chase Village Section 3 has a significant portion of its population aged 18 or younger, accounting for more than a third of its entire population in 2020. Of the 19 incorporated municipalities in

Montgomery County, only the community of Barnesville has a larger portion of its population aged 18 or younger.

c) Changes in Development

Chevy Chase Village Section 3 was incorporated in 1989, and nearly all of the structures are residential. Of the 289 structures only one is non-residential - a church. Most community development relates to social and societal support programs, implemented to include both whole-community activities and address nuanced needs for minor or underserved subsets of the community. Interconnectivity and whole-community support is a leading strength for this municipality.

7. Chevy Chase Village Section 5

a) Open Space

The community is comprised of 227 homes, with each plot built to near the maximum capacity within compliance with municipal zoning. Any maintained green space within the municipality is residential, aside from trees within the right-of way. Municipal tree maintenance is conducted by a contractor.

b) Demographics

Minimal increases in community population demonstrated by the 2020 census numbers are consistent with expectations. Community leaders report an increase in younger families and families with young children, consistent with demographics changes noted in the tables above.

c) Changes in Development

Section 5, while not undergoing many development changes within the municipal boundary, continues to see deep impacts due to development in surrounding unincorporated County. With the significant increases in town homes, multi-family complexes, and associated population increases, traffic considerations are of increasing priority. The community is not slated to be served by public transit for several more years and face a troubling transition while the County moves toward the "15-minute living" concept. A transition that may not be desirable or feasible for older community members.

8. Gaithersburg

a) Open Space

Gaithersburg maintains several community parks including, most recently, Pleasant View Park which opened in the Spring of 2023. The 9.54-acre park with parking, community gardens, a bicycle skills course (pump track), open space, pavilions, a playground, fitness pods, and a welcome plaza.

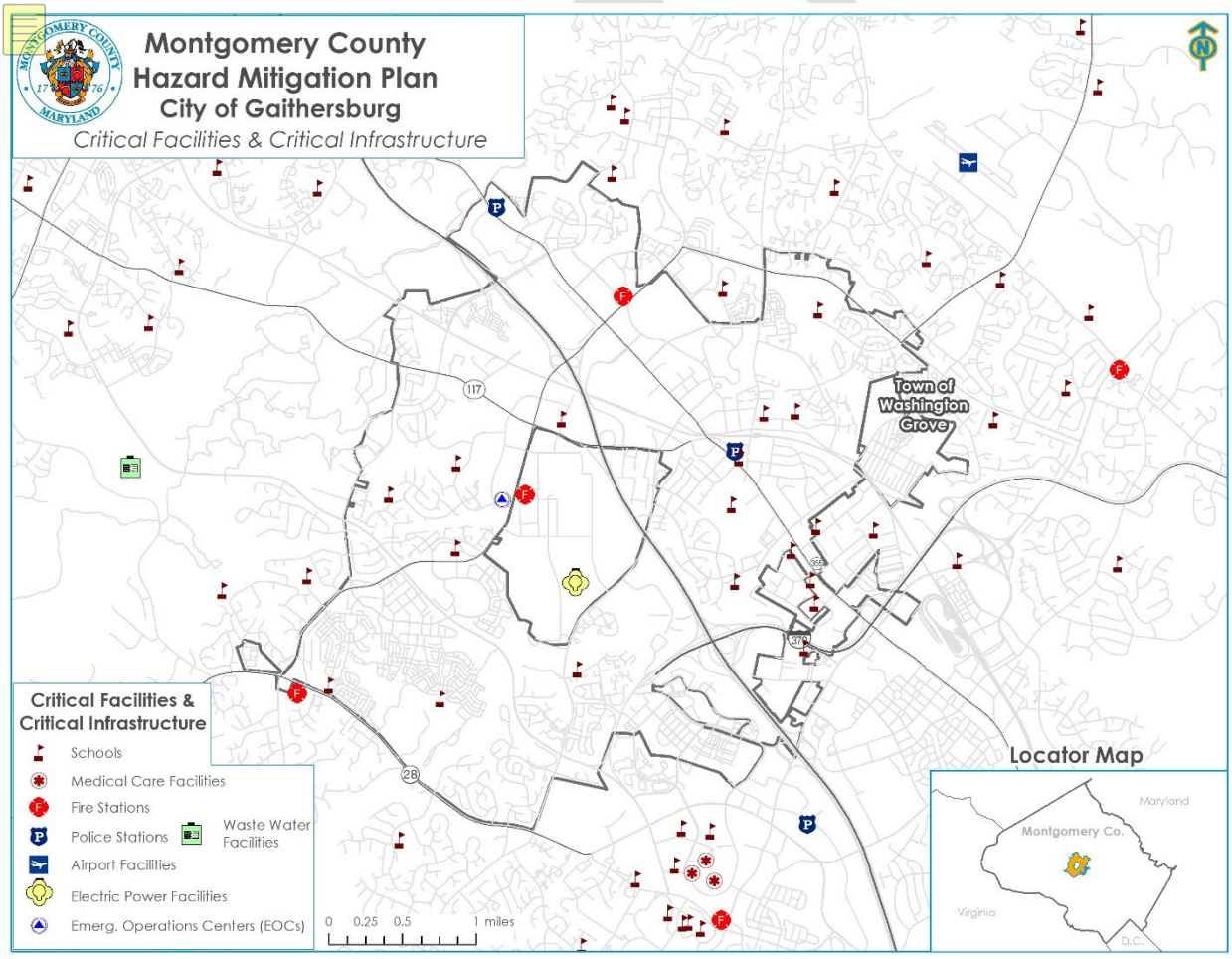
b) Demographics

Gaithersburg is the most diverse community within Montgomery County, with only 31% of the population identifying as white. With population increases falling just slightly behind the county, the majority of the population sits within the age range of working adults.

c) Changes in Development

As a bustling and densely populated city, development within the jurisdiction is continuous and evolving. An overview of planned projects with interactive map, can be located here: https://www.gaithersburgmd.gov/government/projects-in-the-city

Figure 10. Gaithersburg Critical Facilities Map with Washington Grove



9. Garrett Park

a) Open Space

Every plot located within the municipality has been built to the maximum capacity within compliance with municipal zoning. Any maintained green space within the municipality is residential. However, Garrett Park is a living arboretum with trees outnumbering residents 2-1. Many have not been touched in more than 150 years. Within the last few years Town leadership has been working to monitor and maintain the tree health alongside a contracted arborist in.

b) Demographics

As of the 2020 census, the population in Garrett Park was 996, only adding four individuals since 2010. this represents the smallest change in population – positive or negative – of all incorporated municipalities in Montgomery County. Approximately 39% of the population in Garrett Park is age 60 or older, and 23% is 18 or younger.

c) Changes in Development

The Town of Garrett Park was incorporated in 1898 and lies in the southern part of Montgomery County. Community leaders have stated that the community is built out, and development is limited to improvements to existing structures. Interestingly, in 1977 the town was declared an arboretum. Trees outnumber residents 2-1, and most trees have not been touched in more than 150 years. The community is designed to reduce the volume of outside traffic passing through it, but the main CSX railway does run along the northeastern edge of Garrett Park. The railway has created some water drainage issues, and the community is interested in exploring potential remedies to the situation.

10. Glen Echo

a) Open Space

The community is small and relatively built out. Open space is a mix of federal, private, and some publicly maintained, undeveloped area.

b) Demographics

Since the last hazard mitigation plan there has been a relatively small, but surprising increase in population. This increase has not led to a significant shift towards younger residents – as may be expected if families were adding children.

c) Changes in Development

Increases in population as the community is mostly built oy and only includes about 100 houses, and less than 10 commercial businesses. Structures within the community, however,

include an aquarium and shared boundaries with federal entities and the Washington Metropolitan Area Transit Authority. Land on the east side of town is undeveloped and zoned residential however, there is no appetite for development of this area.

11. Kensington

a) Open Space

The Town maintains seven Town parks, and is home to three County parks, designed for the enjoyment of all. All parks within the Town of Kensington are closed from dusk until dawn, daily.

b) Demographics

According to the latest census, the population in Kensington in 2020 was 2,122 individuals. This would represent a 4.3% decrease in population since 2010, but this data may be flawed. According to Kensington officials, the 2010 census mistakenly double counted an apartment complex in the community, and this pushed the 2010 population count higher than it should have been. The mistake was eventually detected, but the decision was made not to adjust the 2010 census data retroactively. Like other communities in Montgomery County, the population in Kensington is trending younger – in 2020, nearly 29% of individuals were 18 or younger, and this aligns with anecdotal evidence from community officials that the town is seeing an increase in kids.

c) Changes in Development

Two of the larger goals expressed by Kensington officials both relate to natural hazards experienced by the community. First, the town is looking to restore some of tree canopy in the area, as a derecho uprooted a significant number of the trees within the community. Additionally, the community is interested in utilizing land currently supporting the Kensington Cabin local park for flood relief improvements. The extent of these improvements is still an open question, but the land has been identified as a key location where improvements can be made to help address flooding that routinely occurs when the community receives heavy rain.

12. Laytonsville

a) Open Space

Laytonville is a semi-rural community surrounded by plenty of open space. The Greater Lyttonsville Sector Plan Design Guidelines provide a framework for the design of new and improved streetscapes, buildings, parks and open spaces in the plan area. They build on the recommendations in the Greater Lyttonsville Sector Plan, which was approved and adopted in 2017.

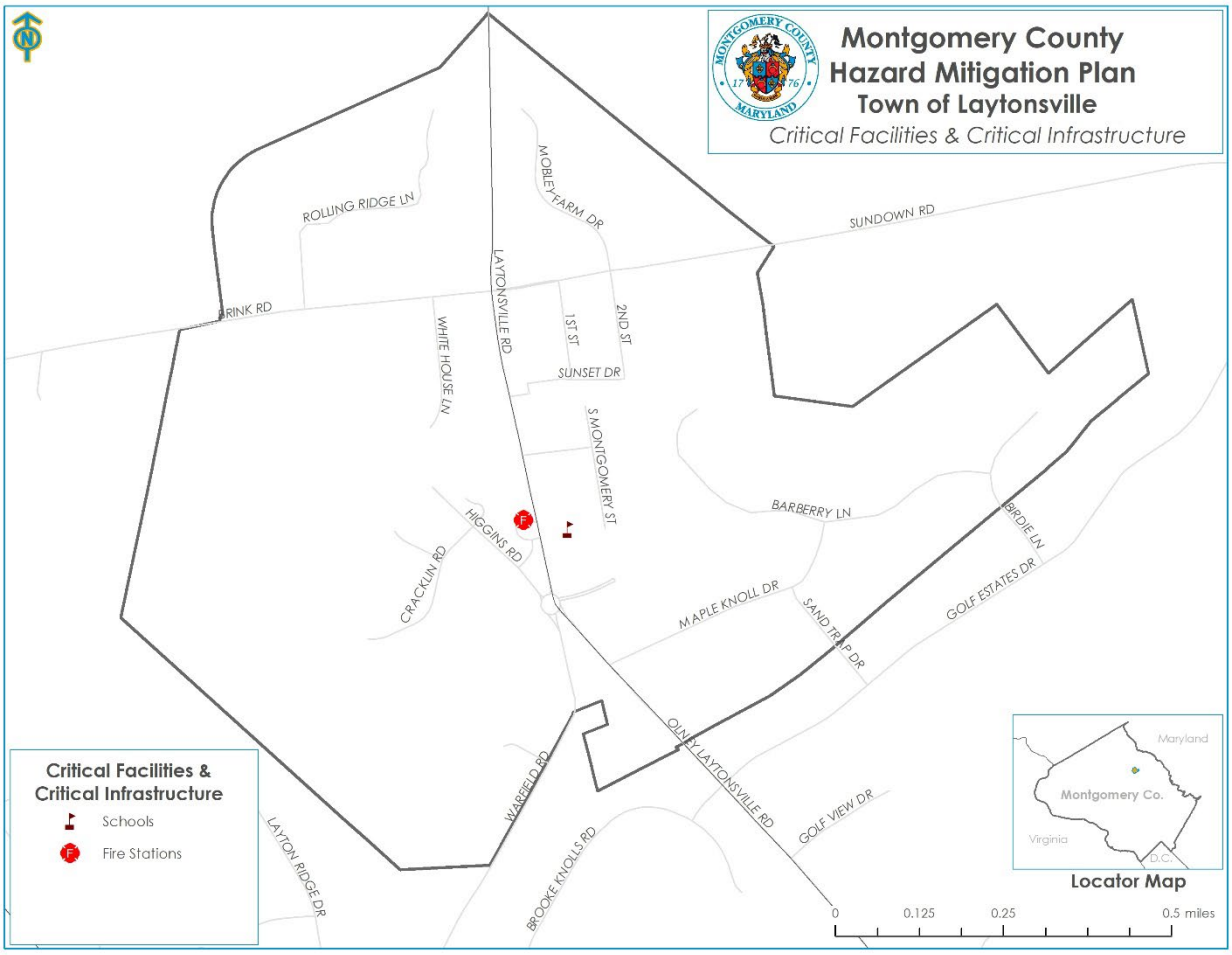
b) Demographics

The population in Laytonsville grew from 353 to 572 between the 2010 and 2020 censuses, which is an increase of 38%. In terms of percent change, Laytonsville's population grew more than any other incorporated municipality in Montgomery County over the same period. In 2020, 27% of the population in Laytonsville was under the age of 18 and 24% was over the age of 60. Community leaders expect the portion of younger residents to grow as new families continue to move to Laytonsville. Of the 572 people living in the community in 2020, 67 identified as Asian, 80 as Black, 78 as Hispanic, and 319 as White.

c) Changes in Development

The population growth in Laytonsville has necessitated new development in the community. Whereas the recent trend in Montgomery County has been for new residential homes to be attached structures, development in Laytonsville has primarily emphasized single-family *detached* homes. Laytonsville currently has two separate development projects, the first of which should add 50 homes, and the second should add another 36 homes. Community leaders believe that after the completion of these two development projects, Laytonsville will have enough room left for roughly another 50 single family detached homes. While the recent development has primarily involved residential structures, there is a proposal to construct a commercial warehouse in the town, but this has not been finalized.

Figure 11. Laytonville Critical Facilities Map



13. Martin's Additions

a) Open Space

In 2017, the Village began a Native Canopy Tree Planting Program on a trial basis. Under this program, the Village of Martin's Additions plants native canopy trees on private property. When a resident requests a tree, the arborist evaluates whether there is an appropriate location on the property for a canopy tree. The Village purchases the trees, pay for installation and provides a water bag to assist residents with the care needed in the critical first year after planting. Residents are responsible for the long-term care of the tree, including watering.

b) Demographics

Martins Additions maintains a fairly stable population, with a slight increase in people over the age of 60, as long-time residents age in place.

c) Changes in Development

No developments were identified as part of this planning process.

14. North Chevy Chase

a) Open Space

Any maintained green space within the municipality is residential, aside from trees within the right-of way, and a single church property. Municipal tree maintenance is conducted by a contractor.

b) Demographics

Through the vocal efforts of residents, the 8800 block of Clifford has been incorporated into the Village of North Chevy Chase. Previously part of unincorporated County, residents sought incorporation for service (snow and trash removal) and logistics purposes. Due to this incorporation, population numbers appear to have increased. However, no actual changes have occurred and the population remains relatively stable

c) Changes in Development

The village is mostly built out with no planned development. However, they have also recently implemented improved drainage grates. Anecdotal evidence indicates that the project is so far successful.

15. Poolesville

a) Open Space

Poolesville prides itself on its spacious small-town feel and maintains open space and large plots accordingly. The smallest are 1/3 of an acre, larger than the county's largest plots, and up to 25 acres. The northwest boarder of the town is abutted by an agricultural reserve established in the 1960s, that restricts the use and sale of heavy machinery, development, and types of utilization. While municipal authority ends at the boundary, the agricultural reserved has the potential for development as an agro-tourism destination.

b) Demographics

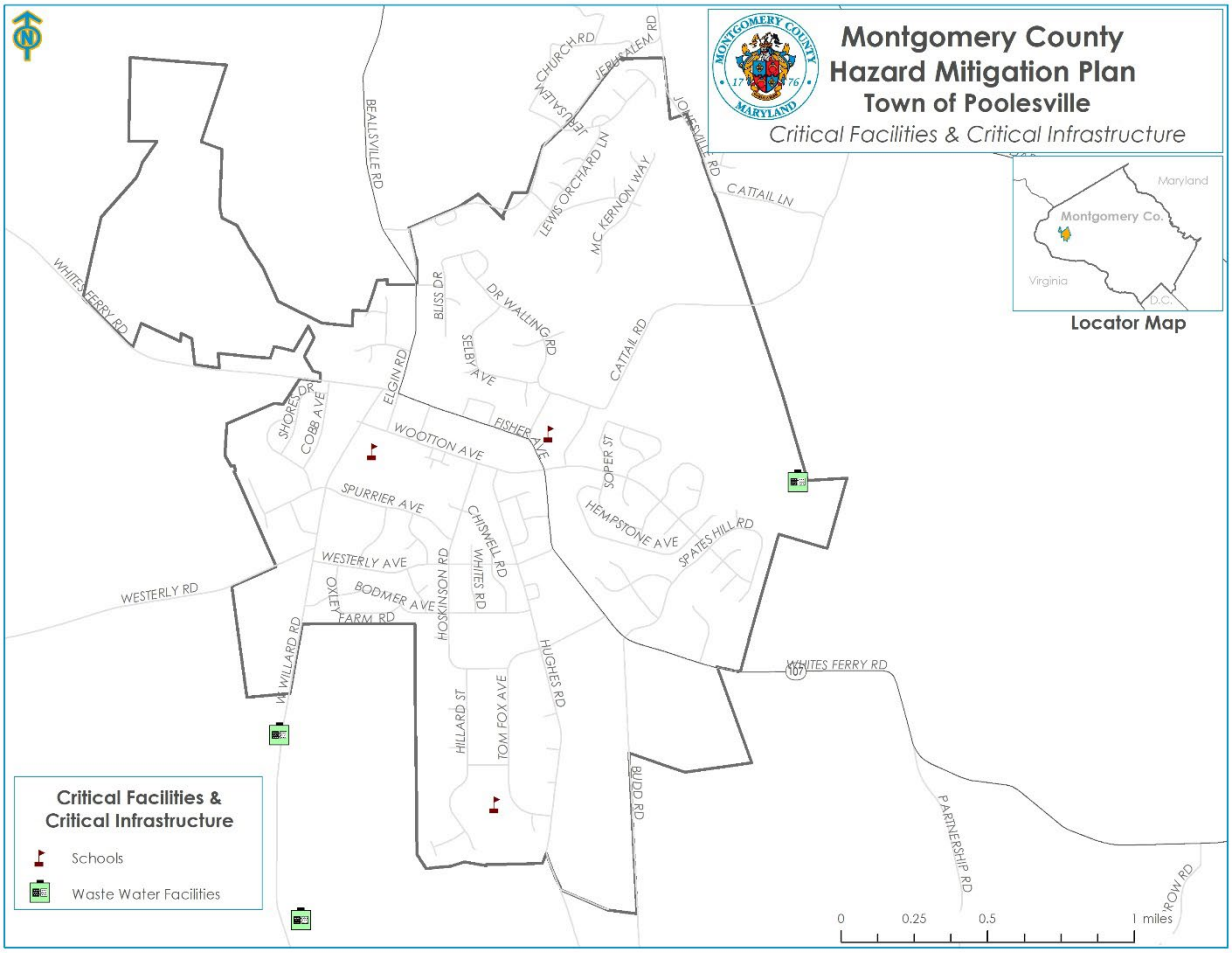
Between 2010 to 2020, the population of Poolesville grew from 4,883 to 5,742. Of the town's 2020 population, approximately 20% were under the age of 18, and another 20% were over the age of 60, leaving 60% of the population in the work force. The community boasts an leading High School for the state and has seen significant influx of families wishing to utilize the high quality education.

c) Changes in Development

Since 2020, 50-75 new homes have been built and more housing developments are planned. The community estimates that 120 new single-family homes and 39 town homes will be added

in the next 5-year period. To better support the ongoing development, Poolesville is exploring actions which will further strengthen the community's position within Montgomery County. These possible actions include implementation of community solar projects and novel uses for areas zoned for agricultural agro-tourism. Poolesville also passed a resolution in 2023 stating the community's desire to be clean-energy independent by 2023. Poolesville includes an historic district with 33 contributing properties, John Poole's log store built in 1793, and town hall that functions as a temporary shelter in emergencies.

Figure 12. Poolesville Critical Facilities Map



16. Rockville

a) Open Space

The City of Rockville Parks, Recreation and Open Space Plan, adopted March 15, 2010 serves as an overview to the city's parks and open space.

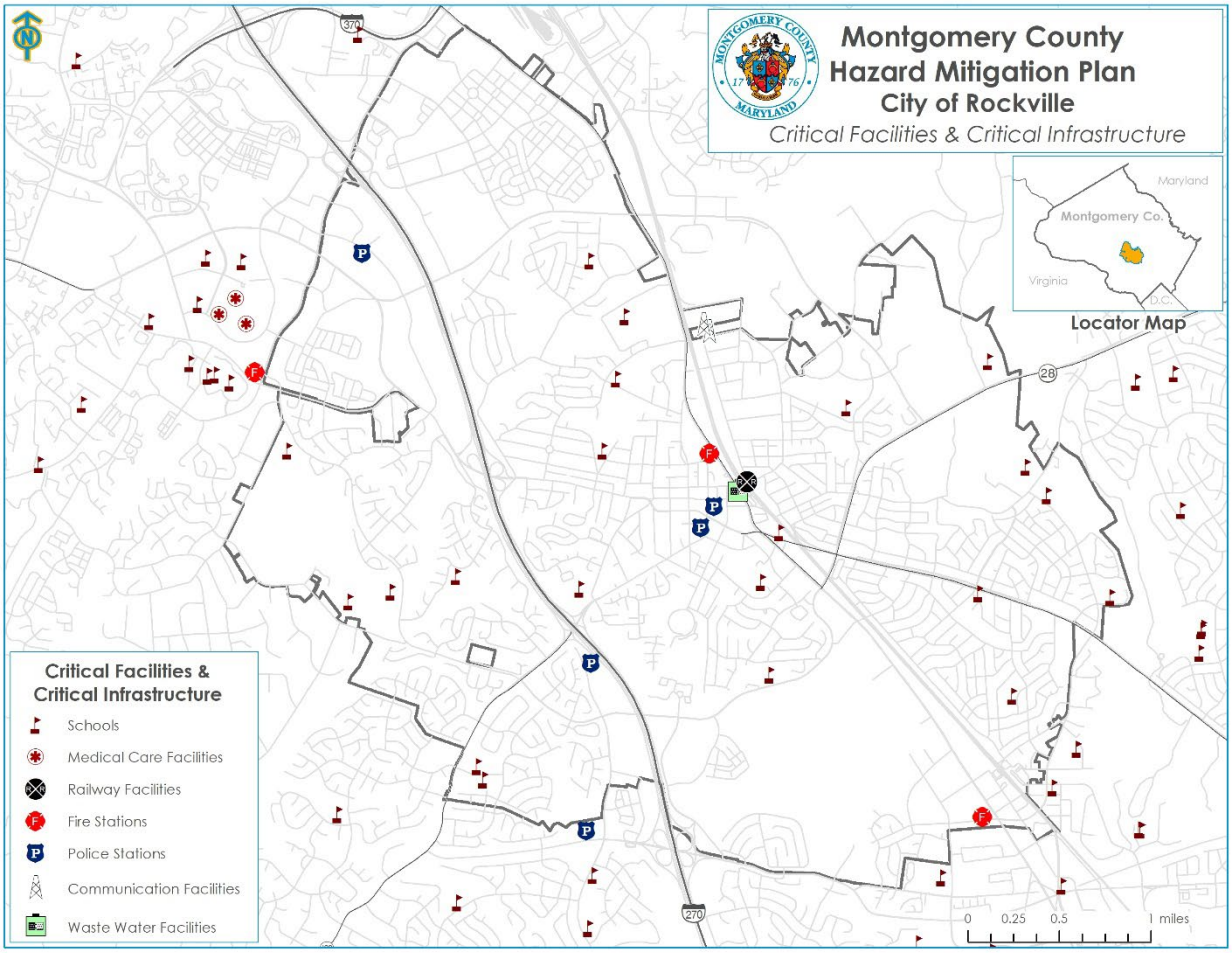
b) Demographics

As of 2020, the population of Rockville is 67,117, which makes it the 2nd most populous incorporated municipality in Montgomery County. Rockville's population grew by approximately 9% between 2010 and 2020. Rockville's population is also one of the more diverse in the County, with only 45% identifying as white with no Hispanic or Latino heritage in 2020. Additionally, 21% of Rockville's 2020 population was 18 or younger, and another 23% were 60 or older.

c) Changes in Development

Rockville, as the seat of the County, has an attractive residential historic district that merges well into the growing business district in the community. Recently, development in the community has shifted more towards redevelopment along Rockville Pike rather than new growth.

Figure 13. Rockville Critical Facilities Map



17. Somerset

a) Open Space

The community within Somerset is nearly built out, with the majority of structures residential. There are a few community spaces, including town hall and the Town pool which resides along the riverfront. Most open space within the community is maintained by MNCPPC.

b) Demographics

Like Barnesville and North Chevy Chase, Somerset is experiencing higher than average populations over the age of 60 as well as higher than average children under the age of 18. The community shows a slight decrease in residents since the 2010 census, through within expectations for the community.

c) Changes in Development

Though significant development is not planned, The community recently engaged contract services to profile flood hazard within the jurisdiction. The result include more than 30 micro-watersheds, and assisted in the identification of neighborhood-scale, watershed restoration projects.

18. Takoma Park

a) Open Space

As a densely populated and robust urban area, maintained open space within the community is limited. In 2020 the community released a Public Space Management Plan. The results of which can be found here: PublicSpaceManagementPlanSurveyResults.pdf (takomaparkmd.gov)

b) Demographics

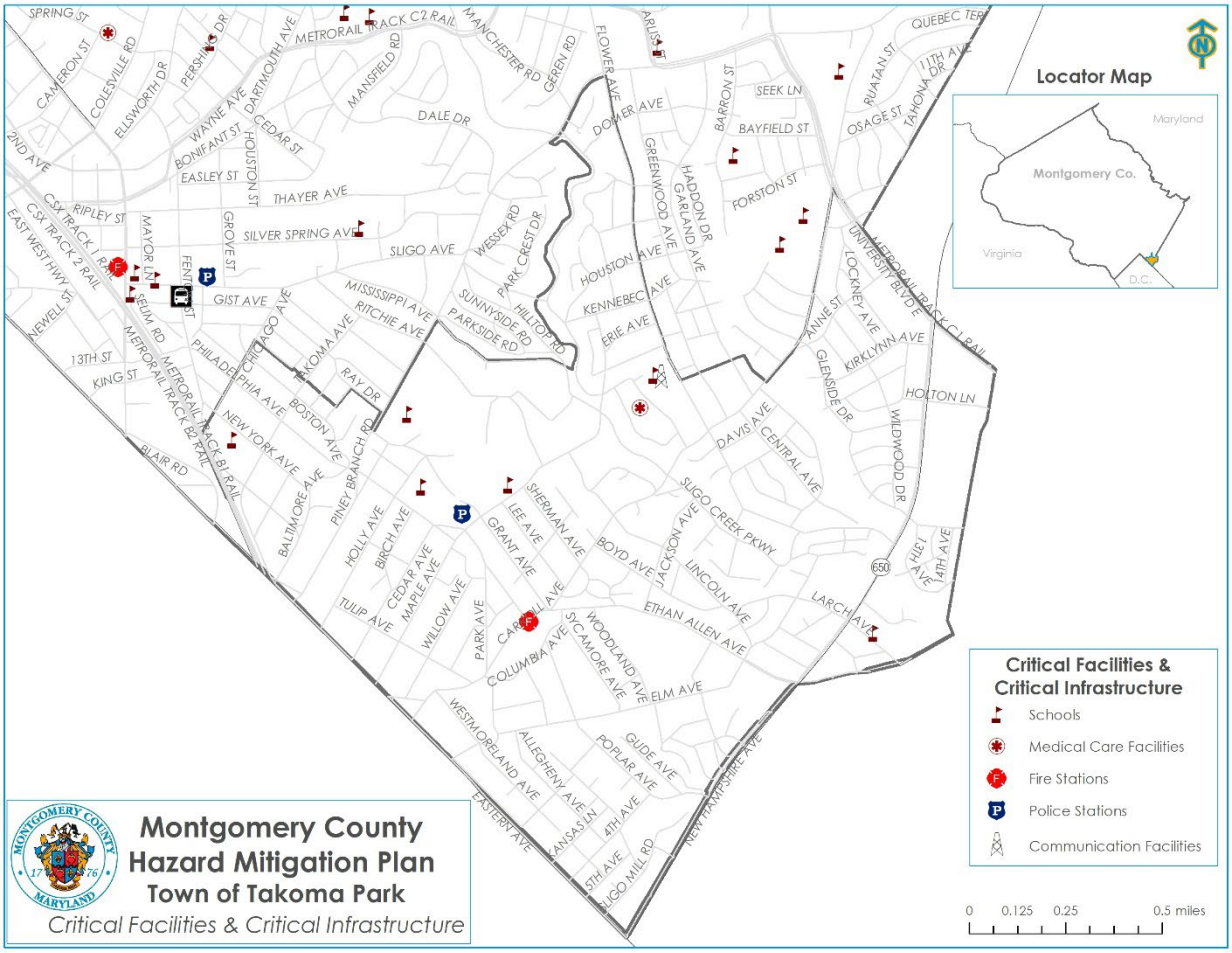
The population of Takoma Park in 2020 was 17,629, which was a 5.2% increase from the community's population in 2010. Local leaders believe that the 2023 population is between 17,500 and 18,000. Takoma Park's population is trending on the younger side, and more than a quarter of individuals in Takoma Park are 18 or younger. Less than 20% of the community's population is 60 or older. Additionally, Takoma Park has one of the more diverse populations in the County; in 2020, only 41% of the individuals in Takoma Park identified as white with no Hispanic or Latino heritage.

c) Changes in Development

The Mayor and City Council of Takoma Park jointly issued the City Master Plan with the Maryland National Capital Park and Planning Commission. The Master Plan articulates a broad vision for Takoma Park and its Central Business District with Silver Spring. It highlights Takoma Park's future development activities. It also guides the City's capital improvement projects.

The Master Plan includes the City's future Land Use Plan, which makes recommendations for future use. Additional information is available from the City's website at www.takomaparkmd.gov. The City of Takoma Park Master Plan identifies stormwater management as a major environmental concern in the Central Business District. Urban renewal areas are covered by the Adopted Urban Renewal Plan. The City updated its Stormwater Management Plan in 2020 and is developing an amendment to the City Master Plan called the "Takoma Park Minor Master Plan Amendment" in conjunction with the County.

Figure 14. Takoma Park Critical Facilities Map



19. Washington Grove

a) Open Space

Washington Grove, also known as the Town within a Forrest, prides itself on the maintained open space that connects each home and parcel. Properties are built with homes not facing the streets, but the wide expanses of canopy trees that connects the neighborhood across 45 acres. The Forestry and Beautification (F&B) Committee of the Town of Washington Grove oversees

the health and maintenance of trees, shrubs and the general appearance of Town land in the residential area of town, including the parks.

b) Demographics

According to the 2020 census, the population of Washington Grove is both aging and decreasing. However, community leaders believe that an error of calculation is inflating the decrease. There have been no major annexations or decreases in the population and the community is fully built out, so not expecting significant change in the future.

c) Changes in Development

The community has been fully built out and has no intention of conducting additional development activities. As a point of interest, more than 50 years ago a development plan was created including maps showing a network of streets with water mains and fire hydrants throughout the wooded area. These have nearly all been removed from public documentation, though they do rarely resurface.

IV. Hazard Identification and Risk Assessment

A. Risk Assessment

This section outlines Montgomery County's Local Hazard Identification & Risk Assessment (HIRA) conducted in updating this Hazard Mitigation Plan. Risk assessments measure the potential impact of hazards on people, the economy, and both built and natural environments. They involve:

1. Identifying and profiling concerning hazards,

2. Cataloging community assets,
3. Analyzing hazard risks, and
4. Summarizing the community's vulnerability to these hazards.

This assessment forms the foundation for our mitigation planning, aiming to prioritize actions that reduce risk from these hazards.

The HIRA is a method used to evaluate risk based on the likelihood of a hazard event, its exposure to people and property, and the resultant consequences. Various methodologies, from qualitative to quantitative, are employed for this purpose.

Montgomery County and its municipalities face numerous natural hazards. Those highlighted in this HIRA are deemed genuine threats by the Montgomery County Mitigation Planning Committee. They align with hazards recognized by the State of Maryland and the Federal Emergency Management Agency for this state and region.

B. Hazard Identification

The county's disaster history helps provide direction on the identification of hazards and their significance. For purposes of providing government disaster assistance, a disaster can be declared at the federal level by a Presidential Disaster or Emergency Declaration or by the Small Business Administration, or at the state level through a Gubernatorial Disaster Declaration or Proclamation. Records of all disaster declarations in Montgomery County since 1953 are available from FEMA. The following table identifies Presidential Disaster Declarations and Emergency Declarations issued between 1964 and 2023 that have affected Montgomery County.

Table 6: Presidential Disaster Declarations & Emergency Declarations

Date	Declaration Number	Event
3/26/2020	FEMA-DR-4491	COVID-19 Pandemic
3/13/2020	FEMA-EM-3430	COVID-19 Pandemic
3/4/2016	FEMA-DR-4261	Severe Winter Storm & Snowstorm
11/20/2012	FEMA-DR-4091	Hurricane Sandy
10/28/2012	FEMA-EM-3349	Hurricane Sandy
8/2/2012	FEMA-DR-4075	Severe Storms & Straight Line Winds
8/27/2011	FEMA-EM-3335	Hurricane Irene
5/6/2010	FEMA-DR-1910	Winter Storm
2/19/2010	FEMA-DR-1875	Winter Storm
7/2/2006	FEMA-DR-1652	Flooding/Tornadoes
9/13/2005	FEMA-EM-3251	Hurricane Katrina
9/13/2003	FEMA-DR-1492	Hurricane Isabel
3/14/2003	FEMA-EM-3179	Snow Storm
4/10/2000	FEMA-DR-1324	Winter Storm
1/11/1996	FEMA-DR-1081	Blizzard

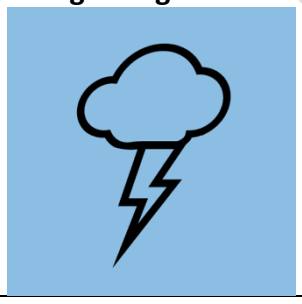
Date	Declaration Number	Event
3/16/1993	FEMA-EM-3100	Winter Storm
8/28/1989	FEMA-DR-839	Severe Storms/High Wind
1/26/1977	FEMA-DR-524	Ice conditions
10/4/1975	FEMA-DR-489	Flooding
6/23/1972	FEMA-DR-341	Tropical Storm Agnes
8/17/1971	FEMA-DR-309	Flooding
3/9/1962	FEMA-DR-127	Severe Storms, High Tides, Flooding

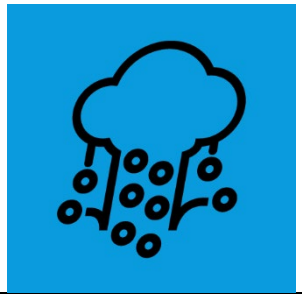
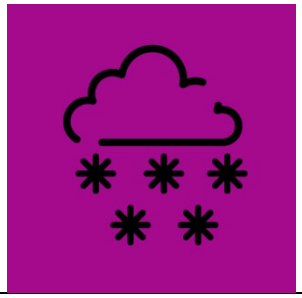
C. Summary of Hazards

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

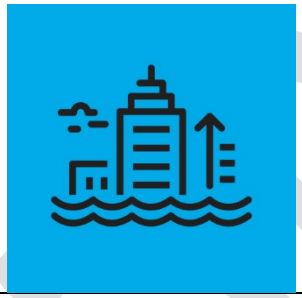
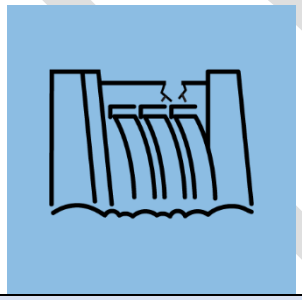
The 17 hazards selected for profiling in the 2023 Plan are provided in the following table, along with hazard descriptions.

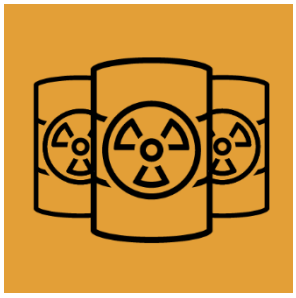
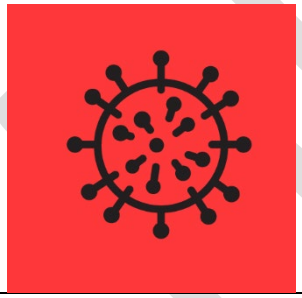
Table 7: List of Hazards Profiled in the 2023 Montgomery County Hazard Mitigation Plan

Profiled Hazards	Description
Natural Hazards	
Severe Storm / High Wind 	There are two basic types of damaging wind events other than tropical systems that affect Maryland: synoptic-scale winds and thunderstorm winds. Synoptic-scale winds are large scale high winds that occur typically with cold frontal passages or Nor'easters. Thunderstorms on the other hand affect relatively small areas but, despite their size, are very dangerous. The typical thunderstorm is 15 miles in diameter and lasts an average of 30 minutes. When thunderstorm winds are over 58 mph, the thunderstorm is considered severe and a warning is issued. "Downbursts" cause the high winds in a thunderstorm. Downburst winds result from the sudden descent of cool or cold air toward the ground. As the air hits the ground, it spreads outward, creating a fast-moving surge of high winds.
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. (NOAA NWS, 2018 and Ready.gov. 2018).

Profiled Hazards	Description
Hailstorms 	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. (FEMA, 2018; NOAA, 2018).
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. (NOAA, 2018).
Extreme Temperatures 	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. (Ready.gov, 2018). 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. (NWS, 2018).
Wildfire 	A wildfire is an unplanned fire that burns in a natural area. 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 (Ready.gov, 2018 and PA DCNR, 2018).

Profiled Hazards	Description
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. 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. (FEMA, 2018). 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. (NESEC, 2018).
Hurricane/Tropical Storm 	A hurricane is a powerful tropical cyclone with sustained winds of at least 74 miles per hour (119 kilometers per hour) that forms over warm ocean waters in the Atlantic Ocean, Caribbean Sea, Gulf of Mexico, or eastern Pacific Ocean. Characterized by a low-pressure center, warm core, and spiral arrangements of thunderstorms, hurricanes can produce heavy rainfall, strong winds, storm surges, and flooding.
Water Shortage/Drought 	Drought is defined as a deficiency of precipitation experienced over an extended period of time, usually a season or more. 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. (National Drought Mitigation Center, 2018; Ready.gov 2018).
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. (FEMA, 2014 and NOAA, 2018).

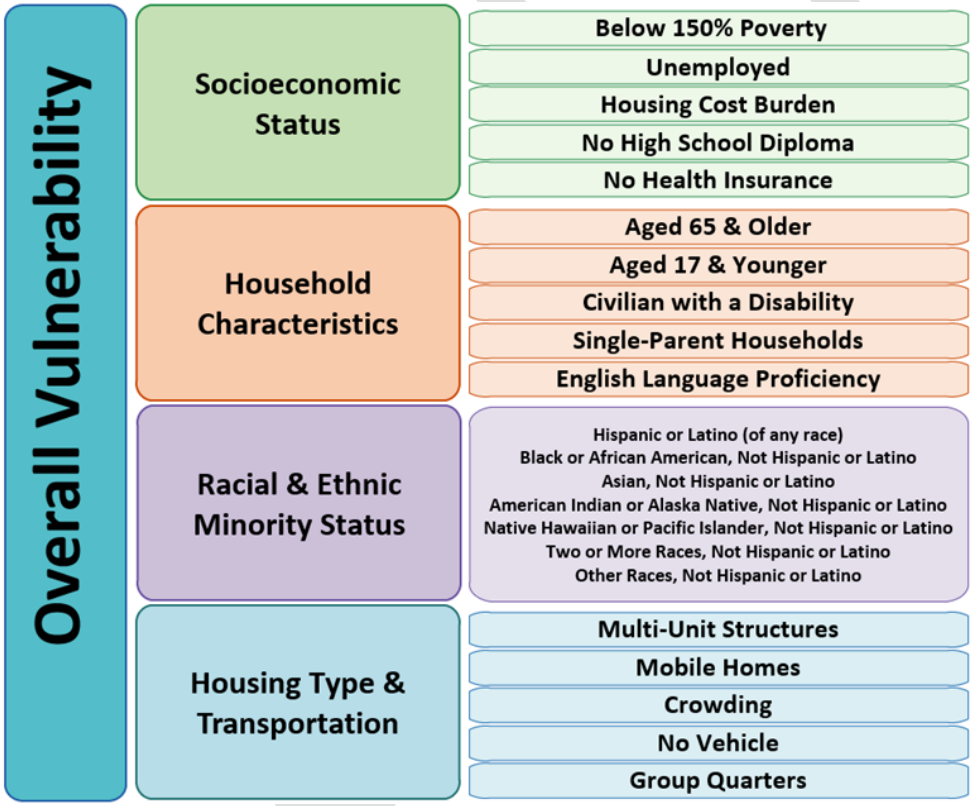
Profiled Hazards	Description
Earthquake 	An earthquake is the motion or trembling of the ground produced by sudden displacement of rock usually within the upper 10-20 miles of the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, or the collapse of underground caverns. Earthquakes 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. (Ready.gov, 2018).
Land Subsidence/Karst 	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. (USGS, 2018 and PA DCNR, 2018).
Sea Level Rise 	Sea-level rise refers to the long-term increase in global average sea levels due to factors such as the melting of polar ice caps, glaciers, and the thermal expansion of seawater as it warms. This phenomenon poses several hazards, particularly to coastal regions and low-lying areas. Here is a description of the hazards associated with sea-level rise:
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. (ASDSO, 2018).
Human-Caused	

Profiled Hazards	Description
Hazardous Materials 	Environmental hazards are hazards that pose threats to the natural environment, the built environment, and public safety through the diffusion of harmful substances, materials or products. 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 (PL 1990-165, § 207(e)). ▪ 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 (Environmental Protection Agency, Natural Disaster PSAs, (2009). ▪ 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 (Environmental Protection Agency, Natural Disaster PSAs, 2009). 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. (FEMA, 1997).
Pandemic / Infectious Disease 	A pandemic is a global outbreak of disease that occurs when a new virus emerges in the human population, spreading easily in a sustained manner, and causing serious illness. An epidemic describes a smaller-scale infectious outbreak, within a region or population, that emerges at a disproportional rate. Infectious disease outbreaks may be widely dispersed geographically, impact large numbers of the population, and could arrive in waves lasting several months at a time. (FEMA, 2018).
Natural Gas Explosions / 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 (U.S. Fire Administration, 2018). 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.

Montgomery County Social Vulnerability Index Assessment:

One of the tools commonly used to assess the overall vulnerability of communities is the Social Vulnerability Index (SVI) developed by the Centers for Disease Control and Prevention (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR). The tool uses 16 different variables like education, disabilities, and access to a vehicle to formulate a rating corresponding to a community's overall ability to prevent human suffering and financial loss in the event of a disaster. The SVI ratings range from 0 to 1, with higher values indicating greater vulnerability. The ratings are based on percentiles among the 16 variables. Communities in the highest 10% (above 90th percentile) for a given variable receive a value of 1 to indicate high vulnerability, while communities within the lowest 10% receive a value of 0.[16] The SVI also organizes the 16 variables into 4 "themes" which help provide insight into specific aspects of vulnerability.

Figure 15 Social Vulnerability Index 2020 Variables



[16] Centers for Disease Control and Prevention and Agency for Toxic Substances and Disease Registry. "CDC SVI Documentation 2020." atsdr.cdc.gov, October 28, 2022. https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2020.html.

Overall, Montgomery County's SVI is .4631 as of 2020. Broadly, this rating can be interpreted as conveying that Montgomery County's capability to prevent human suffering and financial loss in the event of a disaster is better than average when considering all US counties. Of the three bordering Maryland counties, Howard County and Frederick County have better ratings (.1369 and .1827, respectively) while Prince George's County has a worse rating of .7969.[17]

When looking at the overall SVI ratings among all 215 census tracks within Montgomery County, it is evident that the most vulnerable areas are largely clustered in the central region along I-270 and in the south-southeastern portion near the borders with the District of Columbia and Prince George's County. Communities in these areas include Germantown, Gaithersburg, Aspen Hill, Takoma Park, and many others.

[17] Centers for Disease Control and Prevention. "SVI Interactive Map." svi.cdc.gov/map/, 2020. https://svi.cdc.gov/map/.

Figure 16 Relative SVI Ratings Among All Census Tracks in Montgomery County 2020

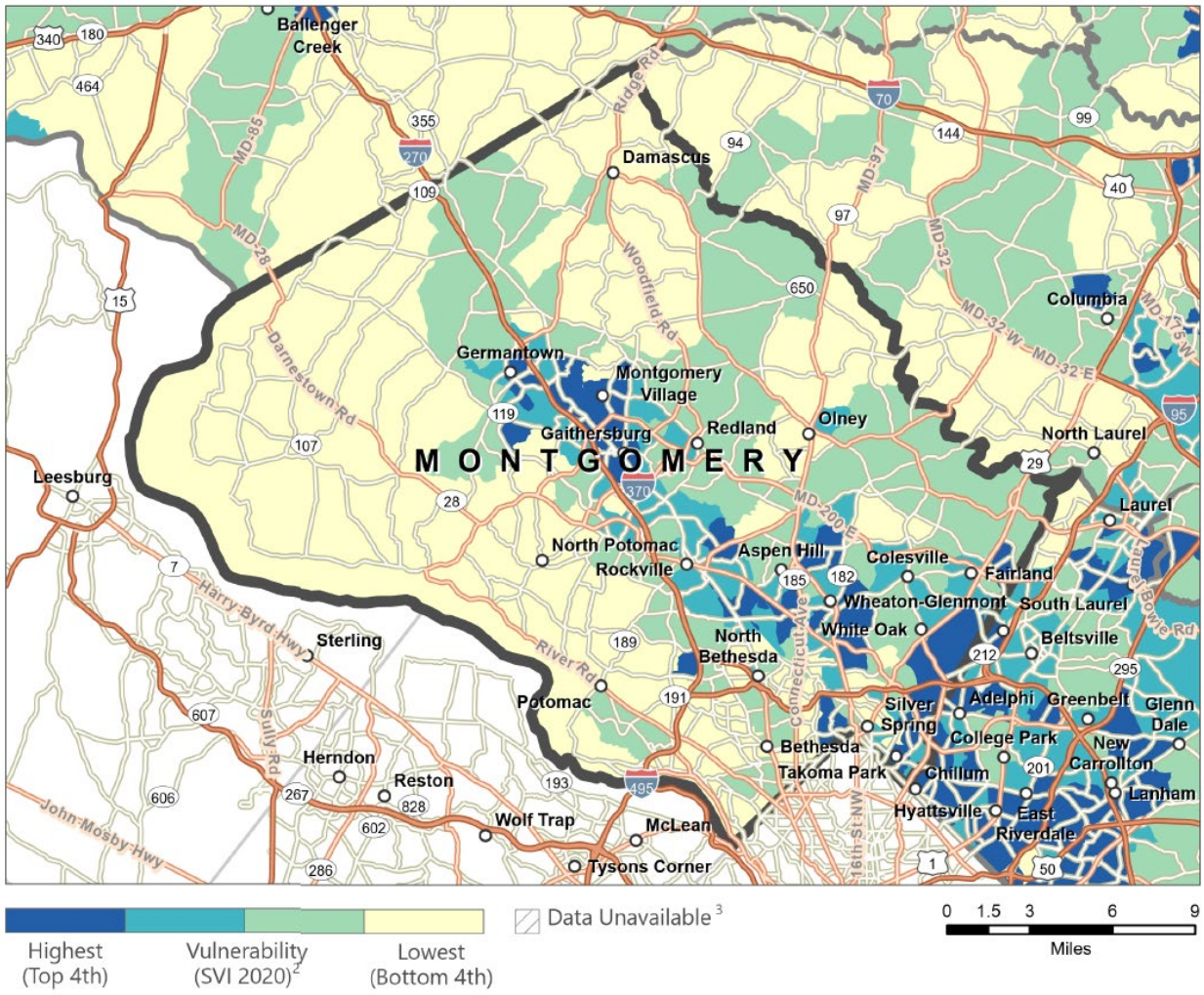
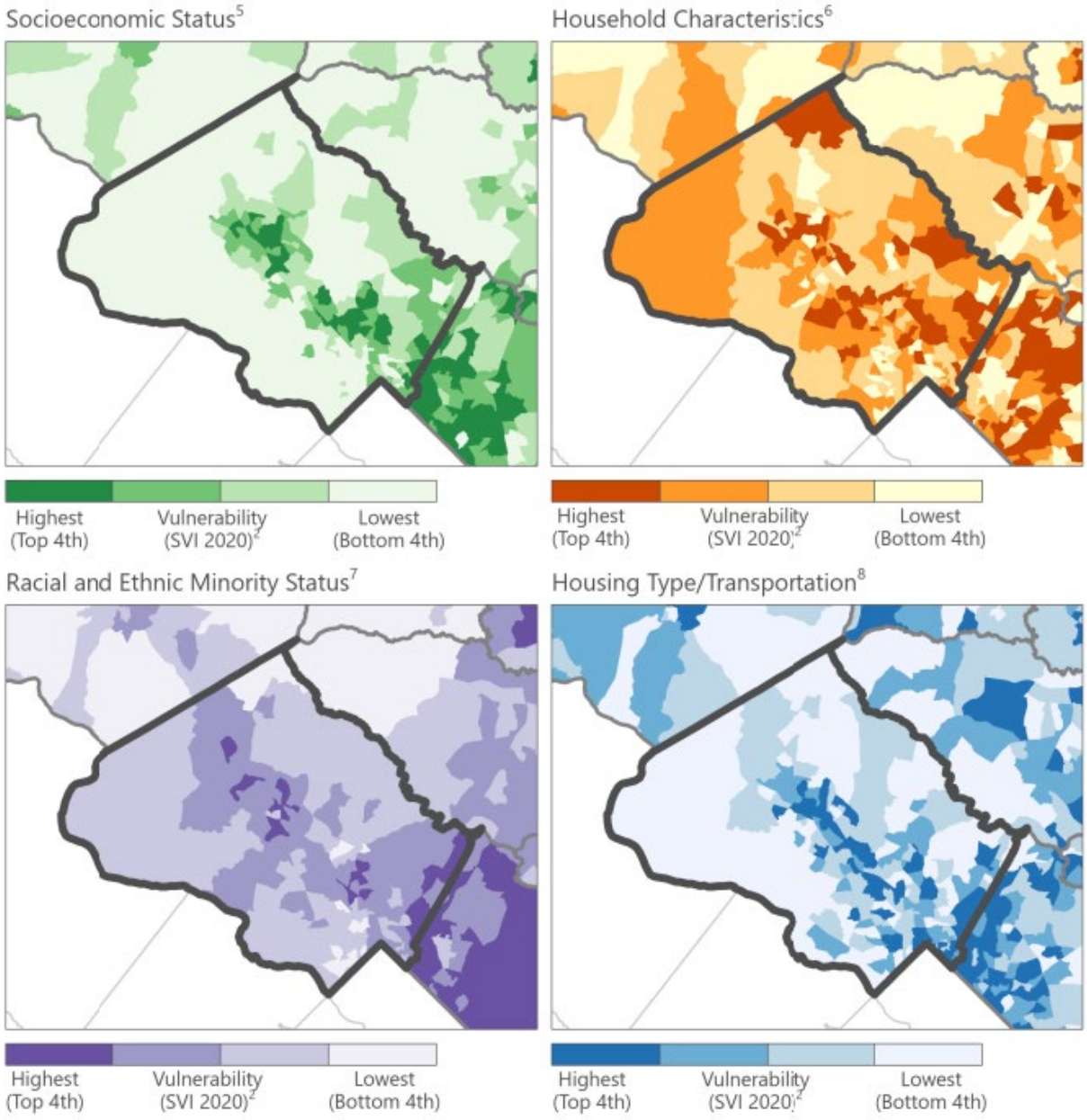


Figure 17 Relative SVI Ratings Among All Census Tracks in Montgomery County by Theme 2020



Clockwise from top left: Socioeconomic Status theme, Household Characteristics theme, Housing Type/Transportation theme, Racial and Ethnic Minority Status theme

<u>Socioeconomic Status:</u>

The first of the four themes in the CDC's SVI is Socioeconomic Status. There are 5 variables included in this theme, and they are (1) the number of people below 150% poverty, (2)

unemployed, (3) with a housing cost burden, (4) without a high school diploma, and (5) without health insurance.[18] As of 2020, Montgomery County's SVI rating for the Socioeconomic Status theme is .2673. As can be seen in figure 10, there are two clusters of census tracks in Montgomery County where this theme is most concerning. These two clusters primarily encompass the incorporated communities of Germantown and Gaithersburg as well as several unincorporated communities between Kensington and Mayland Route 200 (also referred to as the Intercounty Connector). While these census tracks have the highest Socioeconomic Status vulnerability rating within Montgomery County, it should be noted that the countywide SVI rating for this theme is the lowest of the four.

Housing Characteristics:

The second of the four themes in the SVI is Housing Characteristics. This theme is comprised of five variables, which are (1) people aged 65 or older, (2) people aged 17 or younger, (3) civilians with a disability, (4) single-parent households, and (5) English language proficiency.[19] As of 2020, the SVI rating for this theme in Montgomery County is .4351. Although there is some overlap between the census tracks with the highest vulnerability rating for Housing Characteristics and the other three themes, the census tracks with vulnerable housing characteristics are distributed more evenly across Montgomery County. Some of the census tracks with the highest housing characteristics vulnerability ratings are in the northern and eastern portions of the County along the borders with Frederick and Howard Counties. It is important here to highlight these census tracks because they do not stand out when looking at the *overall* SVI ratings of census tracks in Montgomery County.

Racial and Ethnic Minority Status:

The third theme in the CDC's SVI is Racial and Ethnic Minority Status. Unlike the other themes, this one does not have multiple variables. Instead, it is solely determined by the overall percentage of racial and ethnic minorities present in the community. As of 2020, Montgomery County's SVI rating for this theme is .9087. The County's vulnerability rating for this theme is the highest of the four by a significant margin, and it is appropriately classified as a "high level

[18] Centers for Disease Control and Prevention, and Agency for Toxic Substances and Disease Registry. "At A Glance: CDC/ATSDR Social Vulnerability Index." atsdr.cdc.gov, October 26, 2022. https://www.atsdr.cdc.gov/placeandhealth/svi/at-a-glance_svi.html.

[19] Centers for Disease Control and Prevention, and Agency for Toxic Substances and Disease Registry. "At A Glance: CDC/ATSDR Social Vulnerability Index." atsdr.cdc.gov, October 26, 2022. https://www.atsdr.cdc.gov/placeandhealth/svi/at-a-glance_svi.html.

of vulnerability" by the interactive SVI tool.[20] The census tracks within Montgomery County with the highest individual vulnerability ratings pertaining to this theme closely match the census tracks with the highest *overall* vulnerability. These tracks primarily encompass the centrally located communities of Germantown and Gaithersburg as well as communities near the border with Prince George's County.

Housing Type and Transportation:

The final theme incorporated into the SVI tool is Housing Type and Transportation. This theme is comprised of five variables, which are (1) multi-unit structures, (2) mobile homes, (3) crowding[21], (4) no vehicle, and (5) people in group quarters.[22] The latest SVI rating for Montgomery County with regard to this theme is .5726. The census tracks in Montgomery County with the highest vulnerability ratings for this theme encompass many of the communities which are also encompassed by census tracks with high vulnerability ratings for other themes. However, rather than being in discrete clusters, these census tracks form a more continuous corridor stretching from around Germantown to the southeastern border of Montgomery County along I-270.

Social Vulnerability Index Themes	2020 Montgomery County Rating[23]
Socioeconomic Status	0.2673
Household Characteristics	0.4351
Racial & Ethnic Minority Status	0.9087
Housing Type & Transportation	0.5726
Overall SVI	0.4631

Climate and Economic Justice Screening Tool

In January 2021, Executive Order 14008 directed the Council on Environmental Quality (CEQ) to develop a new tool which could better inform the public about the burdens many communities

[20] Centers for Disease Control and Prevention. "SVI Interactive Map." svi.cdc.gov/map/, 2020. https://svi.cdc.gov/map/.
[21] "Crowding" is defined as the percentage of occupied housing units with more people than rooms.
[22] The Census Bureau classifies all people not living in housing units (house, apartment, mobile home, rented rooms) as living in group quarters. This can include institutional facilities such as nursing homes, as well as non-institutional facilities like college dormitories and military barracks.
[23] Centers for Disease Control and Prevention and Agency for Toxic Substances and Disease Registry. "SVI Data and Documentation Download." atsdr.cdc.gov, December 22, 2022. https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html.

experience. The new tool is called the Climate and Economic Justice Screening Tool (CEJST), and it uses datasets that are indicators of burdens in eight categories: climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development. This information helps identify disadvantaged communities at the census tract level (from 2010 Census), and CEJST plots the data on an interactive map.

The latest CEJST data identifies 25 census tracts in Montgomery County as "disadvantaged." Montgomery County has 215 total census tracts within its borders, so approximately 12% of census tracts in the County are disadvantaged, according to the CEJST data.[24] The disadvantaged census tracts largely match the location of tracts with high vulnerability ratings as determined by the Social Vulnerability Index. Although the CEJST has eight categories of burdens, the disadvantage(s) identified within the relevant 25 census tracts in Montgomery County are all within the following four categories: housing, legacy pollution, transportation, and workforce development. In some cases, census tracts in Montgomery County have been identified as having more than one disadvantage.

Table 8 Count of CEJST Disadvantages Identified for Census Tracts within Montgomery County

CEJST Burden Category	Count Census Tracts with an Identified Disadvantage[25]
Housing	5
Legacy Pollution	6
Transportation	2
Workforce Development	23

NOTE: The count is greater than 25 because some census tracts were identified as having more than one disadvantage as determined by the Climate and Environmental Justice Screening Tool

Montgomery County National Risk Index (NRI) Assessment:

The planning team reviewed FEMA's National Risk Index (NRI) in an effort to further assess the hazard risk within Montgomery County. Unfortunately, inconsistent and incorrect data in the

[24] Council on Environmental Quality. "Climate and Economic Justice Screening Tool." Climate and Economic Justice Screening Tool. Accessed October 17, 2023. https://screeningtool.geoplatform.gov.
[25] Council on Environmental Quality. "Climate and Economic Justice Screening Tool." Climate and Economic Justice Screening Tool. Accessed October 17, 2023. https://screeningtool.geoplatform.gov.

NRI severely reduced the reliability of the tool's conclusions. Due to this, an in-depth discussion of the NRI assessment for Montgomery County is not included in this document.

D. Natural Hazards

Montgomery County, along with the State of Maryland and the National Capital Region are prone to a variety of extreme weather phenomena, making the region vulnerable to a range of natural hazards. These include tropical storms and hurricanes, severe thunderstorms, tornadoes, nor'easters, blizzards and ice storms, flooding, droughts, and both heatwaves and cold snaps.

The Mid-Atlantic region has experienced a series of noteworthy weather events in recent years. In February 2010, multiple snowstorms blanketed the area in substantial snowfall, prompting a federal government shutdown for the extended period of 4.5 days.

The impacts of Hurricane Irene in 2011 were felt along the coastal areas, causing significant wind damage. In 2012, Superstorm Sandy, although reclassified as a post-tropical storm, brought forth destructive winds and a storm surge of 4 to 5 feet, leading to the destruction of a large portion of Ocean City's fishing pier and widespread flooding in Crisfield and other low-lying regions of Maryland's Lower Eastern Shore.

June 29, 2012, witnessed the passage of a derecho, characterized by widespread and prolonged thunderstorms with powerful winds, affecting the Ohio Valley and the Mid-Atlantic, with Maryland and the District of Columbia experiencing some of the most severe impacts. The storm left one-third of Maryland residents and one-quarter of DC residents without power, with some enduring outages for more than a week. Multiple communities within Montgomery County recount this event as an impactful and costly disaster event in recent memory.

Both the mountainous terrain in Maryland's narrow western region and densely populated urban areas are particularly susceptible to flash flooding. August 12–13, 2014, brought torrential rainfall of up to 6 to 10 inches, leading to flooding along the coastal plain from Baltimore to New Jersey.

On July 30, 2016, Ellicott City, MD, was struck by an extreme precipitation event, receiving 6 inches of rain within a few hours, resulting in two fatalities. Less than two years later, on May 27, 2018, another extreme precipitation event affected the Ellicott City and Catonsville area, with 6 to 12 inches of rainfall causing catastrophic damage and one fatality. Catonsville recorded a record-breaking 84.6 inches of precipitation that year in the state, highlighting the region's susceptibility to such extreme weather occurrences.

Coastal storms, including hurricanes, tropical storms, and Nor'easters, rank among the most destructive natural phenomena in the United States and its territories. Historical events underscore the immense damage that can occur. For instance, in 2005, Hurricane Katrina resulted in an unprecedented $90 billion in total damage, surpassing the devastation caused by Hurricane Andrew in 1992 multiple times over.

1. Severe Storm/Thunderstorm/High Wind[26]

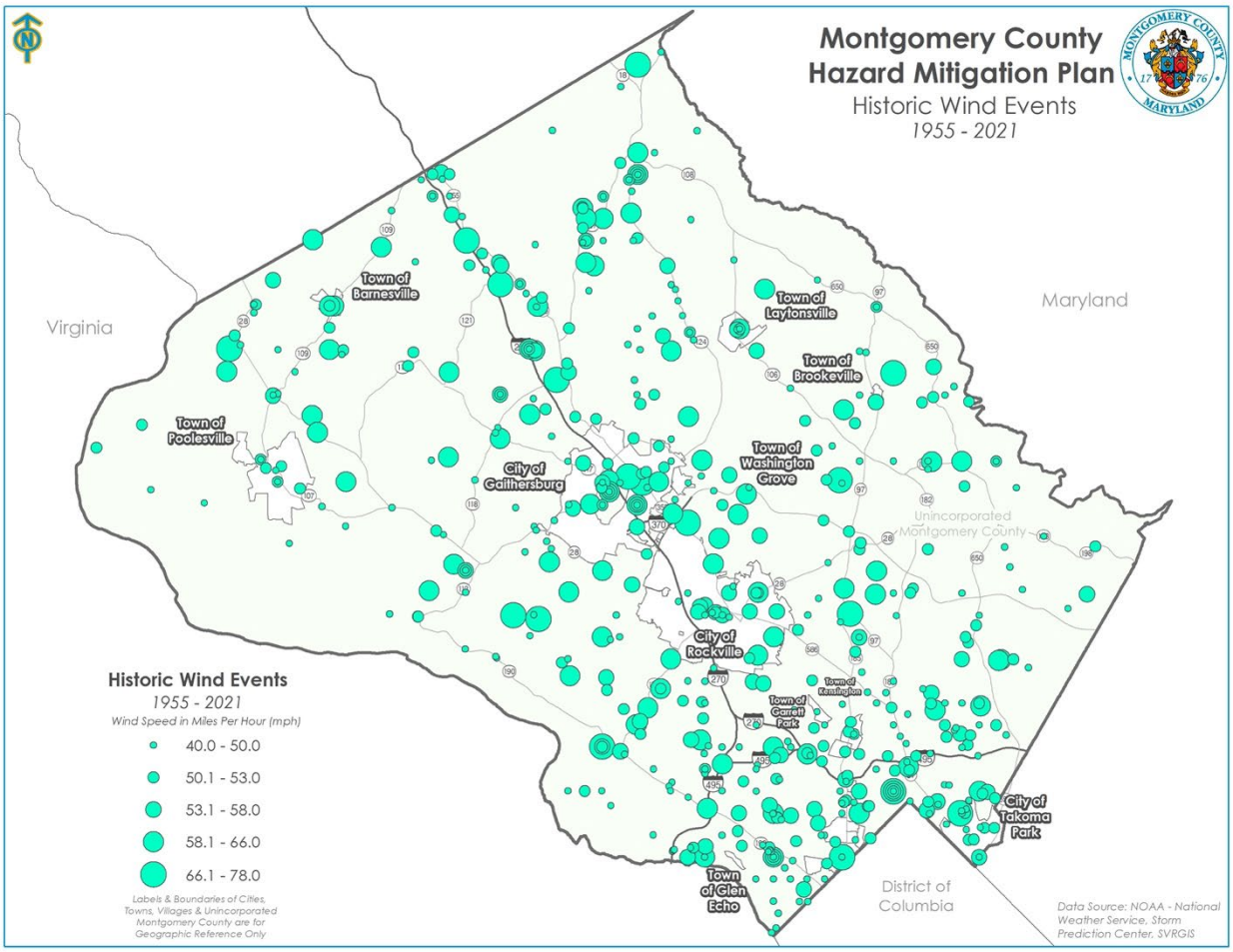
a) Location and Extent

A thunderstorm is typically a widespread atmospheric hazard that can occur in all regions of the United States, and therefore has no geographic boundaries. However, thunderstorms are most common in the central and southern states as the atmospheric conditions in those regions are more favorable for generating these powerful storms. It is assumed that ***Montgomery County has uniform exposure and the spatial extent of an impact could be large.***

As described above, Montgomery County experiences significant and impactful wind events independent of other storm related impacts like rainfall or lightning. However, due to the National Oceanic and Atmospheric Administration's classification of wind events, there was limited data to profile wind as a stand-alone hazard. Wind is the movement of air caused by the uneven heating of the Earth by the sun. Winds generally blow from high-pressure areas to low-pressure areas. The boundary between these two areas is called a front. The complex relationships between fronts cause different types of wind and weather patterns. Wind is often measured in terms of wind shear. Wind shear is a difference in wind speed and direction over a set distance in the atmosphere. Under normal conditions, the winds move much faster higher in the atmosphere, creating high wind shear in high altitudes. The amount of force that wind is generating is measured according to the Beaufort scale.[27]

Figure 18: Map of Wind Events that have Impacted Montgomery County

[26] Includes NCEI classifications of High Wind, Strong Wind, and Thunderstorm Wind
[27] Wind (nationalgeographic.org)



b) Range of Magnitude

The following Beaufort scale is an *empirical measure for the intensity of the wind associated with windstorms.*

Table 9: Beaufort Wind Scale

NUMBER	WIND SPEED (MPH) [28]	DESCRIPTION	WAVE HEIGHT (FT)	SEA CONDITIONS	LAND CONDITIONS
0	<1	Calm	0	Flat.	Calm. Smoke rises

[28] NOAA – National Weather Service. Retrieved on 08/08/2023 from: https://www.spc.noaa.gov/faq/tornado/beaufort.html

NUMBER	WIND SPEED (MPH) [28]	DESCRIPTION	WAVE HEIGHT (FT)	SEA CONDITIONS	LAND CONDITIONS
1	1-3	Light air	0.33	Ripples without crests.	Wind motion visible in smoke.
2	3-7	Light breeze	0.66	Small wavelets.	Wind felt on exposed skin. Leaves rustle.
3	8-12	Gentle breeze	2	Large wavelets.	Leaves and smaller twigs in constant motion.
4	13-17	Moderate breeze	3.3	Small waves.	Dust and loose paper rise. Small branches begin to move.
5	18-24	Fresh breeze	6.6	Moderate (1.2 m) longer waves. Some foam and spray.	Small trees sway.
6	25-30	Strong breeze	9.9	Large waves with foam crests and some spray.	Large branches in motion. Whistling heard in overhead wires. Umbrella use difficult.
7	31-38	High wind, Moderate Gale, Near	13.1	Sea heaps up and foam begins to streak.	Whole trees in motion. Effort needed to walk against the wind.
8	39-46	Fresh Gale	18	Moderately high waves with breaking crests forming spindrift. Streaks of	Twigs broken from trees. Cars veer on road.
9	47-54	Strong Gale	23	High waves (6-7 m) with dense foam. Wave crests start to roll over. Considerable spray.	Larger branches break off trees, and some small trees blow over. Construction/temporary signs and barricades blow over. Damage to circus tents and canopies.
10	55-63	Whole Gale/Storm	29.5	Very high waves. The sea surface is white and there is considerable	Trees uprooted. Considerable structural damage.

NUMBER	WIND SPEED (MPH) [28]	DESCRIPTION	WAVE HEIGHT (FT)	SEA CONDITIONS	LAND CONDITIONS
11	64-72	Violent storm	37.7	Exceptionally high waves.	Widespread vegetation and structural damage.
12	≥73	Hurricane-force	≥46	Huge waves. Sea is completely white with foam and spray. Air is filled with spray, reduced visibility.	Massive and widespread damage to structures.

c) Past Occurrence

According to the National Centers for Environmental Information (NCEI) there have been 810 recorded wind events that have either directly or indirectly impacted Montgomery County since 1950.

Table 10: High Wind Events in Montgomery County 1950-2023

Location	Deaths	Injuries	Property Damage	Crop Damage	Annualized Losses[29]
Montgomery County	5	13	$20,020,100	$57,000	$313,704

Reported thunderstorm wind events over the past 64 years provide an acceptable framework for determining the future occurrence in terms of frequency for such events. The probability of the County and its municipality experiencing thunderstorm winds associated with damages or injury can be difficult to quantify but based on historical record of 810 wind events since 1959 that have either caused damages to buildings and infrastructure or resulted in an injury or death.

d) Future Occurrence

Given the high number of previous wind events that occurred in Montgomery County, it is certain that thunderstorm events, including straight-line wind events, will occur in the future. This results in a probability level of highly likely (100 percent annual probability) for the entire

[29] *(Current Year) 2023] subtracted by [(Historical Year) 1959] =64 Years on Record*

county.

e) Vulnerability Assessment

(1) People

Population growth and distribution, especially increased population density and urbanization in Montgomery County, increases vulnerability to wind hazards. Populations at greater risk to the impacts of windstorms include, but are not limited to, adults 65 years and older (15.62% of the population), individuals with a disability (8.58% of the population[30]), individuals living below the poverty line (7.04% of the population) individuals who are unsheltered, individuals who experience language and communication barriers. Socio-economic factors may not only hinder an individual's ability to prepare for and respond to windstorm events, but also affect their capacity to access services in the aftermath of the storm. Individuals that rely on electricity for life-sustaining equipment are also more at-risk during these events due to the high likelihood of utility disruptions associated with windstorms.

(2) Structures

Fallen trees and debris are common after high wind events, which can block access to roads, bring down power and utility lines, and damage building stock. Areas with tall buildings are at greater risk as increased wind pressure occurs at greater heights. Construction sites are also especially vulnerable to high winds. Loose tools and construction materials, cranes, and scaffolding may loosen from exposure to high winds and become flying debris. Structural vulnerability to wind correlates with a building's construction type. Wood structures and manufactured homes are more susceptible to wind damage, while steel and concrete buildings are more resistant.

(3) Systems

Severe windstorms pose a significant risk to life and property in Montgomery County by creating conditions that disrupt essential systems such as public utilities, telecommunications, and transportation routes. Damage to these critical systems that power our homes and connect us may significantly impact the community. Powerlines and cellphone towers are more vulnerable to high wind events due in part to their height. Above–ground power lines are more vulnerable to high winds and flying debris, which can down both wires and poles. Buried power lines, by contrast, are tucked safely underground, far away from damaging winds. Congestion, limited escape routes, dense infrastructure, and poverty add to the vulnerability that a severe wind event could have on the systems in Montgomery County. Additionally, it's estimated that

[30] https://www.atsdr.cdc.gov/placeandhealth/svi/interactive_map.html

7.35% of the households in Montgomery County lack access to a vehicle. Based on the development goals of the county, this number is likely to rise over time.

(4) Natural, Historic, & Cultural Resources

Montgomery County is one of the oldest communities in Maryland with significant historical and cultural resources, not only important to the surrounding community but to the nation. There are 80 listings on the National Register of Historic Places in Montgomery County.[31] In the case of both windstorms and tornadoes, the greatest impact on the natural environment is on trees and woodland. High winds can easily uproot trees, shrubs, and bushes.

Windstorms, including severe storms, hurricanes, and tornadoes, can have a significant impact on important cultural resources in Montgomery County, Maryland, just as they can in any region. These cultural resources may include historical landmarks, museums, archives, public art, and other valuable assets. Here's how windstorms can affect them:

- **Structural Damage**: High winds can cause structural damage to historical buildings, landmarks, and cultural institutions. Roofs, windows, walls, and architectural features may be compromised, leading to costly repairs and potential loss of historical integrity.
- **Debris Damage**: Flying debris, including tree branches, signs, and other objects, can pose a serious threat to cultural resources. Statues, sculptures, and outdoor artwork may be at risk of being struck or damaged.
- **Power Outages**: Windstorms can lead to power outages, disrupting climate control systems in museums and archives. Fluctuations in temperature and humidity can harm delicate items in collections.
- **Tree Damage**: Large trees near cultural institutions can pose a threat during high winds. Falling trees or branches can damage buildings, sculptures, or outdoor exhibits.
- **Accessibility Issues**: Damage to roads, bridges, and transportation networks can make it difficult for visitors to access cultural resources in the aftermath of a windstorm.
- **Public Safety**: Windstorms can create hazardous conditions for visitors and staff, including falling debris and unsafe structural conditions. Ensuring public safety and securing cultural resources may require temporary closures or restricted access.
- **Financial Impact**: Repairing and restoring cultural resources can be costly. Cultural institutions may face financial challenges in the aftermath of windstorms, diverting resources from their regular operations and preservation efforts.

Table 11: Notable Assets in Montgomery County Damaged by Severe Storms

[31] National Park Service - National Register of Historic Places. Current as of January 19th, 2023.

Approximate Date of Storm	Asset(s)	Category	Description of Damage
July 29, 2023	Dentzel Carousel	Natural, Historic, Cultural	A severe storm struck Glen Echo Park, which contains historic structures like the Dentzel Carousel and the Spanish Ballroom. The Dentzel Carousel was damaged by both wind and water, and the Glen Echo Park Partnership for Arts and Culture established a fund called the "Lift Us Up" campaign to help with the repair costs. Community members were eager to help, and the campaign, which initially had a goal of $50,000, has raised $113,429.63 as of 9/25/23.[32]
June 28, 2012	Power Grid	Systems	A powerful derecho struck the region. According to data reported by PEPCO, BGE, and First Energy, the storm knocked out power for 74% of customers. Additionally, 31 of 34 (91%) of nursing homes lost power, and 550 of 800 (69%) of traffic signals lost power.[33]
June 28, 2012	Water Utilities	Systems	A powerful derecho struck the region. The high winds knocked out power at two Washington Suburban Sanitary Commission (WSSC) water filtration plants. These outages forced the WSSC to issue mandatory water restrictions for both Montgomery and Prince George's County. The restrictions prohibited outdoor water use and requested that water only be used indoors as needed.[34]
July 24, 2005	Power grid	Systems	A severe storm toppled trees and power lines in Montgomery County and surrounding areas. The number of people without power peaked at 52,000, and full restoration of services took

[32] Kate Oczypok. "Microburst Aftermath: Glen Echo Park Needs Your Help!," August 21, 2023. https://georgetowner.com/articles/2023/08/21/microburst-aftermath-glen-echo-park-needs-your-help/.
[33] Montgomery County Government. "June 29, 2012 Severe Storm (Derecho) Overview." montgomerycountymd.gov, June 29, 2012. https://montgomerycountymd.gov/opi/resources/files/pdf/6-29-2012_derecho_overview_powerpoint.pdf.
[34] NBC Washington Staff. "More Than 1.5 Million Without Power; 4 Killed." *NBC4 Washington* (blog), June 28, 2012. https://www.nbcwashington.com/news/local/records-could-be-broken-as-dc-heats-up/1921095/.

Approximate Date of Storm	Asset(s)	Category	Description of Damage
			several days.[35]

To mitigate the impact of windstorms on cultural resources, Montgomery County and cultural institutions within the county often employ several strategies, including:

- Regular maintenance and inspection of historical structures and artifacts to ensure their resilience to wind and weather-related threats.
- Developing and implementing emergency response plans to protect cultural resources during storms and other disasters.
- Investment in climate control systems and disaster preparedness measures to safeguard collections.
- Community outreach and education to raise awareness about the importance of cultural resources and their protection in the face of extreme weather events.

Collaboration between local authorities, cultural institutions, and community organizations is essential to ensure the preservation and resilience of Montgomery County's cultural heritage in the face of windstorms and other natural disasters.

(5) Community Activities

There are potentially direct consequences to the local economy resulting from windstorms related to both physical damages and interrupted activities. Industry and commerce can suffer losses from interruptions in electric service and extended road closures. In addition, they can also sustain direct losses to buildings, personnel, and other vital equipment.

2. Lightning

a) Location and Extent

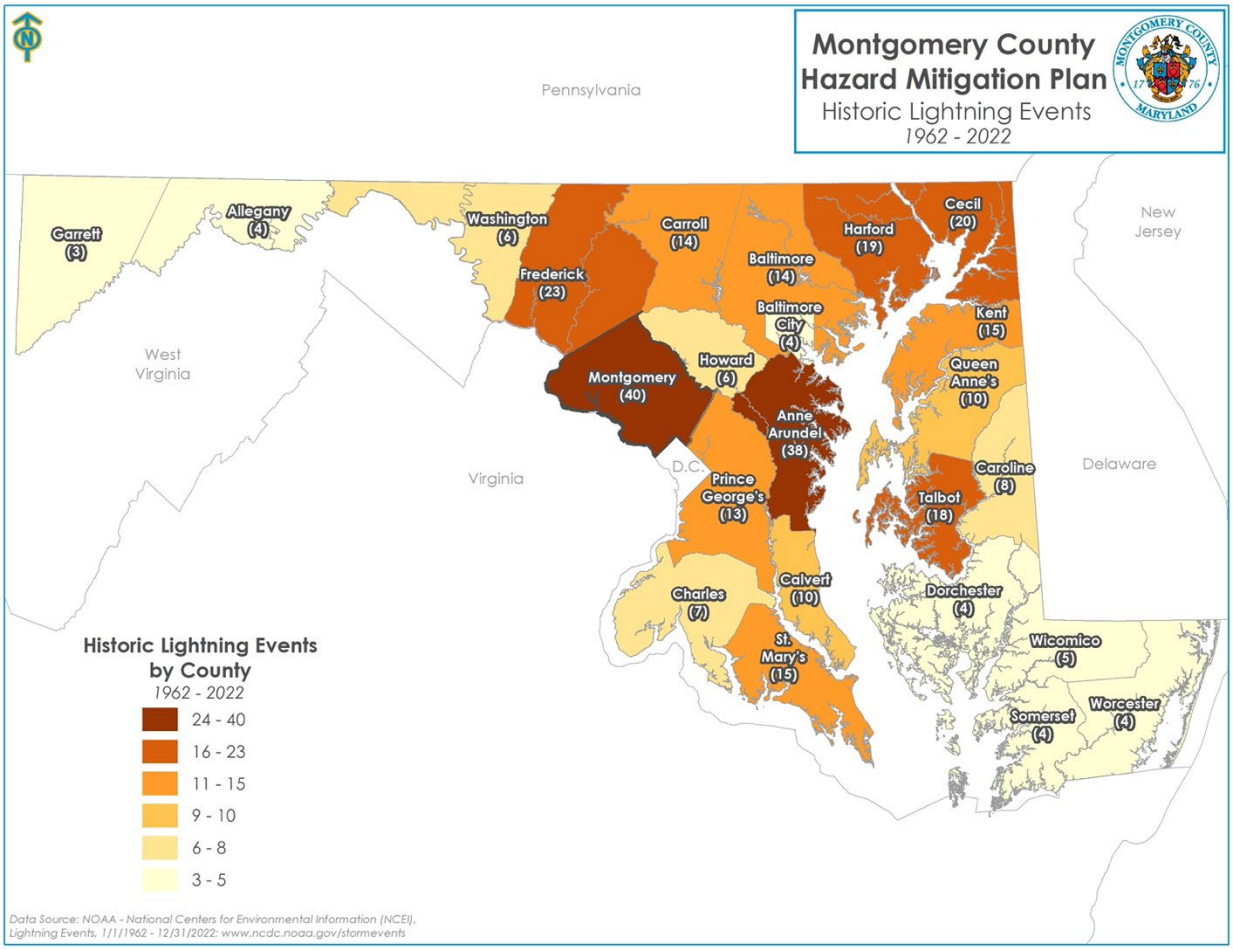
Lightning is a rapid discharge of electrical energy in the atmosphere. The clap of thunder is the result of a shock wave created by the rapid heating and cooling of the air in the lightning channel. All thunderstorms have the capacity to produce lightning, and it is one of the deadliest weather events in the United States, killing approximately 50 people and injuring about 400 each year[36]. Since lightning occurs randomly, it is impossible to predict where and with what

[35] Abel, Jonathan. "16,000 Powerless After Violent Storm Tears Across Region." *Washington Post*, July 24, 2005. https://www.washingtonpost.com/archive/local/2005/07/24/16000-powerless-after-violent-storm-tears-across-region/49c814e8-4c31-4f5f-917f-dc8a41122fa5/.

[36] NOAA Lightning Safety. Retrieved on 09/18/2023 from: https://www.noaa.gov/jetstream/lightning/lightning-safety#:~:text=Lightning%20is%20one%20of%20the,average%20and%20injures%20100s%20more.

frequency it will strike. ***Lightning can occur anywhere there is a thunderstorm, making all of Montgomery County equally susceptible***. More than 100,000 thunderstorms occur in the United States each year, with lightning striking more than 25 million points on the ground. Different geographic areas experience varying event frequencies, but in all cases lightning strikes and associated fatalities occur primarily during the summer months. The map below shows historical lightning events in the County.

Figure 19: Map of Lightning Events that have Impacted Montgomery County



b) Range of Magnitude

Lightning costs more than $1 billion in insured losses every year according to the National Weather Service. 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 millions of dollars in damage to buildings, communications systems, power lines, and electrical systems are also the result of lightning.

An extreme scenario for a direct lightning strike would be in a large group of people, such as at an outdoor sporting event or other gathering. Numerous injuries or deaths could occur. While

lightning itself presents a concern, the potential for cascading impacts are also high. For instance, wildfires can result from lightning hitting vegetated areas – particularly if the vegetation is suffering through drought conditions and/or an extreme heat event - and utility outages are more frequent in urbanized areas. Cell and radio towers are frequently impacted and can result in dispatch center outages and downed power lines. On June 20, 2001, lightning struck an apartment complex in Gaithersburg and started a fire that displaced 80 people. The complex sustained $2 million dollars in damage.

c) Past Occurrence

According to the National Centers for Environmental Information (NCEI), there have been 40 recorded lightning events in Montgomery County since 1996. These events resulted in $8.742 million in damages, as listed in the summary below. Furthermore, lightning has caused four injuries and one fatality in Montgomery County.

On August 10, 2021, lightning struck a 3-story apartment building in the 13100 block of Millhaven Place. The lightning started a severe fire in the attic, causing the building to collapse and displacing a dozen families. Damages are estimated at $2.5 million dollars.

According to the National Weather Service, the

greatest impact due to a lightning strike in Montgomery County occurred on July 25, 2010, when lightning struck in Rockville, killing a man attending an outdoor celebration. An article from Maryland's Gazette explained that he was riding a bicycle to a community picnic when the lightning struck.

According to Maryland's Gazette, in June 2008 a home in Bethesda caught on fire due to a lightning strike. Several fires were started throughout the County during the same storm in Germanton, Damascus, Colesville, and Laytonsville. The cause of at least one of the fires may have been lightning striking the gas meter of the home.

A severe storm also occurred on August 15, 2011, where two houses were struck and sustained some damage due to lightning. That evening over 10,000 residents were without power, according to the Washington Post.

Table 12: Lightning Impacts to Montgomery County 1996 - 2023

Location	Events	Deaths	Injuries	Property Damage	Annualized Losses[37]
Montgomery County	40	1	4	$8,742,000	$323,777

[37] *(Current Year) 2023] subtracted by [(Historical Year) 1959] =64 Years on Record*

d) Future Occurrence

40 Lightning strikes in Montgomery County have resulted in injury or property damage over 27 years of record (1996 to 2023). Future occurrence of lightning in the County is anticipated, and the susceptibility to damage from these events will remain unchanged. The probability of future occurrences is considered highly likely.

e) Vulnerability Assessment

(1) People

Lightning is one of the most underrated and unpredictable weather hazards. With the potential for every thunderstorm to kill, whether it produces a single bolt or a thousand. Because lightning is one of the most capricious and unpredictable characteristics of a thunderstorm, no one can guarantee an individual or group absolute protection from it. As demonstrated above, death and injury are a concern.

(2) Structures

Montgomery County faces an annual average of $323,777 in property damage resulting from lightning strikes. These strikes have the potential to directly impact buildings, monuments, and other cultural structures, posing significant risks. Lightning, with its intense heat, can ignite fires, cause structural harm, and can even lead to explosions, particularly in historic buildings that may lack modern lightning protection systems. The likelihood of lightning striking a structure depends on various factors, including the building's height and its proximity to taller objects. Without lightning rods, lightning typically targets a structures highest point, seeking an uncontrolled path to the ground through antennas, concrete structures, pipes, cables, or other means.

(3) Systems

Any connected system is vulnerable to direct or indirect lightning strikes. An additional consideration is that the amount of voltage lightning discharges will not all be the same. Some bolts will have a higher charge. Even if an object does not get directly hit by lighting, and it strikes nearby, it can still cause damage. This kind of secondhand lightning strike can also damage electronic devices that are not properly grounded or do not have surge protectors. In extreme cases, the wires used on communication towers have been severely burnt.

(4) Natural, Historic, & Cultural Resources

As described above, lightning is a leading cause of wildfire, which can destroy valuable natural resources in the county. Impacts that are exacerbated by other hazards like drought and extreme heat. Fire, from any source, can impact cultural resources within a community. Museums, archives, and cultural institutions holding items of historical or artistic significance. Lightning-induced fires, smoke, or water damage from firefighting efforts can harm these items.

(5) Community Activities

For lightning events, the County has been identified as the hazard area. Therefore, all assets, including people, structures, critical facilities and lifelines are exposed and potentially

vulnerable.

According to the Vaisala Interactive Global Lightning Density Map, Montgomery County experiences 35.8 lightning events per km^2 each year.[38]

Table 13: Notable Assets in Montgomery County Damaged by Lightning Strikes

Approximate Date of Event	Asset(s)	Category	Description of Damage
April 22, 2023	Single family home	Structures	Lightning struck a gas line near a home in the community of Colesville. The event ignited a fire in a home, but the occupants were able to evacuate the structure. A spokesperson for Montgomery County Fire and Rescue stated "this happens quite often, unfortunately, with these lightning strikes. They cause the gas lines to catch on fire."[39]
August 10, 2021	Apartment building	Structures	A three-story apartment building in Germantown was struck by lightning. The strike ignited a severe fire which eventually caused the building to collapse. A dozen families were displaced, and property damage was estimated at $2.5 million.[40]
July 28, 2010	Watkins Pond Community Garden	Natural, historic, cultural/ Community activities	Showers and thunderstorms developed along and ahead of a cold front. Tragically, lightning struck and killed one individual during a picknick at the Watkins Pond Community Garden. Others had taken shelter when the storm rolled through, and the fatality was discovered when others returned to the garden after the storm passed.[41]

[38] Lightning data from 2016 to 2022 collected by Vaisala's NLDN and GLD360 detection networks, which monitor in-cloud and cloud-to-ground lightning 24/7 worldwide. Retrieved on 08/09/2023 from: https://interactive-lightning-map.vaisala.com

[39] Flores, Christian. "Lightning Strikes Montgomery County Home as Saturday Storms Keep First Responders Busy." WBFF, April 22, 2023. https://foxbaltimore.com/news/local/weather-severe-lightning-strike-fire-maryland-montgomery-county-colesville-storms-rain-wind-dmv-first-responders-power-outage-weekend-temperature.

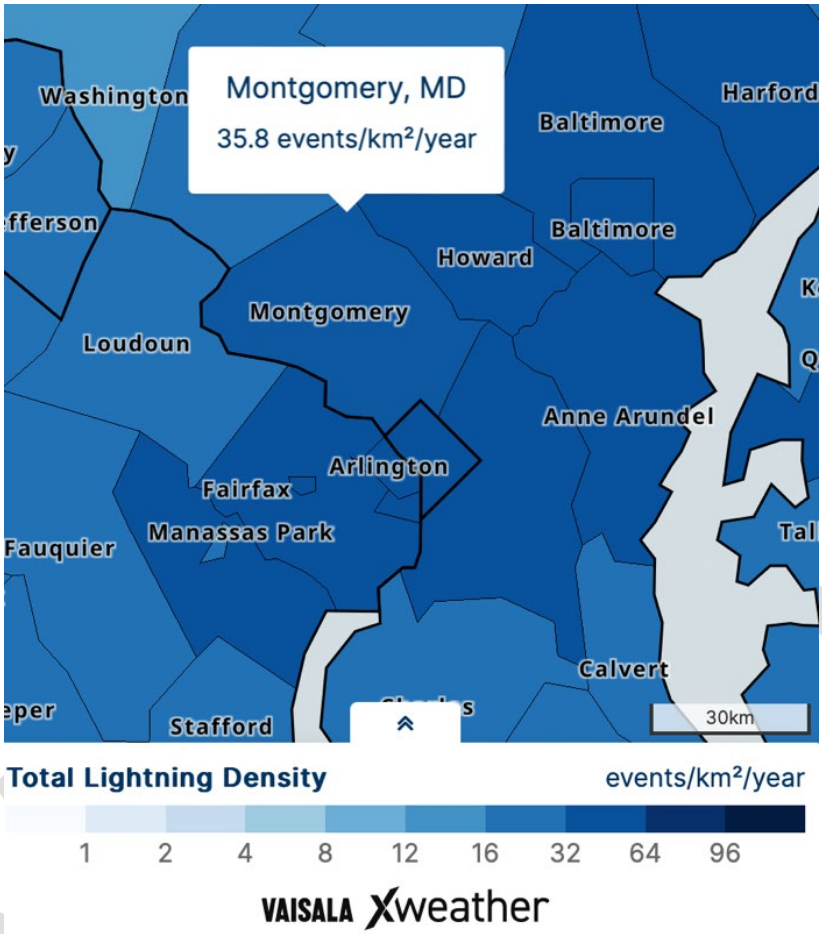
[40] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 27, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=966520.

[41] Kathy Banks. "Rockville Activist Dies After Lightning Strike." *NBC4 Washington* (blog), July 28, 2010. https://www.nbcwashington.com/news/local/rockville-activist-dies-after-lightning-strike/2099363/.

Approximate Date of Event	Asset(s)	Category	Description of Damage
May 25, 2004	Powerlines	Systems	Lightning strikes brought by a string of severe thunderstorms contributed to downed trees across the D.C. metropolitan area. Multiple powerlines were damaged by toppled trees, and this caused power outages for over 100,000 customers in the area.[42]
June 20, 2001	Apartment building	Structures	Scattered thunderstorms rolled through Montgomery County and produced frequent lightning strikes. An apartment complex in Gaithersburg was stuck, and the resulting fire damaged the building. 80 individuals were displaced, and property damage was estimated at $2 million.[43]

[42] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 27, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5396434.
[43] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 27, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5254214.

Figure 20 Lightning Density Map for Montgomery County[44]



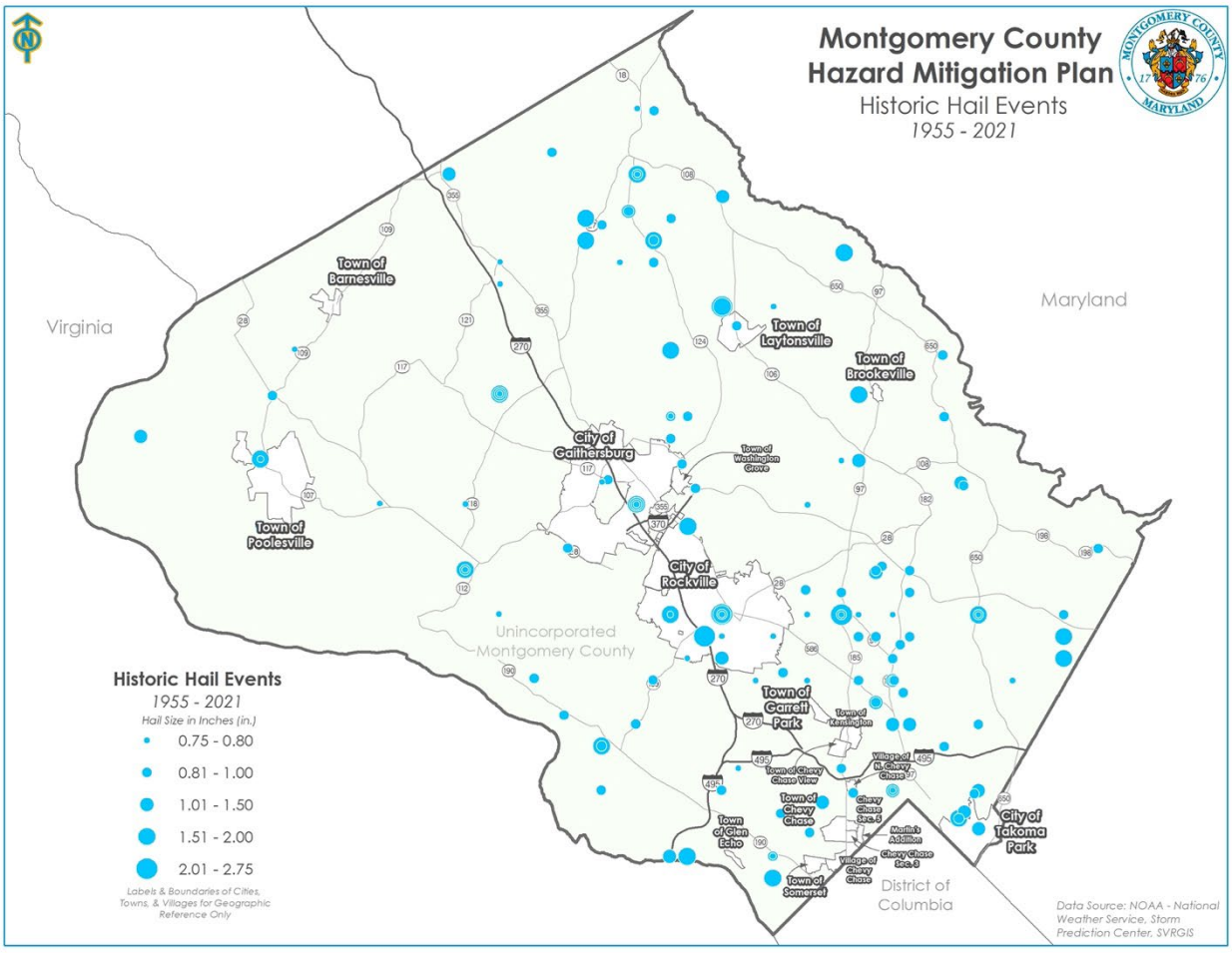
3. Hailstorm

a) Location and Extent

Hailstorms also have equal potential to impact all of Montgomery County. Neither the duration of the storm or the extent affected by such can be predicted. Large hail can damage structures, break windows, dent vehicles, ruin crops, and kill or injure people and livestock. Based on past occurrences, hail sizes greater than 2 inches in diameter are possible and should be accounted for in future planning activities.

[44] Vaisala Lightning Detection Network – Interactive Global Lightning Density Map. Retrieved on 09/29/2023 from: https://interactive-lightning-map.vaisala.com

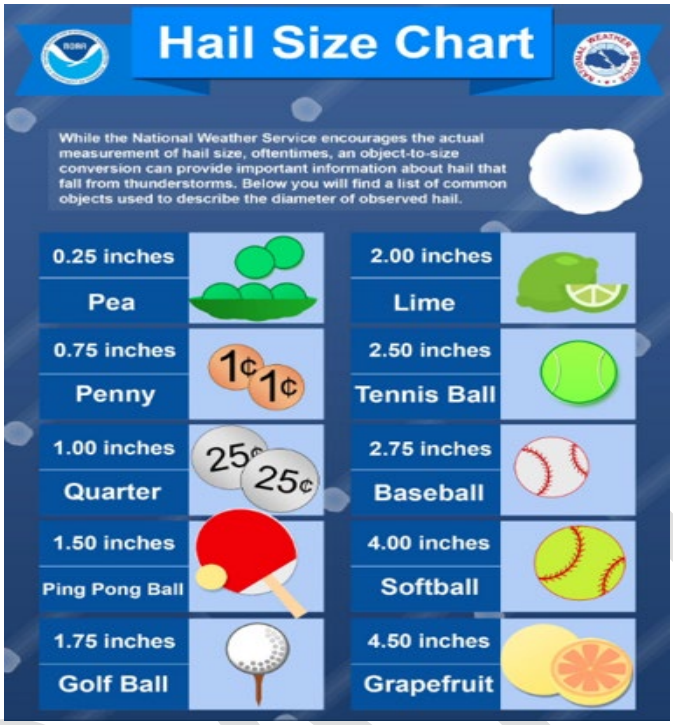
Figure 21: Map of Hailstorm Events that have Impacted Montgomery County



b) 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. Effects of other hazards such as strong winds, intense rain and lightning often occur concurrently because hail precipitation usually occurs during thunderstorms. The figure below depicts the National Weather Service's hail sizing chart.

Figure 22: National Weather Service's Hail Size Chart



c) Past Occurrence

Hailstorms can occur as part of severe weather across Montgomery County. According to NOAA's National Centers for Environmental Information (NCEI) Storm Events Database, Montgomery County experienced 185 hailstorm events between 1965 and 2023, but just four that caused a combined $116,000 in property damage. No deaths or injuries were reported for any of these events. The following table shows hailstorm events recorded since 1965.

Table 14: Hail Events in Montgomery County 1965 - 2023

Location	Events	Deaths	Injuries	Property Damage	Annualized Losses[45]
Montgomery County	185	0	0	$116,000	$2,000

Based on reports from the NCEI, Montgomery County's worst hailstorm incident occurred on June 2nd, 1998, where the strongest cells produced hailstones ranging from 1.75" to 2.50" in diameter; the strong updrafts in each storm combined with steep atmospheric lapse rates to produce not only large hail but long-duration hail as well. Some areas experienced up to 20 minutes of hail, and many residents noted hail which covered the ground. Reported damage included some stripped siding, varying sized dings and dents, as well as shattered glass, in numerous vehicles; stripped paint from homes and vehicles, small limb and leaf debris, and

[45] *(Current Year) 2023] subtracted by [(Historical Year) 1965] =58 Years on Record*

likely crop damage or destruction. The main hail-producing storm affected portions of northern Montgomery, Howard, southern Carroll, southern Baltimore, and northern Prince George's and Anne Arundel Cos - all between 1800 and 1945 EST.

d) 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 Montgomery County will usually occur every year between April and July. Based on historical occurrences of hailstorm events retrieved from NCEI, the probability of occurrence for hailstorm events in Montgomery County is considered Highly Likely.

e) Vulnerability Assessment

We conducted a comprehensive assessment that encompassed all assets within Montgomery County, including its buildings and infrastructure. The assessment focused on evaluating damages caused by severe storms, which are primarily attributed to high winds, lightning strikes, hail, and flooding. While most structures, including critical county facilities, are expected to offer sufficient protection against hail, it's worth noting that they may still experience issues such as broken windows and exterior dents.

f) Severe Storm Summary (Wind, Lightning, Hail)

Montgomery County is susceptible to severe thunderstorms that carry the potential for flash flooding, tornadoes, downbursts, and debris-related hazards. These severe weather events are primarily characterized by the historical and future damages they can inflict through elements like high winds, lightning strikes, heavy precipitation, and the subsequent flooding that follows.

Efforts to mitigate building damage have been most effective when strict building codes have been implemented in areas prone to high winds and designated special flood hazard zones. These regulations, when enforced by local authorities and adhered to by builders, have proven instrumental in reducing the impact of severe storms. Additionally, there are established techniques to minimize lightning damage, notably through grounding methods for buildings.

Critical facilities, including fire and police stations, water and wastewater treatment facilities, community healthcare centers, and schools constructed prior to 1965, may exhibit increased susceptibility to wind damage. As part of the plan implementation process, it is essential to assess these facilities for wind load vulnerabilities and undertake retrofitting measures to mitigate potential wind-related harm. This category of facilities encompasses public shelters, water filtration and pump stations, police and fire stations, schools, and various government buildings in general.

High wind speeds can significantly affect infrastructure, especially communications and utilities. Mass power outages have a profound impact on the functioning of County facilities and utility companies alike. These outages disrupt services, impair transportation networks due to downed power lines and fallen trees, and limit access to and from communities for extended durations. The process of restoring power, clearing debris, and repairing damaged power lines can extend over days, or even weeks. The speed at which a community can recover following a

disaster event plays a crucial role in its resilience. Consequently, continuity planning, both for the public and private sectors, is integral to mitigating prolonged interruptions and fostering a more resilient community.

Table 15: Notable Assets in Montgomery County Damaged by Hail

Approximate Date of Event	Asset(s)	Category	Description of Damage
July 10, 2001	Residences	Structures	Golf ball size hail was recorded in Germantown. The hail damaged homes and cars, although damage was estimated as only $5,000.[46]
June 2, 1998	Residences	Structures	On the evening of June 2, 1998, strong thunderstorms produced hail measured between 1.75" to 2.50". The hail shattered glass, stripped paint from homes and vehicles, and destroyed crops.[47]
November 1, 1994	Mormon Temple	Natural, cultural, historic	Marble to ping-pong ball sized hail was reported in the Kensington area, with several reports from near the Mormon Temple. Damage was estimated to be $5,000.[48]

4. Winter Storm

a) Location & Extent

Winter storms[49] have significantly impacted Montgomery County in the past. Winter storms are regional events that can cause hazardous driving conditions, communications and electrical power failure, community isolation and can adversely affect business continuity.

[46] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5259332.
[47] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5658293.
[48] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=10329594.
[49] In this context, Winter Storms includes the defined events of Blizzard, Heavy Snow, Ice Storm, Winter Storm, and Winter Weather according to NCEI.

b) Range of Magnitude

Blizzards, as defined by the National Weather Service, are a combination of sustained winds or frequent gusts of 35 mph or greater and visibilities of less than a quarter mile from falling or blowing snow for 3 hours or more. A blizzard, by definition, does not indicate heavy amounts of snow, although they can happen together. The falling or blowing snow usually creates large drifts from the strong winds. The reduced visibilities make travel, even on foot, particularly treacherous. The strong winds may also support dangerous wind chills. Ground blizzards can develop when strong winds lift snow off the ground and severely reduce visibilities.

Heavy snow, in large quantities, may fall during winter storms. Six inches or more in 12 hours or eight inches or more in 24 hours constitutes conditions that may significantly hamper travel or create hazardous conditions. The National Weather Service issues warnings for such events. Smaller amounts can also make travel hazardous, but in most cases, only results in minor inconveniences. Heavy wet snow before the leaves fall from the trees in the fall or after the trees have leafed out in the spring may cause problems with broken tree branches and power outages.

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 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 storms develop when a layer of warm (above freezing), moist air aloft coincides with a shallow cold (below freezing) pool of air at the surface. As snow falls into the warm layer of air, it melts to rain, and then freezes on contact when hitting the frozen ground or cold objects at the surface, creating a smooth layer of ice. This phenomenon is called freezing rain. Similarly, sleet occurs when the rain in the warm layer subsequently freezes into pellets while falling through a cold layer of air at or near the Earth's surface. The U.S. National Weather Service defines an ice storm as a storm which results in the accumulation of at least .25 inch of ice on exposed surfaces. Extended periods of freezing rain can lead to accumulations of ice on roadways, walkways, power lines, trees, and buildings. Almost any accumulation can make driving and walking hazardous. Ice accumulations can lead to downed trees, utility poles and communication towers. Ice can disrupt communications and power while utility companies repair significant damage. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

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.

c) Past Occurrence

According to the National Oceanic and Atmospheric Administration (NOAA) and National Centers for Environmental Information (NCEI) Storm Events Database, Montgomery County experienced 442 winter storm events between 1996 and May 31, 2023. Total property damages resulting from these winter storm events were estimated at $2.9 million in Montgomery County.

Table 16: Winter Storm Events in Montgomery County 1996 - 2023

Event Type	Events	Deaths	Injuries	Property Damage	Annualized Losses[50]
Blizzard	2	0	0	$10,000	$370
Heavy Snow	6	0	0	$30,000	$1,111
Winter Storm	50	2	8	$5,000	$185
Winter Weather	158	0	0	$0	$0
Ice Storm	5	0	0	$2,900,000	$107,407
Total	**221**	**2**	**8**	**$2,945,000**	**$109,074**

The most notable event of record was an ice storm that began on January 14th, 1999. A strong arctic cold front moved slowly southeast across the Mid-Atlantic region from late on the 13th to midday on the 15th. This front brought a thick layer of sub-freezing air to the lowest levels of the atmosphere, but just off the surface warmer air moved in. A low-pressure system developed on the 13th over the Tennessee Valley. The low moved into the Mid-Atlantic region over the next few days, spreading precipitation region wide from early on the 13th through midday on the 15th. The precipitation started as snow but melted into rain as it fell through the warm layer of air. Unfortunately, west of the cold front the ground was below freezing during the period, so the rain froze on every surface it came in contact with. This created ice accumulations of one quarter to one half inch north and west of a line from Montgomery County to Harford County through early afternoon on the 14th. By 9 AM on the 15th, ice accumulations from one quarter to nearly one inch occurred across all Western and Central Maryland, except Charles, Calvert, and St. Mary's County where a trace to one quarter inch accumulated.

[50] *Current Year) 2023] subtracted by [(Historical Year) 1996] =27 Years on Record*

d) Future Occurrence

The history of winter storm events indicate that future winter storm events of varying degrees will occur in across the County. The frequency of major events in the past throughout the region suggests that many people and properties will remain at future risk.

Based on NCEI Storm Event data, the probability of future occurrence for winter storm events in Montgomery County is considered ***likely***.

e) Vulnerability Assessment

(1) People

Secondary effects of winter storms can increase the risk to life and health in Montgomery County's population. Snow accumulation and frozen/slippery road surfaces increase the frequency and impact of traffic accidents for the general population, resulting in personal injuries. Winter storms can disproportionately affect the sick, older adults aged 65 or older, and children under the age of 5 due to the exacerbation of chronic illnesses such as asthma, and the inability to effectively regulate body temperatures. Low-income, displaced persons, and unsheltered populations frequently lack access to adequate home heating systems during winter storm events. No matter age or vulnerability, people exposed to cold temperatures for extended periods of time run the risk of developing dangerous conditions such as hypothermia or frostbite. Severe winter storm events can also reduce the ability of these populations to access emergency services.

(2) Structures

Winter storms can also cause structural losses. Building collapses and structural damage can occur when snow accumulates on flat rooftops, or porch awnings. As snow melts, it can collect in depressed or recessed areas, a condition commonly known as ponding. This additional weight from either snow accumulation or ponding jeopardizes a building's structural soundness and may lead to total collapse. Vulnerability to the effects of winter storms on buildings is dependent on the age of the building, what building codes may have been implemented at the time of construction, the type of construction and condition of the structure, including how well has the structure been maintained.

(3) Systems

Severe winter weather can immobilize a region, shutting down all air and rail transportation, stranding commuters, stopping the flow of supplies, and disrupting medical and emergency services. Winter weather can also cause building collapses and can bring down trees, electrical wires, telephone poles, lines and communication towers. Damages to utilities can disrupt communications and power for days while utility companies work to repair the issues. In addition, severe winter weather can affect rail beds and the switch systems. Winter weather

may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

(4) Natural, Historic, & Cultural Resources

There are no known vulnerabilities to natural resources from winter weather hazard other than potential damage from heavy snow and ice accumulation.

(5) Community Activities

Severe winter weather has the potential to immobilize the region causing cancellations of planned events or activities. However, this is short lived and rather temporary.

Table 17: Notable Assets in Montgomery County Impacted by Winter Storms

Approximate Date of Event	Asset(s)	Category	Description of Damage
January 14, 1999	Power grid	Systems	Freezing rain left created ice accumulations of one quarter to one half inch. The storm knocked out power for approximately 187,000 customers, and 11 of 41 sub-stations were knocked out. Many homes did not have power restored for several days, and the Maryland governor declared a state of emergency in Montgomery County. Additionally, the ice resulted in 30 cases of Montgomery County school buses slipping off roads, although there were no reported fatalities.[51]
January 7, 1996	Rail Infrastructure	Systems	An historic winter storm dubbed the "Blizzard of '96" crippled all of Maryland west of the Chesapeake Bay. Shortly after the onset of the storm, a train with three persons aboard slid into another in Montgomery County, killing the driver. The following evening, 80 passengers were stranded when a train got stuck between stations. Many above-ground stations remained

[51] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 27, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5680091.

Approximate Date of Event	Asset(s)	Category	Description of Damage
			closed throughout the following work week.[52]

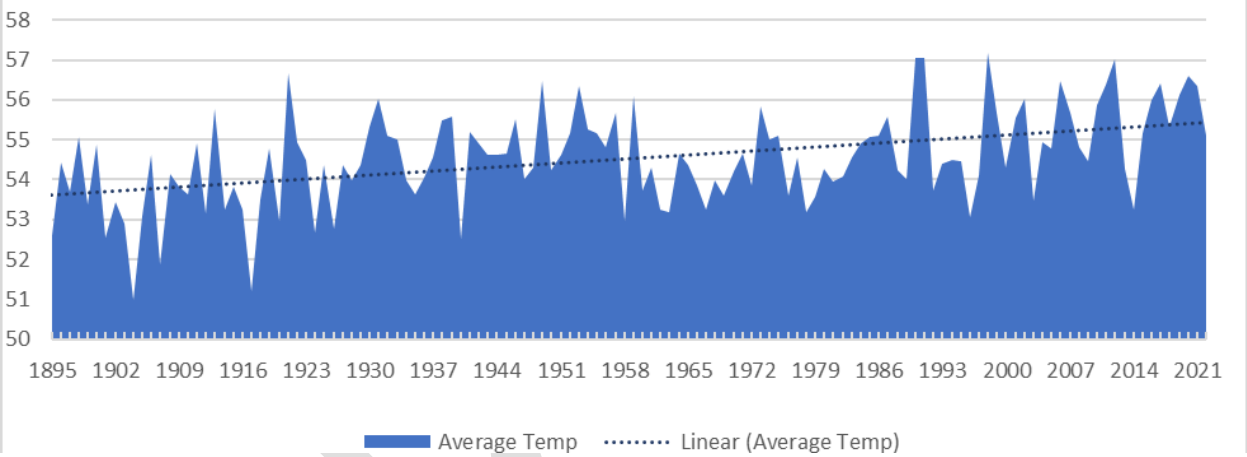
5. Extreme Temperatures (Heat and Cold)

a) Location & Extent

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.[53] 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.[54]

The following figure depicts the average yearly temperatures across Montgomery County.

Figure 23: Average Yearly Temperature in Montgomery County 1895 - 2022

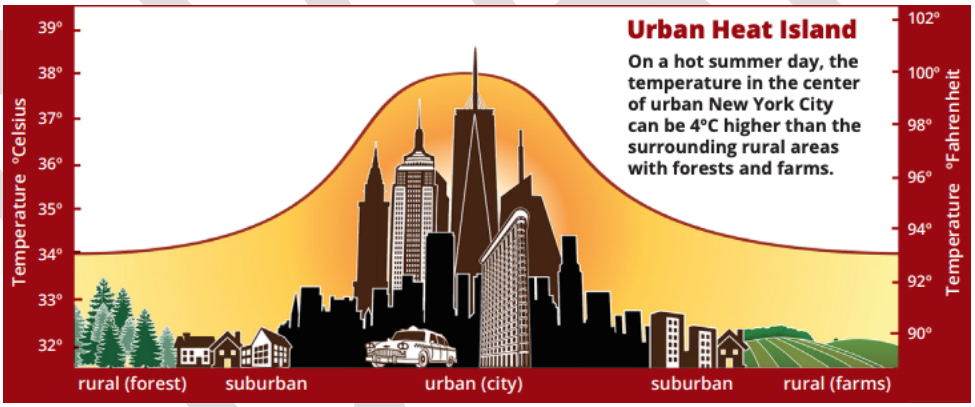


[52] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 27, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5541126.
[53] Ready.Gov – Heat. Retrieved on 07/06/2023 from: https://www.ready.gov/heat
[54] Centers for Disease Control (CDC) – Hypothermia. Retrieved on 07/06/2023 from: https://www.cdc.gov/disasters/winter/staysafe/hypothermia.html

Montgomery County 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 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.[55] The image below depicts the differences in temperatures from urban and rural areas.

Figure 24: Urban Heath Island[56]



[55] 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

[56] My NASA Data – Interpreting a Graph of Surface Temperature of Urban Areas. Retrieved on 08/30/2023 from: https://mynasadata.larc.nasa.gov/mini-lessonactivity/interpreting-graph-surface-temperature-urban-areas

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.

b) Range of Magnitude

Extreme temperatures can lead to higher utility costs and pose significant health risks. Prolonged exposure to extreme heat can result in conditions ranging from heat stress to heatstroke, with potential outcomes including heat cramps, heat syncope, heat exhaustion, and even death. The effects of these high temperatures are individual-specific, influenced by factors like age, health, and others. Notably, the elderly and young children are the most susceptible to health issues caused by extreme heat.

On the other end of the spectrum, cold temperatures, without adequate heat and shelter, can result in hypothermia, frostbite, and in extreme cases, death. Instead of absolute temperatures, wind chill values are often cited due to the amplified cold effect wind can have on the body. In

Montgomery County, wind chill warnings are triggered when forecasts predict values plunging to -25°F or below, while advisories are issued at values approaching -15°F.[57]

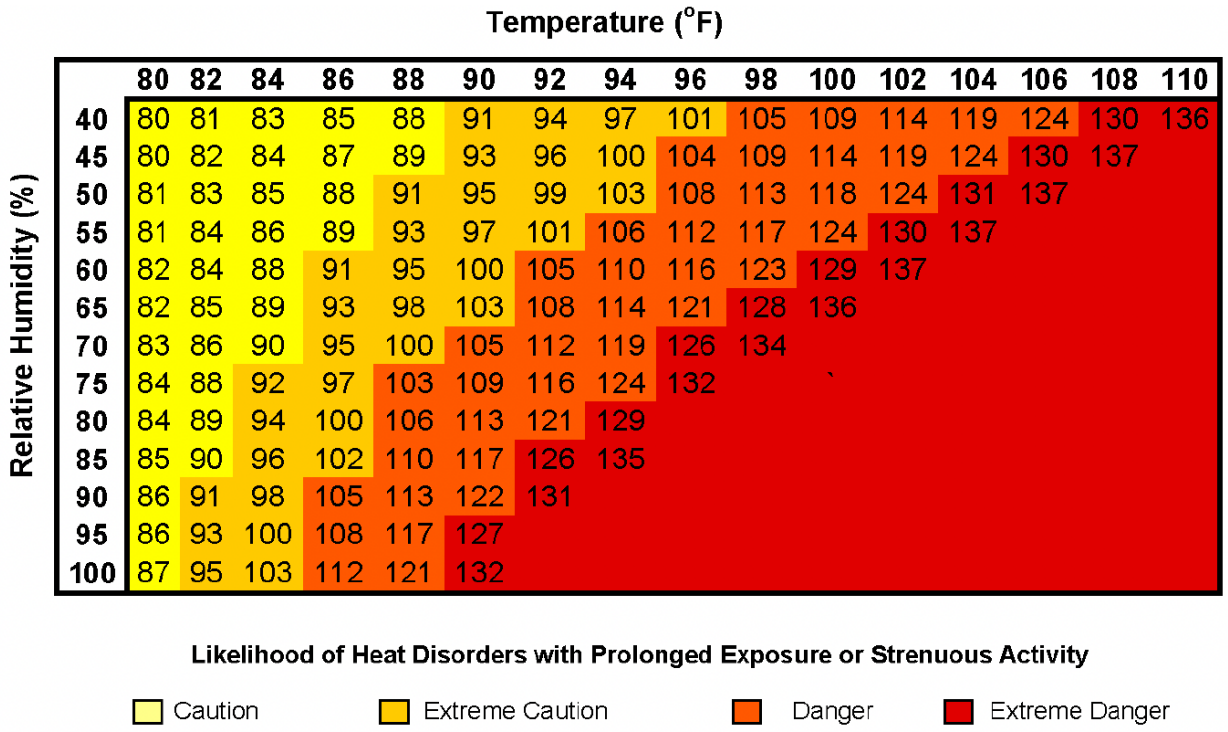
Temperature advisories, watches and warnings are issued by the National Weather Service relating the above impacts to the range of temperatures typically experienced in Maryland. Exact thresholds vary across the region, but in general Heat Advisories are issued when the heat index will be equal to or 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.

Extreme Heat

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 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 25: National Weather Service Heat Index

[57] National Weather Service. Weather Field Office Baltimore/Washington



NOAA bases its heat alert procedures on the heat index, which is expressed in degrees Fahrenheit (°F). The heat index combines the actual air temperature with relative humidity to convey how hot it feels. To determine this value, both temperature and relative humidity are required. Notably, the given heat index values are calculated for conditions in the shade with light winds. Direct sunlight can elevate these values by as much as 15°F.[58]

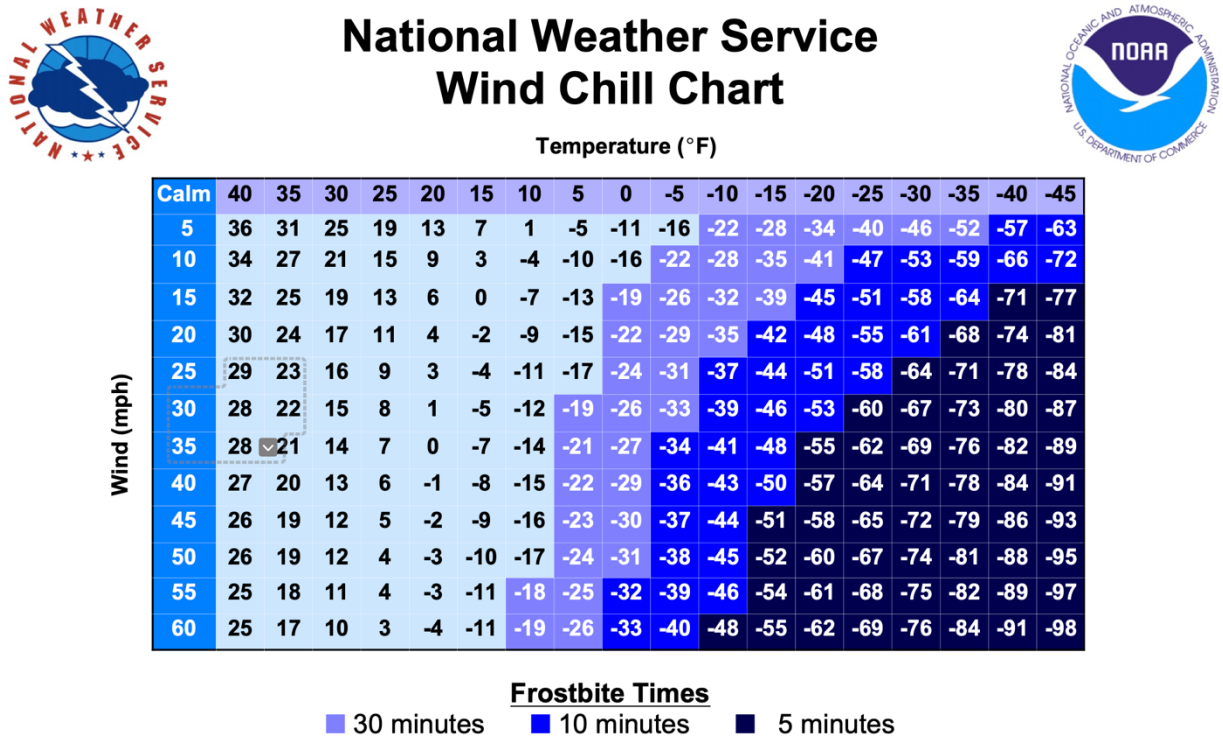
Extreme Cold

The Wind Chill Temperature (WCT) Index is a primary measure of extreme cold temperatures. It represents the perceived temperature experienced by humans and animals, factoring in the cooling effects of wind on exposed skin. With increasing wind speeds, our body cools more rapidly, which can lower skin temperature. The WCT Index also indicates when and how long it

[58] National Weather Service. Weather Field Office Baltimore/Washington

takes for frostbite to occur based on temperature, wind speed, and exposure duration, as detailed in the figure below. [59]

Figure 26: National Weather Service Wind Chill Chart



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

Temporary periods of extreme hot or cold temperatures typically do not have significant environmental impacts but have serious health impacts, especially in urban areas experiencing the heat island effect. However, prolonged periods of hot temperatures may be associated with drought conditions and can damage or destroy vegetation, dry up rivers and streams, and reduce water quality. Prolonged exposure to extremely cold temperatures can kill wildlife and vegetation.[60]

[59] National Weather Service. Wing Chill. Retrieved on 08/10/2023 from: https://www.weather.gov/ama/WindChill#:~:text=Wind%20Chill%20is%20a%20term,skin%20if%20you%27re%20outside.

[60] 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

c) Past Occurrence

Since 1996, Montgomery County experienced more than 59 extreme temperature events.[61] These events have been responsible for 3 death and 38 injuries. Please note that extreme temperature data is regional, and the temperatures, deaths and injuries were not necessarily in Montgomery County. It should also be noted that the deaths and injuries were due to excessive heat events.

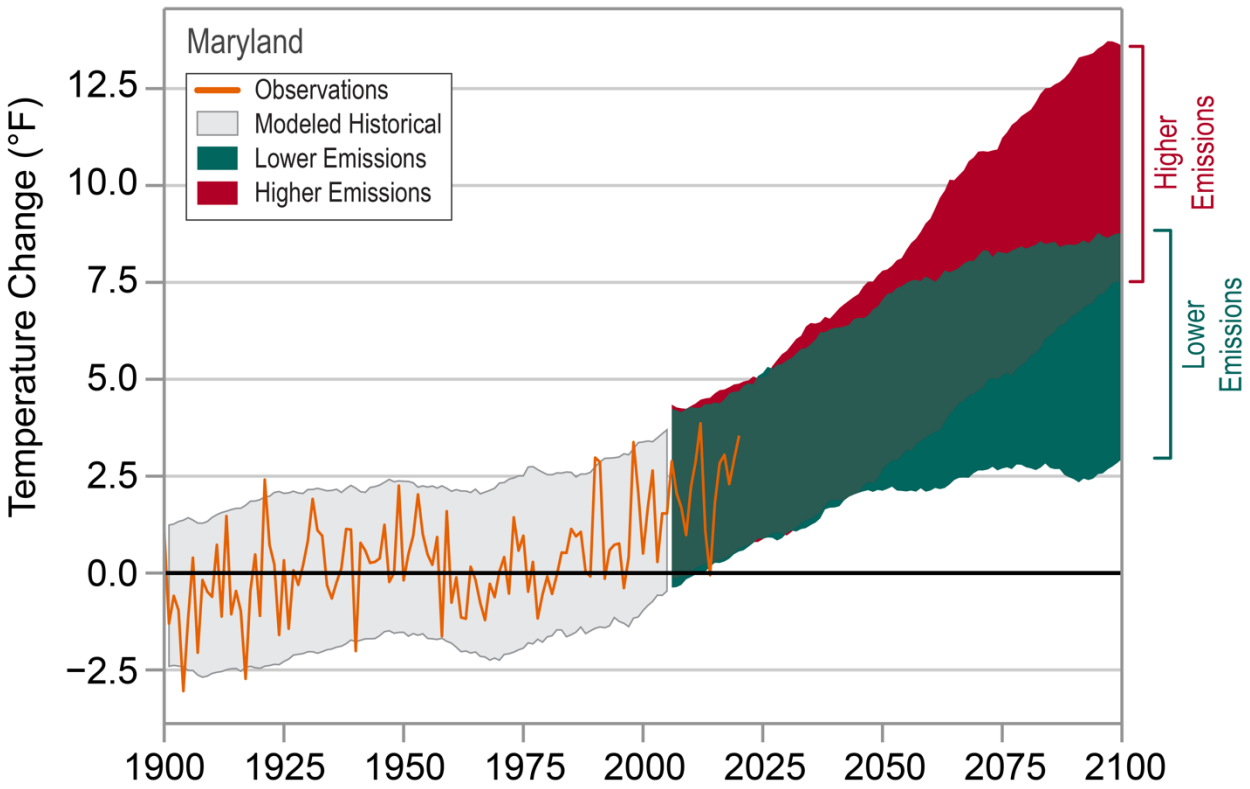
Table 18: Extreme Temperature Events in Montgomery County 1996 - 2023

Event Type	Events	Deaths	Injuries	Property Damage	Annualized Losses[62]
Cold / Extreme Cold	14	0	0	$0	$0
Heat / Excessive Heat	45	3	38	$0	$0
Montgomery County Total	**59**	**3**	**38**	**$0**	**$0**

Maryland has experienced a notable temperature increase of approximately 2.5°F since the dawn of the 20th century (as depicted below). In the 21st century, temperatures have consistently exceeded those of any previous era, marking a period of unprecedented warmth. The year 2012 holds the record as the warmest on record, with 7 of the 10 warmest years occurring since the turn of the millennium. In the year 2020, which stands as the second warmest on record, July etched its name in history as the hottest month ever recorded for both the city of Baltimore and the entire state of Maryland.

Figure 27: Observed & Projected Temperature Change in the National Capital Region

[61] National Centers for Environmental Information – Storm Events. Retrieved on 08/10/2023.
[62] *(Current Year) 2023] subtracted by [(Historical Year) 1996] =27 Years on Record*

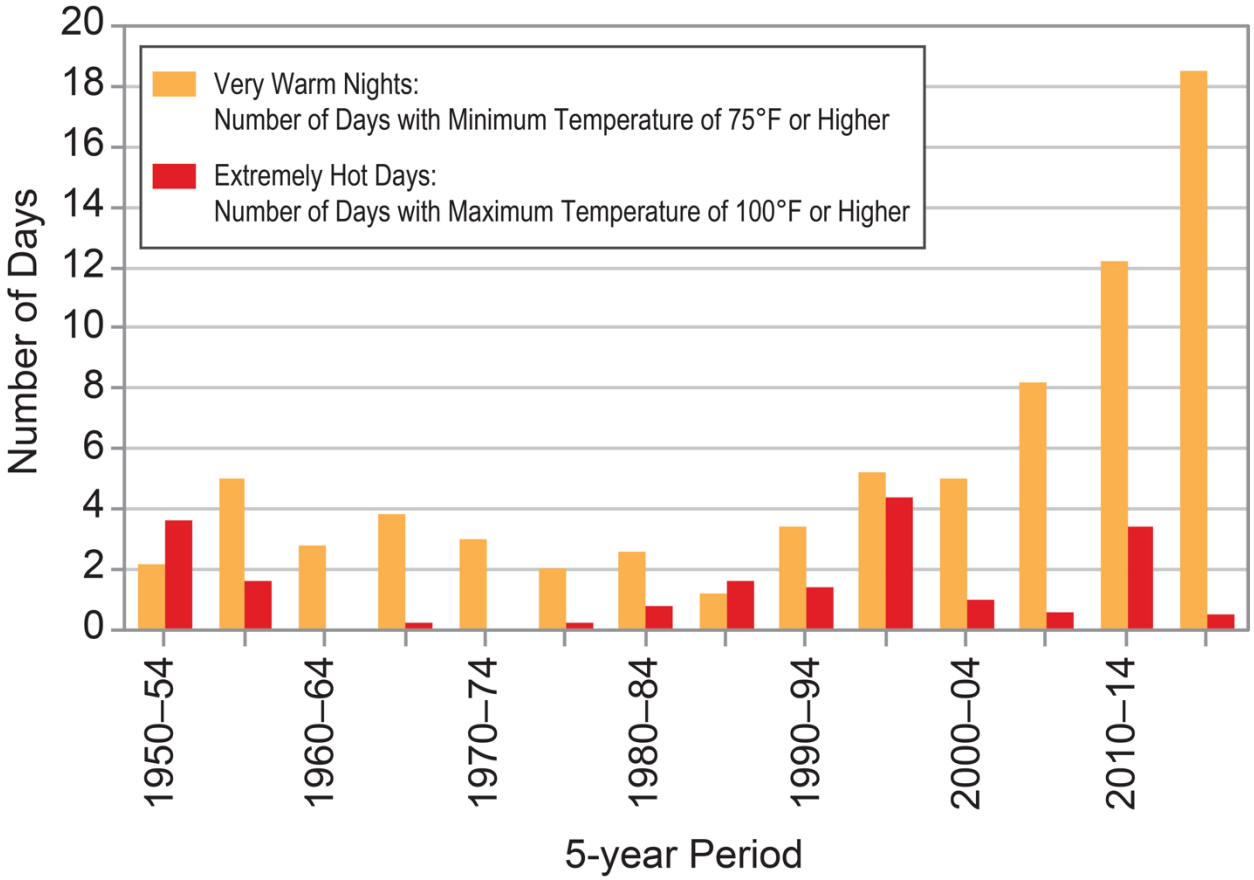


The figure below displays the observed annual occurrences of two distinct weather phenomena in the District of Columbia: very warm nights, defined as nights with a minimum temperature of 75°F or higher, and extremely hot days, characterized by maximum temperatures of 100°F or higher. Each bar represents the average count over 5-year intervals, with the final bar representing a 6-year average.[63]

The data reveals that there has been no discernible trend in the frequency of extremely hot days since 1950. Conversely, the number of very warm nights has exhibited a consistent and upward trajectory since 1985. Notably, the most substantial multiyear averages have materialized during the 2005–2020 period.

- [63] NOAA NCEI, n.d.: Climate at a Glance: Statewide Time Series, Maryland. National Oceanic and Atmospheric Administration, National Centers for Environmental Information, Asheville, NC, accessed March 8, 2020. https://www.ncdc.noaa.gov/cag/statewide/time-series/18/

Figure 28: Very Hot Days in District of Columbia[64] [65]



d) Future Occurrence

Montgomery County's geographical location makes it more susceptible to excessive heat rather than extreme cold weather. The county's topography and vegetation play a significant role in influencing temperature variations across its expanse. Consequently, it is anticipated that the entire county will continue to face annual temperature extremes, which could potentially trigger secondary hazards. These secondary hazards may include events such as snowfall, hailstorms, icy conditions, windstorms, thunderstorms, droughts, adverse effects on human health, interruptions to utility services, and transportation accidents.

Probability of Future Occurrences

[64] The Cooperative Institute for Satellite Earth System Studies
[65] NOAA – National Center for Environmental Information

Over the 27 years of record keeping of extreme temperature events (1996-2023), there have been 59 recorded events, an average of 2.18 events per year. As such, the probability that Montgomery County will experience an extreme temperature event in any given year is ***Highly Likely***.

e) Vulnerability Assessment

(1) People

Extreme temperatures can have a disproportionately negative impact on socially disadvantaged people, exacerbating existing inequalities and vulnerabilities. Here are several ways in which extreme temperatures can affect them:

- **Health Risks**: Socially disadvantaged populations, often with limited access to healthcare and resources, are more susceptible to heat-related illnesses such as heat exhaustion and heatstroke during extreme heatwaves. Chronic health conditions can worsen due to heat stress.
- **Housing Inadequacies**: Low-income individuals and families may live in substandard housing, lacking proper insulation or air conditioning. This can make their homes unbearable during extreme heat or cold, putting their health and well-being at risk.
- **Energy Poverty**: Many socially disadvantaged households struggle with energy poverty, meaning they cannot afford to adequately heat or cool their homes. This can lead to discomfort and even life-threatening situations during temperature extremes.
- **Financial Strain**: Extreme temperatures can result in increased utility bills for heating or cooling, putting an additional financial burden on low-income households. They may have to choose between paying for energy bills and other essentials like food or medication.
- **Limited Mobility**: Extreme temperatures can restrict mobility, making it difficult for socially disadvantaged individuals, especially those without access to personal transportation, to reach cooling or heating centers, medical facilities, or emergency shelters.
- **Increased Vulnerability**: Those experiencing homelessness are particularly vulnerable to extreme temperatures, as they lack a safe and stable shelter. Exposure to extreme cold or heat can lead to hypothermia or heat-related illnesses, often with fatal consequences.
- **Education Disruption**: Schools without proper climate control may close during extreme weather, disrupting the education of disadvantaged children who rely on school meals and a safe environment.

- **Workplace Safety**: Socially disadvantaged individuals are often employed in jobs that require outdoor labor or exposure to extreme temperatures, such as agricultural or construction work. They may face health risks due to these working conditions.
- **Disaster Vulnerability**: During extreme weather events like hurricanes or wildfires, socially disadvantaged populations may lack the resources or support networks to evacuate or recover from disasters, leading to greater vulnerability and long-term displacement.
- **Mental Health Impacts**: Prolonged exposure to extreme temperatures and the associated stress of trying to cope with adverse conditions can contribute to mental health challenges, which may be compounded by limited access to mental healthcare.

Addressing the impacts of extreme temperatures on socially disadvantaged populations requires comprehensive strategies that encompass affordable housing, improved access to healthcare, energy assistance programs, and community support systems. Climate adaptation and resilience efforts should prioritize these vulnerable communities to ensure equitable protection against extreme weather events.

(2) Structures

Portions of Montgomery County's utility infrastructure are vulnerable to extreme temperatures, which can lead to two significant issues: overloading the power grid and damage to the pipes responsible for water, wastewater, and natural gas distribution. During extreme cold spells, the freezing or fracturing of pipes and water intakes can result in disruptions to services related to water, drainage, and gas supply.

To mitigate potential service interruptions, utility providers, such as BG&E, PEPCO, First Energy/Potomac Edison, and Washington Gas, proactively monitor weather conditions, conduct routine maintenance, and promptly address any emerging problems.

(3) Systems

Transportation infrastructure can also be impacted by extreme temperatures. During extreme heat, roads and bridges can buckle due to expansion and heat kinks can form on railway lines. The County, MDOT, FLASH, Amtrak, and private railroads routinely monitor their infrastructure’s condition and perform maintenance and regular inspections. Extreme cold can result in freeze-thaw cycles that cause cracking or potholes in roadway surfaces. This requires the County and MDOT to conduct regular repairs. Roadway repair from this type of winter damage is the major driver of economic losses related to extreme temperatures in Montgomery County.

(4) Natural, Historic, & Cultural Resources

Extreme temperatures could have detrimental effects on Montgomery County's cultural resources, including historical landmarks, artifacts, artistic works, and cultural institutions. Here are several ways in which extreme temperatures could impact these valuable assets:

- **Physical Damage**: High temperatures can accelerate the deterioration of historical buildings and monuments. Prolonged exposure to extreme heat can cause structural damage, such as cracks in stone or the weakening of wooden components.
- **Artifacts and Artwork**: Extreme temperatures, especially in the form of heatwaves, can damage sensitive artifacts and artwork. Materials like paper, textiles, and organic substances can degrade, fade, or become brittle when exposed to excessive heat and humidity fluctuations.
- **Thermal Stress**: Rapid temperature fluctuations, such as those experienced during heatwaves followed by cool nights, can subject cultural resources to thermal stress. This can lead to the expansion and contraction of materials, potentially causing cracking or warping.
- **Mold and Pest Infestations**: Heat and humidity can create conditions favorable for mold growth and pest infestations within cultural institutions like museums and archives. Mold can irreparably damage documents, books, and artwork, while pests can feed on or damage historical materials.
- **Energy Costs**: Extreme temperatures often require cultural institutions to use more energy for climate control and preservation. This can strain their budgets, diverting resources away from conservation and education efforts.
- **Visitor Access**: Uncomfortable temperatures, whether due to extreme heat or cold, can deter visitors from cultural sites and institutions. Reduced visitation can impact revenue and community engagement.
- **Outdoor Cultural Spaces**: Extreme heat or drought conditions can negatively affect outdoor cultural spaces, such as gardens, sculptures, and open-air theaters. Plant life can wither, and sculptures may deteriorate more rapidly under intense sunlight.
- **Community Events**: Cultural events, festivals, and gatherings may be affected by extreme temperatures. High heat can pose health risks to attendees, while extreme cold can limit outdoor event participation.
- **Historical Landscapes**: Historic landscapes and gardens may suffer from drought and heat stress, potentially leading to the loss of rare or culturally significant plant species.
- **Risk to Archives and Records**: Extreme heat can pose a threat to historical archives and records, which are often stored in temperature-controlled environments. If cooling systems fail during heatwaves, these records could be at risk of damage.

To mitigate the impact of extreme temperatures on cultural resources, communities and cultural institutions in Montgomery County could implement climate control measures, invest in preservation techniques, and develop emergency plans for extreme weather events. Additionally, raising awareness about climate change and its effects on cultural heritage can encourage proactive efforts to protect these valuable assets for future generations.

(5) Community Activities

During extreme temperature events it may be necessary to cancel outdoor activities due to unsafe temperatures. In a heatwave in early September 2023, the City of Baltimore issued a Code Red for excessive heat and closed schools that were not air conditioned, canceled after school outdoor activities and canceled other outdoor sporting events.[66]

Table 19: Notable Assets in Montgomery County Impacted by Extreme Temperatures

Approximate Date of Event	Asset(s)	Category	Description of Damage
June 12, 2000	Kemper Open	Natural, historic, cultural	Abnormally hot and humid weather resulted in cases of heat exhaustion and dehydration among spectators at the Kemper Open. Two spectators required hospitalization to treat their symptoms.[67]
July 13, 1997	Area medical facilities	Structures	A heat way resulted in average daily temperatures above 90 degrees Fahrenheit for 7 days. Local hospitals became strained as many dozens of individuals were treated for heat exhaustion and heat stroke. Two deaths were recorded in Montgomery County as a result of the heatwave.[68]
April 10, 1997	Farmland/ crops	Natural, historic, cultural	A record cold artic air mass descended over Maryland, dropping temperatures below 20 degrees Fahrenheit. The unusual cold came at a critical time for crops, and near total kills of peaches, strawberries, cherries, plums, and

[66] WBAL TV – September 2023 Heath Wave. https://www.wbaltv.com/article/weather-summer-heat-wave-september-3-6-2023/44984563
[67] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5600185.
[68] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5611120.

Approximate Date of Event	Asset(s)	Category	Description of Damage
			apples occurred. At least 1870 acres were affected in Montgomery, Washington, Frederick, and Allegheny County.[69]

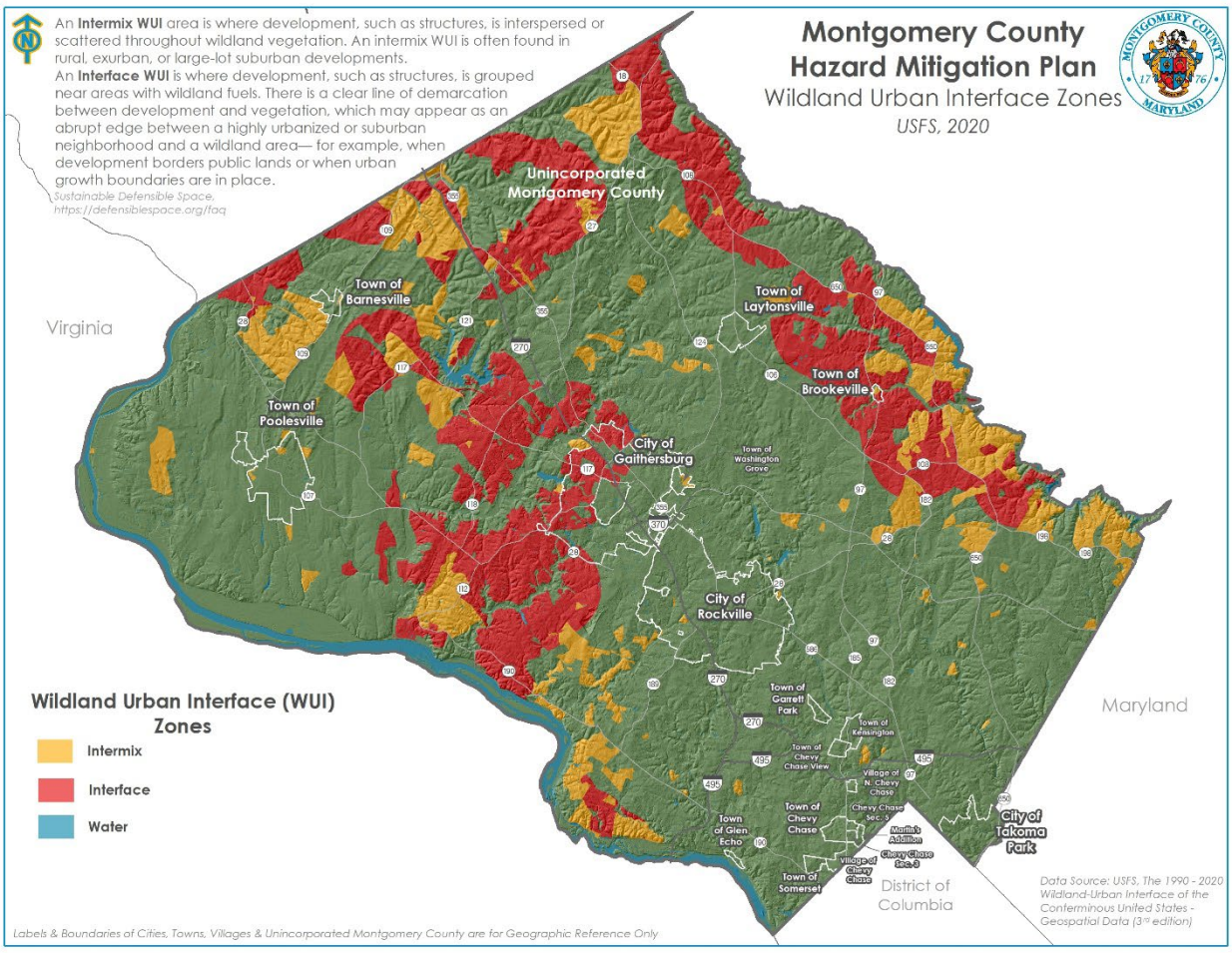
6. Wildfire

a) Location & Extent

Montgomery County is not typically associated with high wildfire risk when compared to regions in the western United States or areas with dry climates. However, like many regions, it is not immune to the possibility of wildfires under certain conditions. Some parts of Montgomery County have areas where urban development meets natural landscapes or wooded areas. These wildland-urban interface (WUI) zones can be at greater risk for wildfires, especially during dry conditions. Extended periods of drought can increase the risk of wildfires by drying out vegetation, making it more susceptible to ignition. While Maryland does not experience drought conditions as frequently as some other states, droughts remain a possibility and can be difficult to predict.

[69] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5600181.

Figure 29 Wildland Urban Interface and Intermix Zones in Montgomery County



Human activities, such as campfires, discarded cigarettes, and arson, can lead to wildfires. With the presence of parks, forests, and recreational areas in the county, there is a potential for human-caused wildfires. Changes in climate patterns, including temperature and precipitation, can influence the frequency and severity of wildfires. While the region does not typically experience extreme arid conditions, shifts in climate can still impact wildfire risks. Proper forest management practices, including controlled burns and vegetation clearance, can mitigate wildfire risks. Inadequate forest management can contribute to the buildup of flammable materials. High winds can facilitate the rapid spread of wildfires, even in regions not typically associated with fire risk. Wind-driven embers can carry the fire to new areas.

Most wildfires in Maryland are surface fires, which burn fallen leaves, twigs, and debris on the ground. Under this fallen debris is often a layer of partially decomposed vegetation, called "duff." During dry periods, fires can burn in this duff layer underneath the surface, and these fires can be very difficult to extinguish. If the conditions are sufficient, these duff fires can burn for weeks, or even months. In addition to the direct impacts of the flames, large fires can

generate massive volumes of smoke, and wind can carry the smoke across hundreds of square miles. Prolonged exposure to smoke can be harmful, particularly for sensitive populations like young children, the elderly, and individuals with asthma or other respiratory conditions.

b) Range of Magnitude

If the conditions are right, wildfires can burn hundreds or even thousands of acres, but wildfires of such a scale are rare. Typically, most wildfires are smaller in size and burn less than 10 acres. However, even small wildfires are often larger than fires in the urban areas, and specialized equipment and tactics are often necessary to properly contain and control them. The Maryland Forest Service responds to approximately 123 wildfires per year that burn an average of 1,780 acres, and most of these occur in rural and suburban regions of Maryland.[70]

Wildfires can spread faster than the visible flame front travels, and they may even appear to skip over areas altogether. This is partly due to the tendency of embers, which are also called firebrands, to be carried as far as 25 miles by the wind before landing. When they land, firebrands can spark new fires in areas previously unmolested by the initial fire. The speed at which wildfires are capable of spreading can catch communities off-guard – wildfires have been documented moving at nearly a mile every 4 minutes.[71] Furthermore, wildfires can expand in multiple directions simultaneously, and extreme examples like the 2018 Camp Fire were observed expanding at a rate of approximately one football field every second.[72] At this pace, the Camp Fire grew by nearly 10,000 acres in a 90-minute span.

c) Past Occurrence

According to the Maryland Department of Natural Resources, 96% of wildfires which have occurred in Maryland are caused by human activity, with the remaining 4% being the result of lightning strikes. The specific human activities which have led to the most wildfires in Maryland are improper burning of debris (35%) and arson (30%). Additional wildfires have ignited because of equipment failures, campfires, smoking, railway sparks, downed powerlines, fireworks and other miscellaneous human activity.

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[70] Maryland Department of Natural Resources. "Wildland Fire in Maryland." Maryland Department of Natural Resources. Accessed September 21, 2023. https://dnr.maryland.gov/forests/Pages/default.aspx.
[71] Mercury Insurance. "How Wildfires Start and Spread," March 30, 2022. https://www.mercuryinsurance.com/resources/weather/how-wildfires-start-and-spread.html.
[72] Jones, Judson. "One of the California Wildfires Grew so Fast It Burned the Equivalent of a Football Field Every Second." CNN, November 9, 2018. https://www.cnn.com/2018/11/09/us/california-wildfires-superlatives-wcx/index.html.

As of September 2023, a detailed database of historic wildfires in Montgomery County could not be identified. However, news articles and anecdotal evidence provide glimpses of previous fires which affected Montgomery County and the central portion of Maryland:

> **April 12, 2023**: Montgomery County Fire and Rescue responded to a brush fire near Dickerson. The fire occurred near railroad tracks used by both CSX and Maryland Area Rail Commuter (MARC) trains. These services were temporarily delayed as a result of the fire.[73]
>
> **March 31, 2015**: A brush fire ignited near Laytonsville. According to Montgomery County Fire and Rescue, the fire grew to encompass an area larger than 30 acres. Containing this fire required 10 fire engines, 8 water tankers, 12 brush trucks, and a helicopter.[74] Fortunately, there were fatalities or injuries reported because of the fire.
>
> **February 19, 2011:** A wildfire ignited near the Ancient Oaks North Subdivision, which is south of Germantown. The fire quickly grew to nearly 500 acres and became one of the largest wildfires on record in Montgomery County. Containing the fire required 330 personnel from county, state, and federal agencies. An Incident Status Summary (incident no. 11-0020592) reveals that 8 civilians were evacuated, and 7 responders were injured. Additionally, 6 residences were damaged, and 6 minor structures were destroyed.[75]

The above incidents reinforce the reality that, although the threat is lower than in other parts of the U.S., wildfires in Montgomery County can occur and threaten both people and property. It should also be noted that many wildfires in Montgomery County are less than 10 acres in size and may not be reported on by news outlets.

d) Future Occurrence

In Maryland, wildfire occurrence is highest in the spring and fall when forest fuels are the driest and weather conditions — warm, dry, and windy — are most conducive for the spread of fire.

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[73] Fox 5 Digital Team. "Brush Fire Disrupts Some CSX, MARC Traffic in Montgomery County." FOX 5 DC, April 12, 2023. https://www.fox5dc.com/news/brush-fire-disrupts-some-csx-marc-traffic-in-montgomery-county.
[74] Montgomery County Fire & Rescue. "Wildfire." montgomerycountymd.gov, March 14, 2018. https://www.montgomerycountymd.gov/frs-gl/Resources/Files/operations/wildfire/Wildfire_Presentation_Notes.pdf.
[75] Montgomery County Fire & Rescue. "Darnestown Complex Wildland Urban Interface Fire." fmontgomerycountymd.gov, February 19, 2011. https://www.montgomerycountymd.gov/frs-gl/resources/files/swsj/operations/pia/2011/cy11-02_19_Darnestown_Complex_WUI-FINAL.pdf.

In spring, with the absence of moist deciduous vegetation and forest canopy shade, the sun warms the forest floor pre-heating the fuels. In fall, an abundance of new fuel accumulates with leaf fall. Given adequate rainfall amounts throughout the state, wildfires are mostly suppressed on initial attack and can be intense but are relatively short-lived. However, unusually hot and dry conditions or drought can turn a mild fire season into a serious challenge; wildfires which occur under such conditions often require extended attack operations to completely suppress.

Recent development trends have resulted in more and more homes being built in or near wildland urban interface and intermix zones. Because most wildfires in Maryland are the result of human activity, the increasing presence of human structures near natural fuels in wildland urban interface and intermix zones makes them highly vulnerable to wildfire events. The 2021 Maryland State Hazard Mitigation Plan assessed that the central region of Maryland, which includes Montgomery County, is among the most vulnerable regions in the state to the impacts of wildfires. This assessment is largely based on the expansion of human activity in and around heavily wooded areas. With the population of Montgomery County projected to continue growing through at least 2045, further development in the wildland urban interface and intermix zones is likely.

Already, the risk of wildfires in Montgomery County is a routine concern posing a threat to its residents, structures, and essential infrastructure. Each year, from early spring to late fall, the county faces heightened wildfire risks during the warmer, drier months. On days when the threat of wildfires is high, the Maryland Department of Natural Resources will issue a “red flag” status, and red flag statuses may become more common in the near future as many of the impacts associated with climate change can affect the severity of wildfires.[76] Short-term weather conditions influence the likelihood of ignition, how quickly a fire spreads, and how large it becomes. Longer-term climate patterns – such as prolonged droughts – may also play a role by creating or exacerbating conditions that are conducive to wildfires.

Human activities and land management practices also affect wildfire activity, and preferred practices in wildfire management have evolved over time, from older policies that favored complete wildfire prevention to more recent policies of wildfire suppression and controlled burns. Resources available to fight and manage wildfires can also influence the amount of area burned over time.

[76] US EPA, OAR. “Climate Change Indicators: Wildfires.” Reports and Assessments, July 1, 2016. https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires.

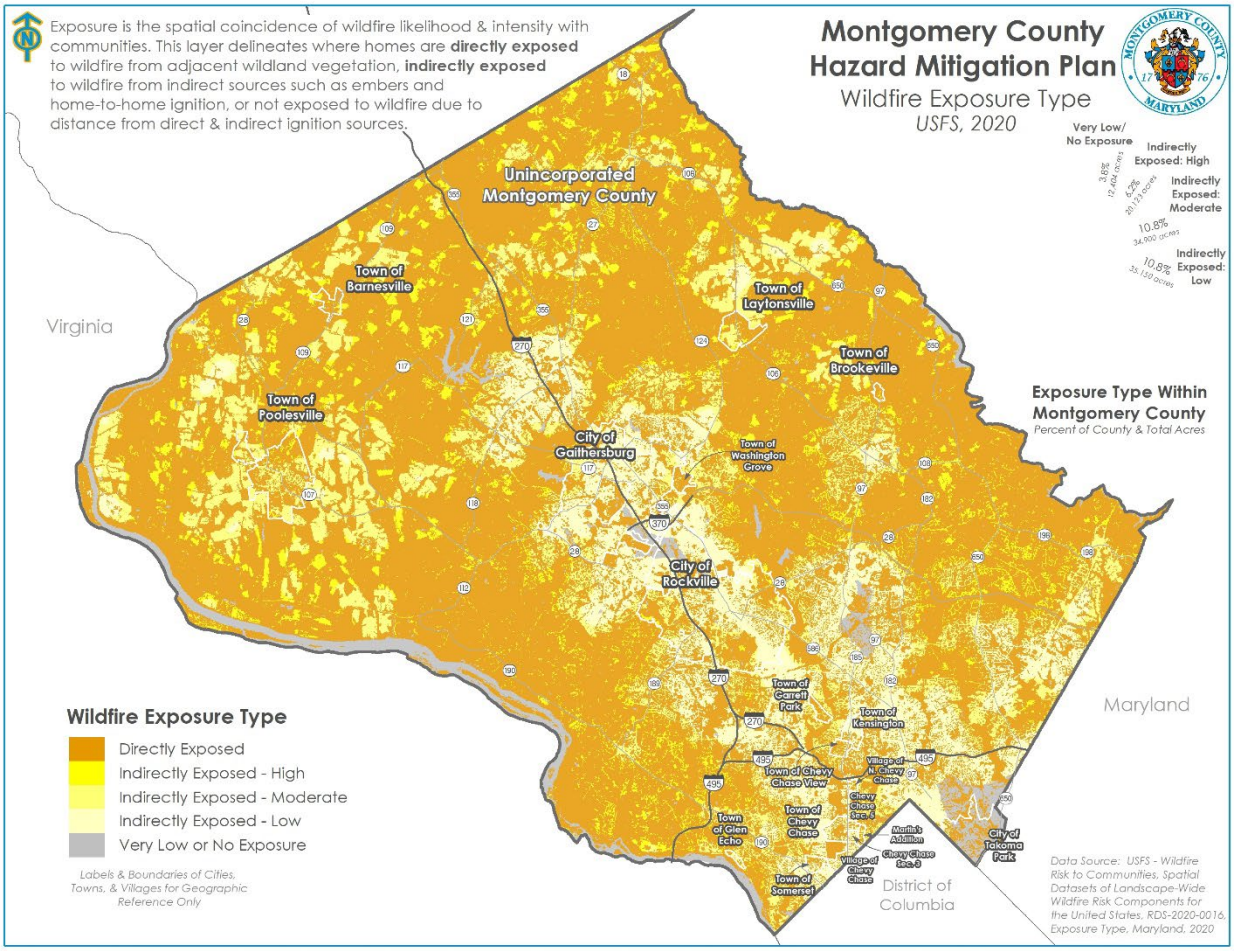
Determining the probability of wildfires occurrences in Montgomery County is slightly more difficult than other hazards because of data limitations. According to the National Centers for Environmental Information's database, there have been no wildfires to occur in Montgomery County since 1950. However, multiple news articles referenced earlier in this section show that fires in wildland areas have occurred relatively recently. Based on the combination of available resources, the probability of wildfires occurring in any given year in Montgomery County is assessed as "possible" with between 1% and 49.9% annual probability.

e) Vulnerability Assessment

Data provided by the U.S. Forest Service (USFS) reveals that nearly 68% of the total area across Montgomery County is classified as "directly exposed" to wildfire from adjacent wildland vegetation. A further 17% of Montgomery County is at a high or moderate risk of wildfires due to indirect exposure, which includes ignition from embers and adjacent structures. Only 14.6% of the County is assessed by the USFS as having low, very low, or no exposure to wildfires. This data helps illustrate the limited volume of land in Montgomery County available for development without at least a moderate exposure risk to wildfires. Although large wildfires remain relatively rare events, the trend nationally is for more wildfires with more acres burned, more structures destroyed, and more civilian fatalities.[77] Continual population growth and urban development in Montgomery County will increase the threat associated with wildfires.

[77] Montgomery County Fire & Rescue. "Wildfire." montgomerycountymd.gov, March 14, 2018. https://www.montgomerycountymd.gov/frs-ql/Resources/Files/operations/wildfire/Wildfire_Presentation_Notes.pdf.

Figure 30 Wildfire Exposure Risk in Montgomery County



Topography and fuel management are two additional factors determining the severity of wildfires in Montgomery County. While it may seem counterintuitive, wildfires can spread faster on a slope than on flat ground. Wildfires can move more quickly on a slope because the rising hot air pre-heat the upcoming fuels, and upward drafts are more likely to create spot fires.[78] Montgomery County officials should be prepared for fires which ignite near or along slopes to quickly climb up the terrain. The density of wildfire fuel, which includes grasses, trees, fallen pine needles, and other flammable materials, can dramatically increase the devastation wrought by wildfires. To help reduce the likelihood of catastrophic wildfires, many communities across the U.S. have fuel management projects which strive to reduce the presence of excess

[78] U.S. National Parks Service. "Wildland Fire Behavior." nps.gov. Accessed September 27, 2023. https://www.nps.gov/articles/wildland-fire-behavior.htm.

fuels. These programs have proven effective in reducing the damage of wildfires, but logistical challenges often force these programs to rotate the area addressed each season. In Montgomery County, areas where wildfire fuel management has not occurred recently or at all may be particularly susceptible to wildfires.

7. Flooding

A flood is a natural occurrence in rivers and streams, manifesting when areas that are usually dry are suddenly submerged in water. This inundation often arises from a combination of factors such as heavy precipitation, snowmelt, and the geography of the surrounding land.

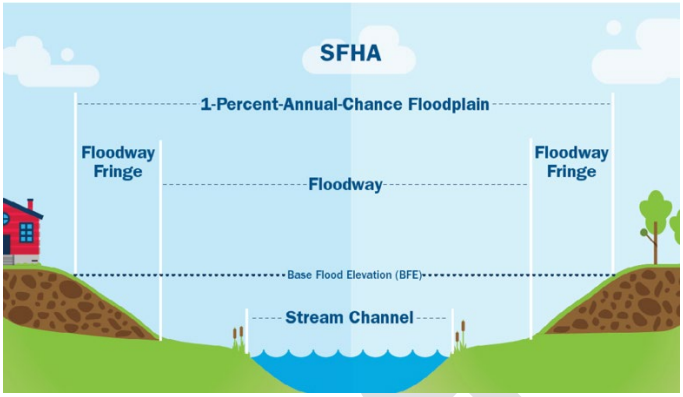
When rain falls or snow melts, the water, in its attempt to reach lower ground, will flow into rivers and streams. If the volume of this water surpasses the capacity of these waterways, it spills over onto the banks and adjacent floodplains. As depicted in the accompanying figure, floodplains are the flat expanses of land next to rivers, streams, and creeks that regularly face the impact of these overflows. These regions play a crucial role in the natural hydrological cycle, acting as buffers by absorbing excess water, thus reducing the severity of potential downstream flooding.

Flash floods present a distinct and sudden threat. Triggered predominantly by intense rainfall over a short duration or rapid snowmelt, they can inundate areas that are not commonly prone to such events. Urban zones, with their concrete expanses and limited natural drainage, are especially susceptible to flash floods due to the rapid runoff generated.

Another lesser-known cause of floods pertains to freezing conditions. Extremely cold temperatures can result in the surface of rivers and streams freezing. This ice can break into chunks, which then accumulate, leading to what are known as "ice jams." These blockages prevent the downstream flow of water, causing it to back up and potentially flood upstream areas.

Understanding these different types of floods and their causes is crucial in planning and implementing measures to mitigate their devastating impacts on Montgomery County.

Figure 31: Floodplain Overview

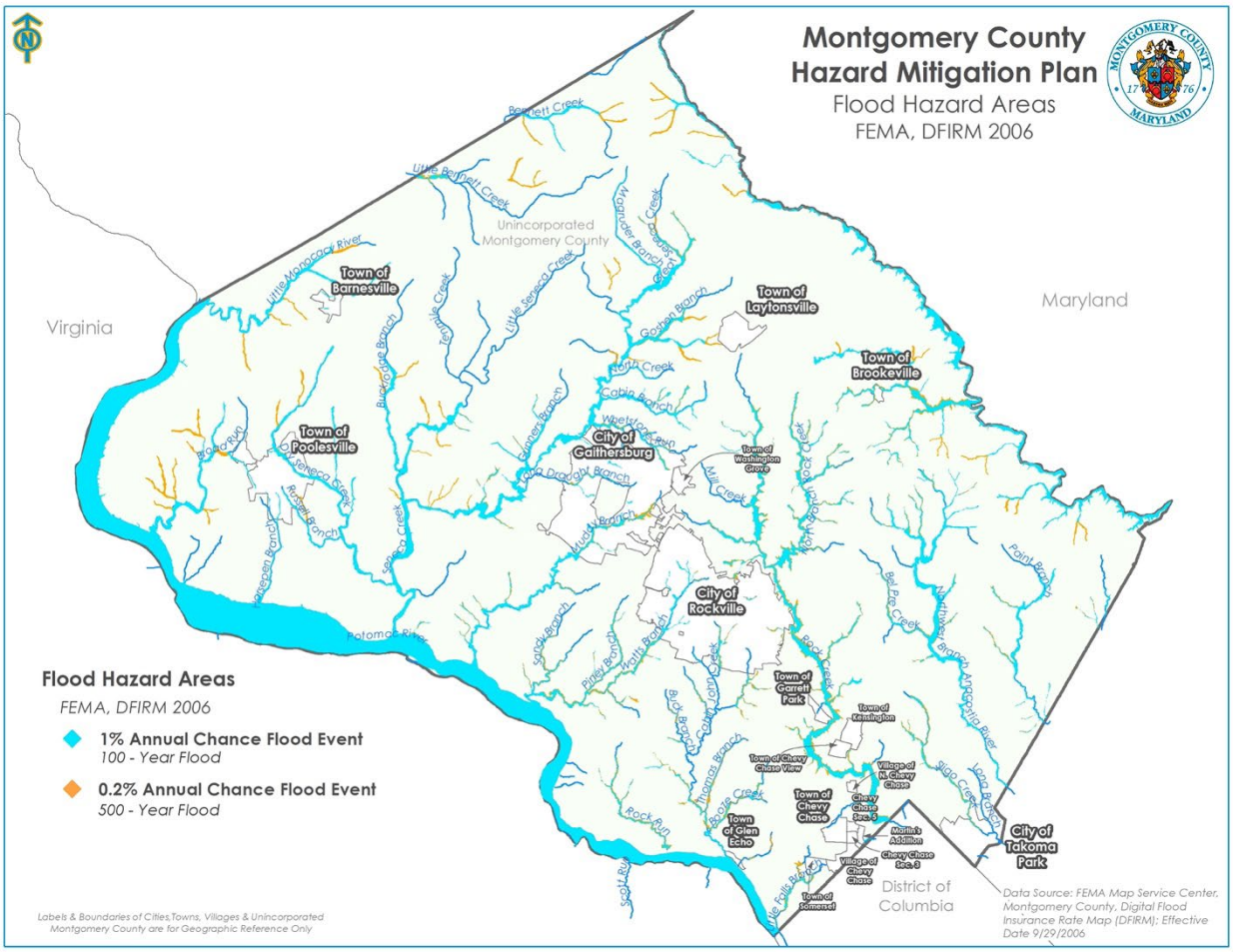


a) Location & Extent

Floods are regarded as significant hazards when they impact both people and property. Nationally, hundreds of floods occur annually, rendering them one of the most prevalent hazards across all 50 states and U.S. territories. In Maryland, flooding is a frequent occurrence, transcending seasonal boundaries and originating from diverse sources.

The majority of injuries and fatalities resulting from floods are attributed to individuals being swept away by powerful flood currents. Likewise, property damage is primarily caused by the inundation of sediment-laden water. Swiftly moving waters have the potential to displace buildings from their foundations and carry vehicles downstream. Infrastructure, including pipelines and bridges, can suffer damage when high water levels converge with flood debris. Basement flooding can inflict extensive harm, while crop fields may face substantial damage, potentially leading to the loss of livestock. Several factors contribute to the severity of floods, encompassing the intensity and duration of rainfall, as well as the local topography and ground cover.

Figure 32: Map of the Special Flood Hazard Areas of Montgomery County



While flooding of major proportions has occurred in Montgomery County, the damage has been light in view of the high intensity of development in the area. This relatively light damage history is due, in large measure, to the lack of extensive encroachment on the floodplains of the several major waterways (i.e., Northwest Branch Anacostia River, Paint Branch, Rock Creek, and Sligo Creek) which flow through the heavily populated areas.[79]

Riverine flooding originates from a body of water, typically a river, creek, or stream, as water levels rise onto normally dry land. Water from snowmelt, rainfall, freezing streams, ice flows, or a combination thereof, causes the river or stream to overflow its banks into adjacent floodplains. Winter flooding usually occurs when ice in the rivers creates dams or streams

[79] Flood Insurance Study – Preliminary July 31, 2023 - FEMA

freeze from the bottom up during extreme cold spells. Spring flooding is usually the direct result of melting winter snowpacks, heavy spring rains, or a combination of the two.

Flash floods can occur anywhere when a large volume of water flows or melts over a short time, usually from slow moving thunderstorms or rapid snowmelt. Because of the localized nature of flash floods, clear definitions of hazard areas do not exist. These types of floods often occur rapidly with significant impacts. Rapidly moving water, only a few inches deep, can lift people off their feet, and only a depth of a foot or two, is needed to sweep cars away. Most flood deaths result from flash floods.

Urban flooding is the result of development and the ground's decreased ability to absorb excess water without adequate drainage systems in place. Typically, this type of flooding occurs when land uses change from fields or woodlands to roads and parking lots. Urbanization can increase runoff two to six times more than natural terrain. (National Oceanic and Atmospheric Administration, 1992) The flooding of developed areas may occur when the amount of water generated from rainfall and runoff exceeds a storm water system's capability to remove it.

Stream Bank Erosion is measured as the rate of the change in the position or horizontal displacement of a stream bank over a period of time. It is generally associated with riverine flooding and discharge and may be exacerbated by human activities such as bank hardening and dredging.

Ice Jams are stationary accumulations of ice that restrict flow. Ice jams can cause considerable increases in upstream water levels, while at the same time, downstream water levels may drop. Types of ice jams include freeze up jams, breakup jams, or combinations of both. When an ice jam releases, the effects downstream can be like that of a flash flood or dam failure. Ice jam flooding generally occurs in the late winter or spring.

Montgomery County and its 19 political subdivisions, which consist of cities, towns, and villages, continue to work together to enforce the local floodplain management ordinance requirements set forth by the National Flood Insurance Program (NFIP).

Table 20: FEMA Community Status in the NFIP

CID	Community Name	Status	Initial FIRM	Effective Map Date
240049	Montgomery County-Unincorporated[80]	Participating	7/02/79	9/29/06
240094	Barnesville	No Elevation Determined	8/10/79	9/29/06
240166	Brookeville	Participating	6/19/89	9/29/06
240122	Chevy Chase	No SFHA	9/29/06	No SFHA
240132	Chevy Chase View	No SFHA	9/29/06	No SFHA
240047	Chevy Chase Village	No SFHA	9/29/06	No SFHA
240136	Chevy Chase Village Section 3	No SFHA	09/29/06	No SFHA
240137	Chevy Chase Village Section 5	No SFHA	9/29/06	No SFHA
540050	Gaithersburg	Participating	12/01/82	9/29/06
240150	Garrett Park	Participating	9/29/06	9/29/06
240142	Glen Echo	Participating	9/29/06	9/29/06
240119	Kensington	No SFHA (ZONE C AND X)	9/29/06	No SFHA
240055	Laytonsville[81]		9/29/06	9/29/06
240113	Martin's Addition	No SFHA	9/29/06	No SFHA
240129	North Chevy Chase	No SFHA	9/29/06	9/29/06
240118	Poolesville	Participating	10/15/82	9/29/06
240051	Rockville	Participating	1/05/78	9/29/06
240134	Somerset	Participating	9/29/06	9/29/06
240126	Takoma Park	Participating	9/29/06	9/29/06
240135	Washington Grove	No SFHA	9/29/06	No SFHA

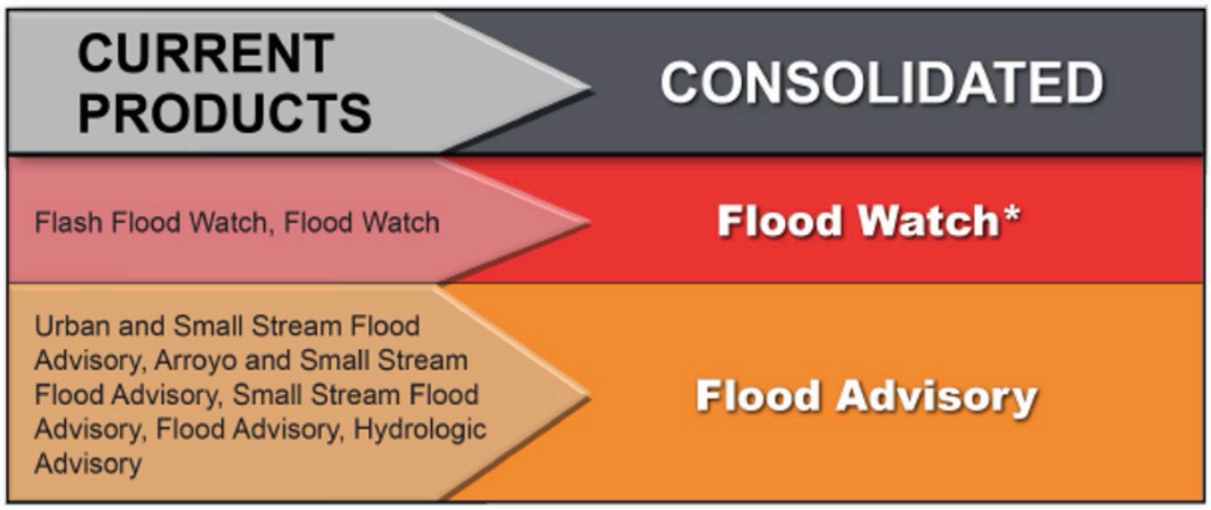
[80] As of January 11, 2019, the CID for Friendship Heights was discontinued. Community has been reabsorbed by the County.

[81] Laytonsville is not acknowledged in the FEMA Community Status Book. The municipal limits do not include floodplain, but floodplain maps received by community leadership during the planning process do include regulatory floodway and Special Flood Hazard Area within the jurisdictional boundary to the southwest of town.

b) 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.

Figure 33: NWS Consolidation of Flood Products



The National Weather Service (NWS) issues several different flood products, listed below, depending on the degree of flooding that is expected.

- **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.[82]

c) Past Occurrence

Large floods have occurred along the major streams in the basin during all seasons of the year. However, the most devastating floods have occurred between the months of March and June. The maximum flood of record occurred along the Potomac River in March 1936. Along small tributaries, flood stages can rise from normal flow to extreme flood peaks, with accompanying high velocities, in a relatively short period. Along the Potomac River, floods rise to their crest over a longer period and remain out of banks for a more extended length of time.

Based on the review of historical data, it is probable that the five (5) largest floods in Montgomery County occurred in 1936, 1937, 1942, 1972, and 1996. Historical Crests for the five largest floods of record for the Potomac River at Little Falls are shown below.

Table 21: Discharge Values for Largest Floods along Potomac River at Little Falls

Date of Crest	Feet
03/19/1936	28.10
10/17/1942	26.88
04/28/1937	23.30
06/24/1972	22.03
01/21/1996	19.29

Information on historical floods in Montgomery County along the main stem of the Potomac River and was obtained from stream gauging stations maintained by the USGS at several locations within the drainage basin.

Table 22: Flood Categories for Potomac River at Little Falls

Category	Feet
Major Flood Stage	**14’**
Moderate Flood Stage	**12’**
Flood Stage	**10’**
Action Stage	**5’**

[82] NWS – Safety. Flood Warning vs. Watch. Retrieved on 08/14/2023 from: https://www.weather.gov/safety/flood-watch-warning

According to the mode recent Flood Insurance Study, a synopsis of historical flood problems describes the following events.

The flood from Tropical Storm Agnes which occurred in June of 1972 was particularly severe throughout Maryland, with considerable damage sustained in Montgomery County. The magnitude of this flood varied from a frequency of once in 400 years on the Northwest Branch Anacostia River, once in 250 years on Rock Creek, and once in 200 years on the Seneca River, to approximately once in 35 years on the Potomac and Patuxent Rivers. Estimates of the damage caused by the Agnes flood in Montgomery County ranged from up to $2.5 million. Over eighty county roads were rendered impassable during the flood including five bridges that were destroyed, requiring replacement, and three large culvert crossings that required partial or complete replacement. The Agnes flood caused five deaths, destroyed 25 homes, and caused major damage to 28 other homes. Three hundred families suffered losses and approximately five thousand people required emergency shelter at one time or another during or after the flood.

The flood from Tropical Storm Haze" that occurred in 1956 was similar in magnitude to the 1972 flood but was less concentrated in the heavily populated areas. Between 1956 and 1971 the county suffered little in the way of flood damage. In the late summer of 1971, however, storms of a local nature but high intensity caused unprecedented damage in the northern tip of the county. Heavy flooding from storms in early August and early September of 1971 resulted in extensive damage in the north and northwestern areas of the county. Although this area is sparsely settled, 13 homes were destroyed, and four homes suffered major damage. In addition, twelve bridges on the Monocacy, Great Seneca Creek, Little Seneca Creek, the Patuxent River, Goshen Branch, and Cabin Branch were structurally damaged, ten of which required total replacement. A flood of this magnitude is estimated to have a recurrence frequency of once in 200 years. Total damage due to both floods which occurred in 1971 exceeded $2.5 million.

In July of 1975, another high intensity storm in a small area caused considerable flooding on Turkey Branch and Bel Pre Creek east of Maryland Route 97. This unusually high intensity storm cause flooding greater than Tropical Storm Agnes at this location, flooding several apartment buildings, a church, and inundating Maryland Route 97. The Montgomery County Office of Civil Defense estimated that over $1 million in damage resulted from this rare, local event.

The following table reflects historical flood elevation measurements according to US Geological Survey (USGS) gage records.[83]

Table 23: Historical Crests of River Gauges in Montgomery County

Gauge	Flood Categories	Historic Crests	Date	Description
Northwest Branch Anacostia River near Colesville.	Major 19' Moderate 12' Flood 9' Action 6'	15.89	06/22/1972	@19' Water reaches Randolph Rd.
Potomac River at Edwards Ferry	Major 24' Moderate 17' Flood 15' Action 12.25'	22.45'	06/05/2018	@28' Tchiffely Mill Road begins to flood due to backwater effects. Most of the C&O Canal towpath is flooded.
Seneca Creek at Dawsonville	Major 16' Moderate 11' Flood 7.5' Action 5'	16.40'	06/22/1972	@34' Water covers the Route 28 bridge near Dawsonville.
Paint Branch Near College Park	Major 22' Moderate 14' Flood 12' Action 9'	8.85'	08/14/2011	@22' Interstate 95 is flooded at Paint Branch.

According to the NCEI Montgomery County has been impacted by 392 flood events since 1996. Of those events, 149 occurred on separate days.

Table 24: Flood Events in Montgomery County 1965 – 2023

Location	Events	Deaths	Injuries	Property Damage	Annualized Losses[84]
Montgomery County	392	3	6	$23,675,600	$876,874

d) Future Occurrence

Given the history of flood events that have impacted Montgomery County, 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 County in the past suggests that many people and properties are at risk from the flood hazard in the future.

[83] USGS – Historical Flood Crests. Only those gauges with a historical record were included.
[84] *(Current Year) 2023] subtracted by [(Historical Year) 1965] =58 Years on Record*

Probability of Future Occurrences

The probability of occurrence for flood events in the Montgomery County is considered ***Highly Likely***.

e) Vulnerability Assessment

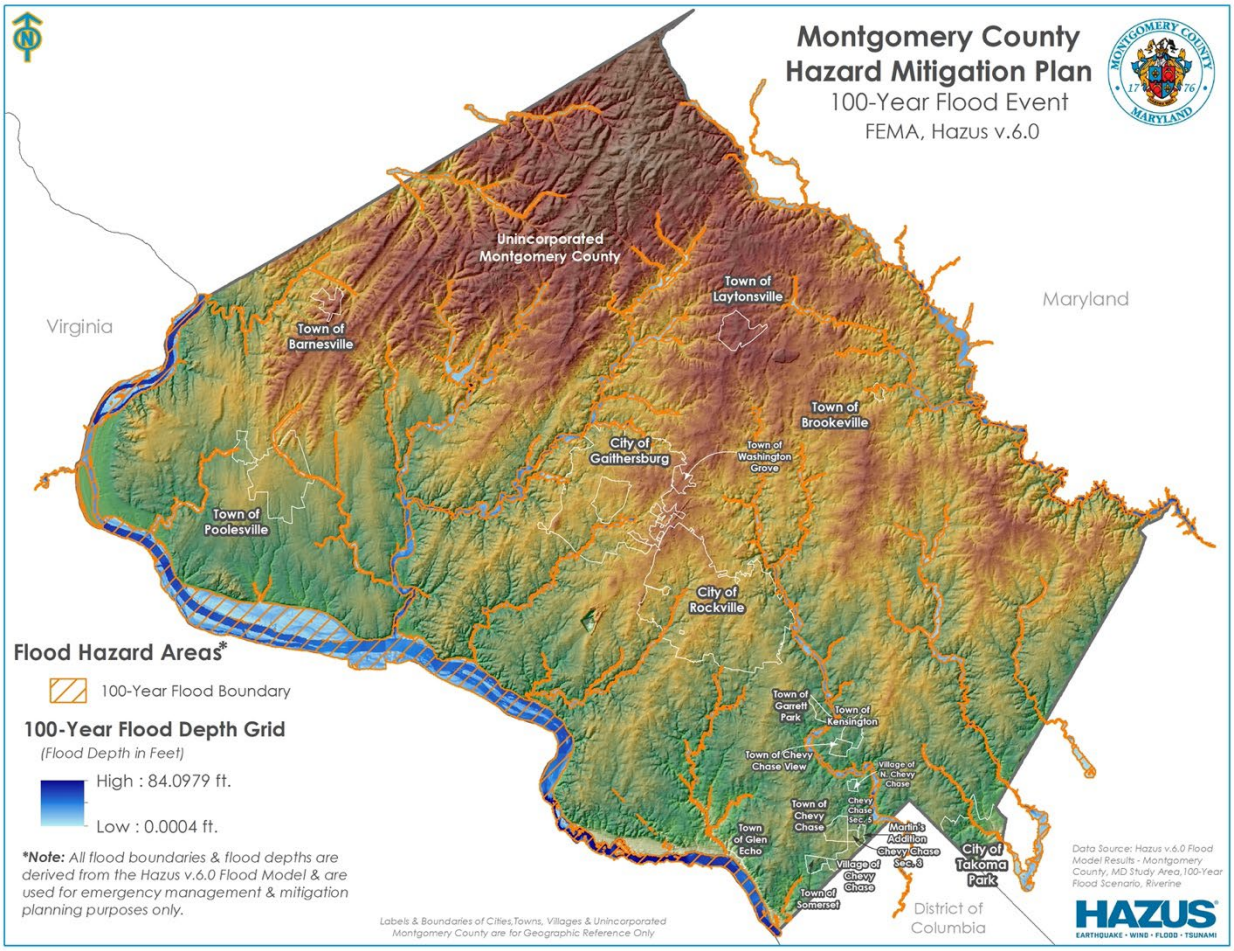
The method used in determining the types and numbers of potential assets exposed to flooding was conducted using a loss estimation model called Hazus-MH. Hazus-MH is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Buildings Sciences (NIBS). For this Plan update, a 100-year flood scenario was modeled and the results are presented below.

Hazus-MH 100-Year Flood Scenario

Hazus estimates that approximately 361 buildings will be at least moderately damaged which is over 43% of the total number of buildings in the scenario. There are an estimated 97 buildings that will be completely destroyed. The tables below summarize the expected damage by general occupancy for the buildings and the expected building damage by building type in the study region.

The map below shows the results of the Hazus model depicting a 100-year flood event.

Figure 34: Hazus 100-Year Flood Model



(1) People

Critical facilities are essential to the health and welfare of the whole population and are especially important following hazard events. Hazus indicates that for this scenario no damage is expected to critical facilities. It should be noted that the County and Hazus may have slightly different definitions as to what is deemed as critical. Hazus also estimates that there would be no loss to the number of hospital beds available due to flood damage. There exists significant barriers socially disadvantaged people face in interacting with bureaucratic systems to receive housing and other types of aid. Some of these barriers include a lack of knowledge of the systems through which disaster survivors receive aid; discomfort with these systems; and issues in getting to and from disaster assistance centers, such as transportation, childcare, and work schedules.

(2) Systems

Floods can cause power, water, and gas outages; disrupt transportation routes and commercial supplies; pollute drinking water systems; damage homes, buildings, and roads; and cause

severe environmental problems including landslides and mudslides. Flooding can strain transportation networks in both the short- and long-term through transportation delays, infrastructure damage, and recovery, and potentially affect economies. Nearly all transportation modes (e.g., roads, transit, aviation, etc.) are highly dependent on the supporting network of infrastructure and are vulnerable to disasters such as flooding events. While no major airports are in Montgomery County, there are major hubs located in Northern Virginia as well as Baltimore. Widespread flood events effect the transportation network and its connectivity by reducing, deviating, or canceling travel for passengers, goods, and services due to roads being submerged, closed, or unsafe to travel.

The impacts of flooding provide a glimpse of the vulnerability that the transportation sector faces due to floods. With increases in urbanization and flooding in the future, systems and infrastructure networks in existing and new developments need to be developed for resiliency to future disasters.

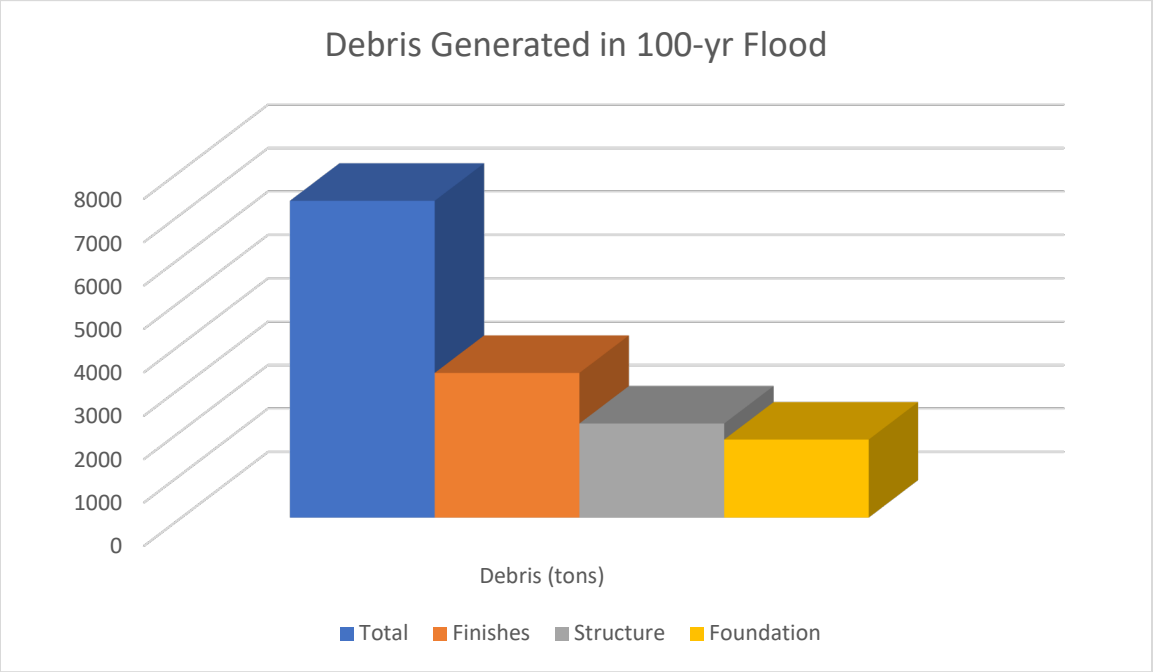
Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories:

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

This distinction is made because of the different types of material handling equipment required to handle the debris. The model estimates that a total of 7,299 tons of debris will be generated. Of the total amount, Finishes comprises 46% of the total, Structure comprises 30% of the total, and Foundation comprises 25%. If the debris tonnage is converted into an estimated number of truckloads, it will require 292 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Figure 35: Hazus Estimates for Debris Generation from 100-yr Flood



Economic Losses

The total economic loss estimated for the flood is $456.56 million dollars, which represents 2.81% of the total replacement value of the scenario buildings.

(3) Structures

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood. The total building-related losses were $321.13 million dollars. 30% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 62.51% of the total loss. The table below shows a summary of the losses associated with the building damage.

Figure 36: Building-Related Economic Loss Estimates (in Millions)

Category	Area	Residential	Commercial	Industrial	Other	Total
Building Loss	Building	$158.43M	$9.75 M	$3.78 M	$3.87 M	$175.83 M
	Content	$85.13M	$27.16 M	$7.94 M	$22.25 M	$142.48 M
	Inventory	$0.00M	$1.35 M	$1.30 M	$0.17 M	$2.82 M

Category	Area	Residential	Commercial	Industrial	Other	Total
	Subtotal	$243.56M	$38.26 M	$13.02 M	$26.29 M	$321.13 M
Business Interruption	Income	$0.43M	$18.41 M	$0.14 M	$9.07 M	$28.04 M
	Relocation	$27.70M	$3.55 M	$0.13 M	$4.51 M	$35.89 M
	Rental Income	$12.66M	$2.41 M	$0.04 M	$0.24 M	$15.35 M
	Wage	$1.03M	$24.96 M	$0.25 M	$29.92 M	$56.15 M
	Subtotal	**$41.81 M**	**$49.33 M**	**$0.56 M**	**$43.73 M**	**$135.43 M**
All	**Total**	**$285.37 M**	**$87.59 M**	**$13.57 M**	**$70.02 M**	**$456.56 M**

(4) Natural, Cultural, & Historical Resources

Flooding risk has long been a major challenge for many historic properties. Changing weather patterns, stronger hurricanes and other extreme weather events, sea level rise, increased nuisance flooding, king tides, and continuing development in floodplains are some of the factors increasing the risk of flooding events, both in terms of their frequency and magnitude. Some historic properties that have never flooded before may now be exposed to this risk, and those that flooded infrequently in the past may experience more instances of flooding or of

water reaching higher levels than ever before. In fact, the Secretary of the Interior adopted Guidelines on Flood Adaptation for Rehabilitating Historic Buildings in response to flooding.[85]

(5) Community Activities

Flooding events can cause widespread cancellations of community events and activities due to direct or indirect damage due to flooding. Flooding can leave long lasting recovery efforts to get the community back to normal and it remains pivotal that the community maintains a vision for the future while undertaking mitigation strategies.

Table 25: Notable Assets in Montgomery County Damaged by Flooding

Approximate Date of Event	Assets(s)	Category	Description of Damage
September 1, 2021	Apartment buildings	Structures	Heavy rainfall across portions of northern and central Maryland generated excess runoff and riverine flooding. Floodwaters surged into the Rock Creek Woods Apartments shortly before 3am EST, according to Montgomery County Police and Fire officials. The water nearly reached the ceilings, and one individual was killed. Three other individuals were hospitalized, and one firefighter suffered minor injuries. Property damage was estimated at $1,000,000.[86]
July 8, 2019	Roadways	Systems	Numerous roads across Montgomery County were rendered unusable due to heavy rainfall. Numerous vehicles were caught in the floodwater, and more than two dozen individuals required rescue from their vehicles by emergency services. The road closures generated significant delays, particularly among those who commuted to Washington D.C.[87]
June 25, 2006	Rock Creek	Natural,	A slow-moving storm unleashed 4-7 inches of

[85] National Park Service. Guidelines on Flood Adaptation for Rehabilitating Historic Buildings. 2021 https://www.nps.gov/orgs/1739/upload/flood-adaptation-guidelines-2021.pdf
[86] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 27, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=986683.
[87] CBS Broadcasting. "Flooding Washes Away Roads, Home; Forces Water Rescues In Montgomery County," July 8, 2019. https://www.cbsnews.com/baltimore/news/motorists-rescued-house-collapses-in-montgomery-county-after-flash-flooding/.

Approximate Date of Event	Assets(s)	Category	Description of Damage
	Regional Park/Lake Needwood	cultural, historic	rain from 06/25-06/26. The deluge led to substantial urban flooding, and the water level in Lake Needwood within Rock Creek Regional Park rose to a dangerous point. Due to concerns about imminent failure of the Lake Needwood Dam, 2000 individuals were evacuated from the area. The dam fortunately did not fail, but repairs and cleanup were required.[88]
September 6, 1996	Farmland/ crops	Natural, cultural, historic	Torrential rainfall caused the rapid onset of riverine flooding along the Potomac River. Substantial agricultural damage occurred in Montgomery County, as 450 acres of corn and soybeans were destroyed. The flooding also washed out bridges and left debris strewn across fields and roads.[89]
January 19, 1996	Chesapeake & Ohio Canal	Natural, cultural, historic	Snowmelt combined with 1 to 5 inches of rain to produce catastrophic river flooding. Unfortunately, the flooding caused severe damage to the National Park Service's Chesapeake & Ohio Canal. The damage was estimated to $20 million.[90]

8. Hurricane/Tropical Storm

Hurricanes, typhoons, and cyclones are all terms used for the same meteorological event: tropical cyclones. The specific term used to describe these events is primarily determined by culture and geography – the term hurricane is mainly used for systems which form in the Atlantic Ocean or eastern Pacific Ocean and typically impact North America. Typhoons and cyclones are terms commonly used to describe systems in the Western Pacific and Indian

[88] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 27, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5515181.
[89] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5572372.
[90] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 27, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5541353.

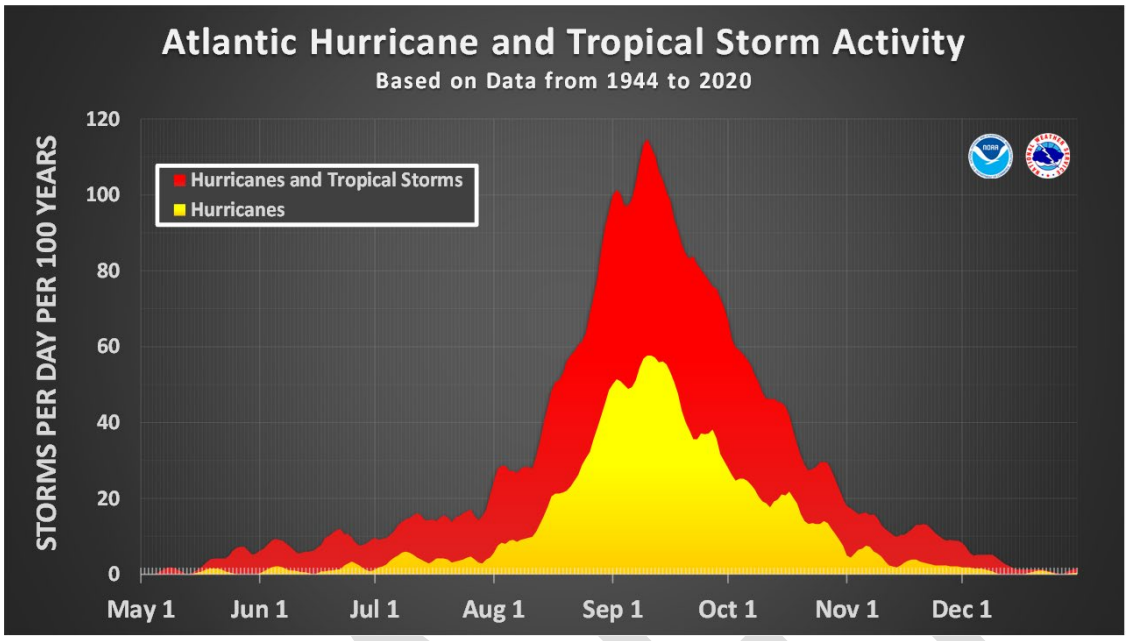
Oceans, with typhoons being north of the equator and cyclones being south. Tropical cyclones virtually never occur within 5 degrees of the equator. Additionally, tropical storms and depressions are tropical cyclones with sustained windspeeds below the threshold for hurricanes. When tropical cyclones travel far enough away from the tropics to no longer be powered by warm water, they are typically considered extratropical storms. These systems are usually weaker than hurricanes and other tropical cyclones, but this is not a requirement. Instead, the difference between tropical and extratropical cyclones is their primary source of energy; tropical cyclones draw most of their strength from warm water, whereas extratropical ones derive their strength from atmospheric instability.

a) Location and Extent

Montgomery County is not typically a region that experiences the direct impact of major hurricanes due to its inland location. However, it can still be affected by the remnants of hurricanes or tropical storms that move inland from the Atlantic coast. According to data from the U.S. National Oceanic and Atmospheric Administration (NOAA), the U.S. mainland is impacted by an average of 18 hurricanes per decade, and most of these events make landfall along the Atlantic coast.[91] Hurricanes, like other meteorological events, require a proper set of conditions to form, and the Atlantic hurricane season is June 1st to November 30th. Hurricanes in the Atlantic nearly always begin as minor disturbances somewhere between the western coast of Africa and the Caribbean Sea. If the right conditions are present – particularly warm water and wind shear – then these disturbances will grow in strength and size as they travel west.

Figure 37: Atlantic Hurricane & Tropical Storm Activity

[91] National Oceanic and Atmospheric Administration. "U.S. Hurricane Strikes by Decade." nhc.noaa.gov. Accessed September 18, 2023. https://www.nhc.noaa.gov/pastdec.shtml.



Tropical cyclones which make landfall along the gulf coast or southeast Atlantic coast can still have an impact on Montgomery County as rainbands of such storms can be hundreds of miles away from the eye of the system. The rainfall from remnants of tropical cyclones can be immense. On September 1, 2021, the remains of Hurricane Ida – which was downgraded to an extratropical storm on the same day – unleashed as much as 3-4 inches of rain within 45 minutes near Rockville.[92] This event demonstrates the reality that even when tropical cyclones have significantly weakened, they can still be extraordinarily dangerous to both people and property.

b) Range of Magnitude

The intensity of a hurricane does not remain consistent over the duration of the system's existence. Generally, the hurricanes which impact the Atlantic coast of the U.S. begin as minor storms in the mid-Atlantic Ocean. If the conditions are right, these storms will begin to gain size and intensity, and they will be classified as tropical depressions once they achieve organized deep convection and a closed surface wind circulation about a well-defined center.[93] If a tropical cyclone has maximum sustained winds (defined as a one-minute average) of 38 mph or

[92] US Department of Commerce, NOAA. "Remnants of Hurricane Ida: September 1st, 2021." NOAA's National Weather Service. Accessed September 27, 2023. https://www.weather.gov/lwx/Remnants_of_Ida.
[93] US Department of Commerce, NOAA. "Tropical Definitions." NOAA's National Weather Service. Accessed September 18, 2023. https://www.weather.gov/mob/tropical_definitions.

less, the system is considered to be a tropical depression. If the sustained winds are between 39 and 73 mph, then the system is a tropical storm. A tropical cyclone is officially classified as a hurricane only once the sustained winds reach or exceed 74 mph.[94]

In the U.S., hurricanes are rated on the Saffir-Simpson Hurricane Scale (SSHS). The SSHS uses sustained windspeeds to categorize hurricanes on a scale from 1-5, with category 5 storms having the highest sustained windspeeds. The U.S. National Hurricane Center (NHC) defines sustained windspeeds as the highest one-minute average wind at an elevation of 10 meters.[95] The NHC classifies category 3 or higher hurricanes as "major hurricanes" due to the destructive potential of these storms, although category 1 and category 2 hurricanes still have the potential to cause property damage and may result in fatalities.

Figure 38: Saffir-Simpson Hurricane Wind Scale

Category	Sustained Winds	Types of Damage Due to Winds
1	74-95 mph	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	111-129 mph	Devastating damage will occur: Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.

[94] US Department of Commerce, NOAA. "Tropical Definitions." NOAA's National Weather Service. Accessed September 18, 2023. https://www.weather.gov/mob/tropical_definitions.
[95] National Hurricane Center. "Glossary of NHC Terms." nhc.noaa.gov. Accessed September 19, 2023. https://www.nhc.noaa.gov/aboutgloss.shtml.

Category	Sustained Winds	Types of Damage Due to Winds
4	130-156 mph	Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	157 or higher	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Fortunately, only a very small portion of hurricanes ever reach category 5 strength, and even fewer make landfall in the U.S. at this strength. NOAA data shows that since 1924, there have been 39 tropical cyclones which reach category 5 strength in the Atlantic Ocean, but only four have made landfall in the U.S. at that strength. Of the four hurricanes which made landfall in the U.S. at category 5 strength, three of them did so in the state of Florida, while the fourth made landfall near the border of Mississippi and Louisiana in the Gulf of Mexico.

Although hurricanes are primarily ranked by the windspeeds they generate, there are other hazards which accompany them – the most notable of these is the "storm surge," which is essentially an abnormal increase of the local sea level. The storm surge can be affected by a variety of factors including wind speed, barometric pressure, and the shape of the coastline. The variety and nature of the factors which shape storm surges makes them difficult to accurately predict, although the severity of a storm surge broadly correlates to the overall strength of the hurricane they accompany.[96] Storm surges are important to acknowledge because they present the greatest threat to life, and nearly half of all direct fatalities from hurricanes that make landfall in the U.S. are from storm surges.[97] One particularly infamous example of how dangerous a storm surge can be comes from Hurricane Katrina in 2005 – a

[96] University Corporation for Atmospheric Research. "What Causes Storm Surge? | Center for Science Education." ucar.edu. Accessed September 19, 2023. https://scied.ucar.edu/learning-zone/storms/what-causes-storm-surge.
[97] National Oceanic and Atmospheric Administration. "Hurricanes." noaa.gov, May 1, 2020. https://www.noaa.gov/education/resource-collections/weather-atmosphere/hurricanes.

team of researchers concluded that a majority of the approximately 1,100 deaths from hurricane Katrina were attributable to the storm surge.[98]

Figure 39: Hazards of Hurricanes and Tropical Storms

Hazard	Description
Storm surge	A storm surge is the abnormal rise of water generated by a storm's winds. This hazard is historically the leading cause of hurricane related deaths in the United States. Storm surge and large battering waves can result in large loss of life and cause massive destruction along the coast. Storm surge can travel several miles inland, especially along bays, rivers, and estuaries.
Flooding	Flooding from heavy rains is the second leading cause of fatalities from landfalling tropical cyclones. Widespread torrential rains associated with these storms often cause flooding hundreds of miles inland. This flooding can persist for several days after a storm has dissipated.
Straight-line winds	Straight-line winds from a hurricane can destroy buildings and manufactured homes. Signs, roofing material, and other items left outside can become flying missiles during hurricanes.
Tornado	Tornadoes can accompany landfalling tropical cyclones. These tornadoes typically occur in rain bands well away from the center of the storm.
Waves	Dangerous waves produced by a tropical cyclone's strong winds can pose a significant hazard to coastal residents and mariners. These waves can cause deadly rip currents, significant beach erosion, and damage to structures along the coastline, even when the storm is more than 1,000 miles offshore.

Another important but arguably underappreciated danger of hurricanes is the volume of rain they can unleash in a short time span. Research from National Geographic found that an average hurricane can release more than 9 trillion liters of rain per day, and flooding from rain is second only to storm surges in terms of the number of deaths caused.[99] Additionally,

[98] Rappaport, Edward N. "Fatalities in the United States from Atlantic Tropical Cyclones: New Data and Interpretation." *Bulletin of the American Meteorological Society* 95, no. 3 (March 1, 2014): 341–46. https://doi.org/10.1175/BAMS-D-12-00074.1.

[99] National Geographic Staff. "Forces of Nature." nationalgeographic.com. Accessed September 19, 2023. https://nationalgeographic.org/forces-nature/hurricanes.html.

torrential rain can persist for days, and slower moving storms can be more dangerous in this regard as they stay over the same area for an extended period of time. The dangers of water – both storm surge and extreme rainfall – is why most evacuation orders are given for water, not wind. This is reiterated by the phrase "run from water, hide from wind" which is commonly used in states such as Florida and Georgia which routinely experience strong hurricanes.

c) Past Occurrence

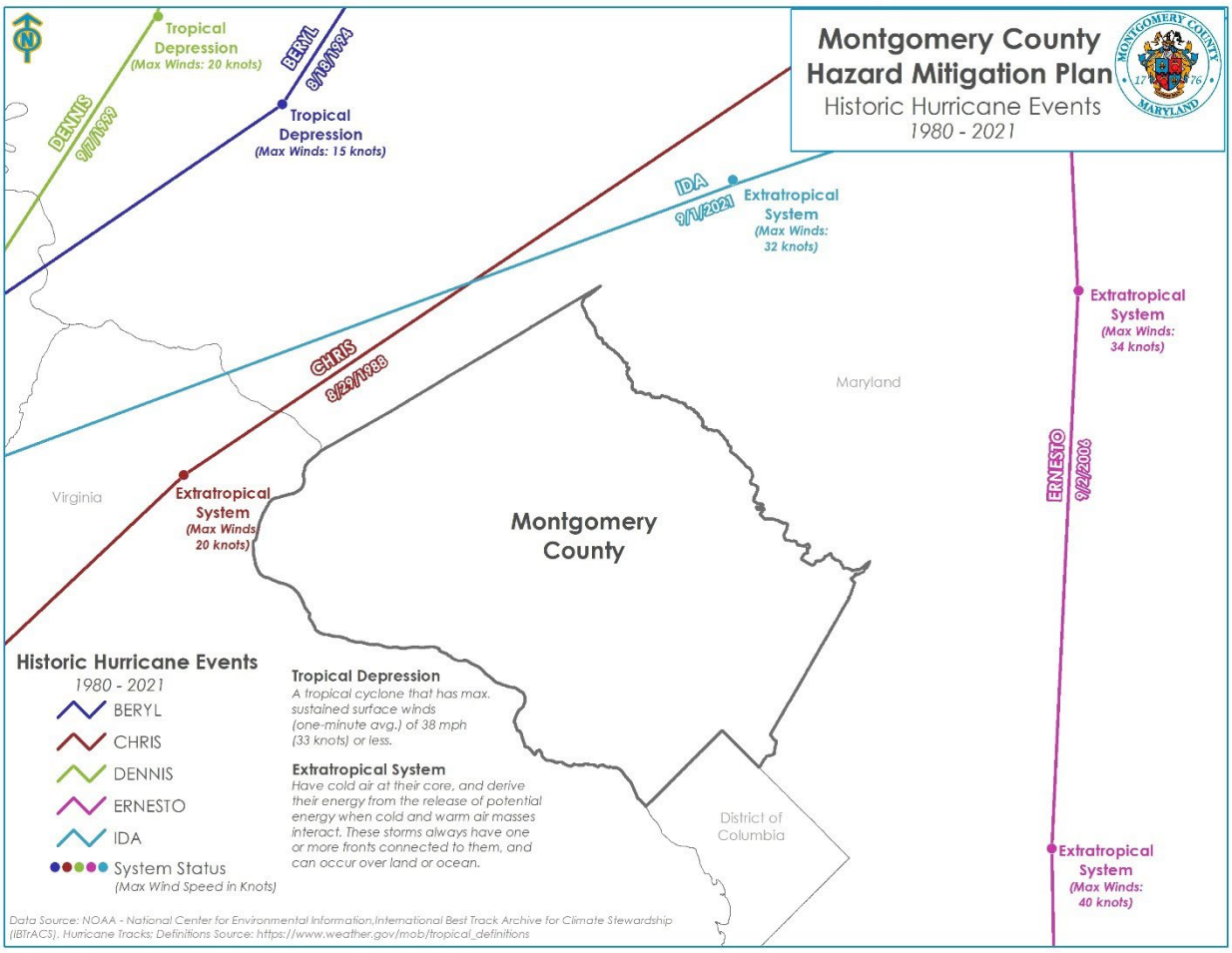
Montgomery County has experienced the effects of multiple hurricanes, but official U.S. data reveals a surprisingly limited number of hurricanes which passed directly over the County. According to NOAA records of tropical cyclone tracks since 1842, only 5 systems have come within 70 miles of Montgomery County at a strength of Category 1 or greater, and only 1 system has passed directly through the County's borders. In addition to the hurricane-strength systems, there have been 30 tropical storms and tropical depressions that have come within 70 miles of Montgomery County, and 7 have passed through the County's borders.[100] A further 18 extratropical storms have passed within 70 miles of Montgomery County during the same time period.

Many systems, which were once tropical cyclones, have impacted the County after becoming extratropical cyclones. According to NOAA, the primary difference between extratropical and tropical cyclones is the how they derive their energy; whereas tropical cyclones are primarily driven by warm water, extratropical cyclones rely on the horizontal temperature contrasts in the atmosphere (baroclinic effects). Although extratropical cyclones are not categorized as hurricanes by the National Hurricane Center, it is possible for them to retain winds of hurricane or tropical storm force.[101]

The following map depicts historical hurricane events in the region between 1980 and 2021.

Figure 40: Historical Hurricane Tracks Near Montgomery County 1980 – 2021

[100] National Oceanic and Atmospheric Administration. "Historical Hurricane Tracks." coast.noaa.gov, September 7, 2023. https://coast.noaa.gov/hurricanes/.
[101] National Hurricane Center. "Glossary of NHC Terms." nhc.noaa.gov. Accessed September 19, 2023. https://www.nhc.noaa.gov/aboutgloss.shtml.



Montgomery County's position inland from the Atlantic Coast means that tropical cyclones which reach the County no longer have access to a large body of warm water necessary to maintain their strength. Therefore, it is relatively uncommon for tropical cyclones to impact Montgomery County while sustaining hurricane-strength winds, although this is not completely unprecedented. However, many systems which make it to Montgomery County may still be classified as tropical storms or tropical depressions, and even the remnants of such storms remain capable of producing strong wind gusts and unleashing torrential rainfall. A few of the most notable tropical cyclones which have impacted Montgomery County are outlined below.

In June 1972, tropical storm Agnes impacted virtually the entire state of Maryland. While not the strongest hurricane in terms of wind speed, Hurricane Agnes was a slow-moving and extremely wet storm. It brought heavy rainfall to the region, including Montgomery County, which led to significant flooding. The flooding from Hurricane Agnes resulted in severe damage to homes, infrastructure, and the environment, including the Potomac River. The event led to widespread flooding, including in the northern tributaries of the Potomac River from Conococheague Creek near Fairview, Maryland, to Washington DC. The flooding levels in these

areas exceeded those expected in a 100-year event. Numerous roads were closed, and evacuations were carried out. Montgomery County and other nearby jurisdictions were designated federal disaster areas. The storm also had environmental consequences for the Chesapeake Bay. The total cost of the resulting damage in Maryland was over $110 million, and there were 19 documented fatalities. The impact of Hurricane Agnes was particularly significant in the area of the county bordering the Potomac River. The flooding caused extensive damage, and it remains one of the most memorable weather events in the region's history.

In September of 1979, Tropical Storm David – having been downgraded from a hurricane – impacted Montgomery County, leading to over $2 million in property damage and more than $20,000 in agricultural losses, as per data from the Spatial Hazard Events and Losses Database for the United States (SHELDUS). The storm caused widespread power failures, shut down roads, and inflicted damage on residential properties.

On September 18, 2003, Montgomery County was struck by the edge of Hurricane Isabel. Even though the eye of Isabel was nearly 90 miles away from Montgomery County at its closest point, its impact on Montgomery County was heavy. Power outages impacted hospitals, nursing homes, and traffic signals. Overturned trees, downed power and communication cables, and flooding led to numerous road closures which disrupted traffic across the County.

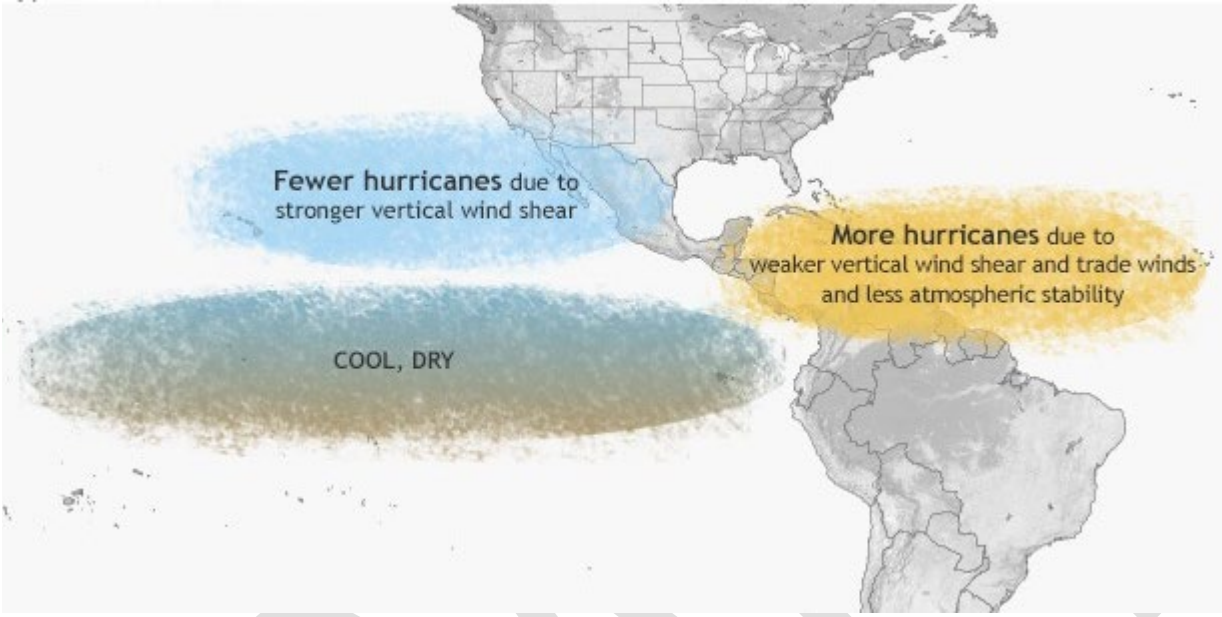
a) Future Occurrence

Historically, Montgomery County has not been uniquely prone to the impacts of tropical cyclones, but the County is certainly familiar with their consequences. However, there are indications that changing climate conditions may be altering the mixture of “ingredients” necessary for the formation of hurricanes. Recent research suggests that as a result of these changes, the average intensity of tropical cyclones forming over the Atlantic Ocean may be increasing, although further studies on this topic should be conducted.

Rising ocean temperatures have been linked to climate change, and larger volumes of water above 79 degrees Fahrenheit means that hurricanes will have more “fuel” to facilitate their development. In 2013, a team of researchers determined that there was a statistically significant correlation between climate change and powerful hurricanes. Specifically, the team

concluded that since 1975, there has been an observable increase in the proportion of category 4 and category 5 hurricanes of 25-30% per °C of anthropogenic global warming.[102]

Figure 41: Typical La Nina Influence on Hurricanes[103]



The number of tropical cyclones which occur over the Atlantic Ocean in a given year has been correlated to the presence of La Niña, which is a large climate pattern in the Pacific Ocean. During La Niñas, trade winds in the Pacific are stronger than usual, and the cascading impacts on atmospheric conditions over the Atlantic create an environment more conducive to hurricane activity.[104] Episodes of La Niña typically last nine to 12 months but can sometimes last for years. La Niña events occur every two to seven years, on average, but they don't occur on a regular schedule. When La Niña patterns are present, Montgomery County should be prepared to experience more direct and indirect effects of tropical cyclones.

The probability of tropical cyclones impacting Montgomery County in any given year is assessed to be "possible" with between 1% and 49.9% annual probability. This assessment is based on

[102] Holland, Greg, and Cindy L. Bruyère. "Recent Intense Hurricane Response to Global Climate Change." *Climate Dynamics* 42, no. 3 (February 1, 2014): 617–27. https://doi.org/10.1007/s00382-013-1713-0.
[103] National Oceanic and Atmospheric Administration. "Hurricane FAQ." *NOAA's Atlantic Oceanographic and Meteorological Laboratory* (blog). Accessed September 18, 2023. https://www.aoml.noaa.gov/hrd-faq/.
[104] National Oceanic and Atmospheric Administration. "Impacts of El Niño and La Niña on the hurricane season." climate.gov, May 30, 2014. http://www.climate.gov/news-features/blogs/enso/impacts-el-ni%C3%B1o-and-la-ni%C3%B1a-hurricane-season.

NOAA's database of hurricanes, tropical storms, tropical depressions, and extratropical cyclones since 1846. When viewing this data with relation to a specific area, NOAA defaults to a 60-nautical mile (70-mile) radius. Within this radius from the borders of Montgomery County, NOAA identifies 47 events over the past 177 years.

b) Vulnerability Assessment

All of Montgomery County is vulnerable to the effects of tropical cyclones, although the degree of vulnerability can vary between localities. Overall, the County's inland position makes it relatively insulated from flooding because of storm surges. However, the western edge of Montgomery County – which is formed by the eastern bank of the Potomac River – is the one portion of the County which *could* experience flooding from storm surge if a particularly intense system impacts the area. The risk of flooding along the eastern bank of the Potomac may also become a greater concern in subsequent decades if the average water level of the Potomac River increases due to climate change and rising sea levels.

High winds and flooding are the primary hazards associated with cyclones, with heavy snowfall also occurring during some nor'easters depending on the storm track. Generally, the vulnerabilities associated with each of these hazards are consistent with those laid out previously in Tornado, Thunderstorm/High Wind, Flood, Flash Flood.

(1) People

As hurricanes and other extreme weather events become increasingly frequent, particularly due to the growing population density in coastal areas, the associated expenses continue to rise. Hurricane Katrina, for instance, resulted in 1.36 million people seeking FEMA assistance and claimed the lives of at least 1,800 individuals. However, these costs are far from equitably distributed. Vulnerability to natural disasters is disproportionately higher among low-income and minority communities, and their recovery is also significantly more challenging.

Lower-income Americans are more likely to reside in neighborhoods and structures that are particularly susceptible to the impacts of severe storms. Subpar infrastructure in affordable housing units and low-income communities places residents at a heightened risk during such events. In the aftermath of Hurricane Harvey, it became evident that low-income neighborhoods bore a greater brunt compared to their wealthier counterparts. This disparity was exacerbated by the fact that impoverished families were concentrated in flood-prone areas of Houston.

(2) Systems

Hurricanes have a profound and multifaceted impact on community systems. Beyond the immediate physical devastation they inflict on infrastructure, homes, and businesses, hurricanes disrupt essential services and strain resources. Power outages, water contamination,

and communication breakdowns become common, affecting daily life and public safety. These extreme weather events also strain healthcare systems, as hospitals may become overwhelmed with injuries and medical needs. Moreover, hurricanes can disrupt transportation networks, making it difficult for residents to access critical services, including emergency assistance and supplies. In the long term, the economic repercussions of hurricane damage can ripple through communities, potentially leading to job losses and hindering the overall socio-economic stability of the area. Additionally, the psychological toll on individuals and communities, often experiencing trauma and loss, further underscores the wide-reaching impact of hurricanes on community systems, emphasizing the need for robust preparedness and recovery strategies.

(3) Structures

A hurricane can cause extensive damage to a community's structures, ranging from homes and businesses to public infrastructure. The specific types and extent of damage can vary based on the hurricane's strength, duration, and proximity to the affected area. Here are some common forms of structural damage caused by hurricanes:

- **Roof and Building Damage**: High winds associated with hurricanes can rip off roofs, shatter windows, and weaken the structural integrity of buildings. Flying debris can puncture walls and cause further damage.
- **Flooding**: Heavy rainfall and storm surge, which is a rapid rise in sea level during a hurricane, can lead to widespread flooding. This can damage the foundation, walls, and electrical systems of homes and buildings.
- **Structural Collapse**: In extreme cases, hurricanes can lead to the complete collapse of buildings, especially those that are not constructed to withstand high winds and flooding.
- **Damage to Infrastructure**: Hurricanes can damage critical infrastructure such as roads, bridges, power lines, and water supply systems. This can disrupt transportation, communication, and utility services in the affected area.
- **Erosion**: Coastal communities are particularly vulnerable to hurricane-induced erosion, which can lead to the loss of beaches, dunes, and even the gradual undermining of structures built near the shoreline.
- **Landslides**: In hilly or mountainous areas, heavy rainfall from hurricanes can trigger landslides, damaging homes and infrastructure and posing additional risks to communities.
- **Debris and Tree Damage**: Hurricanes can uproot trees and send debris flying through the air, which can cause significant damage to structures, vehicles, and power lines.

- **Mold and Water Damage**: Prolonged exposure to moisture after a hurricane can lead to mold growth in buildings, further compromising their structural integrity and creating health hazards.
- **Saltwater Intrusion**: Storm surge and flooding from hurricanes can introduce saltwater into freshwater systems, leading to corrosion of pipes and infrastructure in homes and communities.
- **Economic Impact**: The cumulative structural damage caused by hurricanes can have a profound economic impact on a community, resulting in job losses, reduced property values, and the long-term disruption of local businesses.

In the aftermath of a hurricane, communities often face significant challenges in repairing and rebuilding damaged structures, requiring coordinated efforts from government agencies, relief organizations, and the affected residents to recover and mitigate future risks.

(4) Natural, Cultural, & Historical Resources

Hurricanes can wreak havoc on important cultural resources within a community, causing irreparable damage to cherished landmarks, historical sites, and artistic treasures. These storms can erode the cultural identity and heritage of a region, as iconic buildings, museums, and cultural institutions may suffer severe structural damage or destruction. Priceless artifacts, artworks, and historical documents can be lost or damaged due to flooding, high winds, or roof collapses, resulting in the loss of irreplaceable cultural heritage. The destruction of such cultural resources not only robs a community of its history and sense of place but also undermines tourism and local economies that often depend on these cultural attractions. In the wake of a hurricane, communities must prioritize the preservation and restoration of these valuable cultural assets to maintain their identity and vitality.

Table 26: Notable Assets in Montgomery County Damaged by Hurricanes and Tropical Storms

Approximate Date of Event	Asset(s)	Category	Description of Damage
September 1, 2021	Businesses, homes	Structures	The remnants of Hurricane Idea brough heavy rainfall to Montgomery County. According to local news reports, over 200 homes and businesses were damaged by flooding, and the U.S. Small Business Administration approved a disaster declaration for Montgomery and several

Approximate Date of Event	Asset(s)	Category	Description of Damage
			other counties in Maryland.[105]
October 30, 2012	Power grid	Systems	The impacts of Hurricane Sandy left approximately 10,000 homes in Montgomery County without power. The power outages also affected ten schools, as well as government offices.[106]
September 6, 2008	Roadways	Systems	Tropical Storm Hanna brought torrential rainfall to Montgomery County. Some places experienced 4-8 inches of rain within hours, and the deluge forced numerous road closures.[107]
June 22, 1972	Great Falls Park bridges	Natural, historic, cultural	In 1972, heavy rains from Hurricane Agnes destroyed several footbridges along the Potomac River. These bridges are near Great Falls Park, which the National Park Service called "one of the most spectacular views on the East Coast." The bridges were not rebuilt until the 1990s.[108]

9. Water Shortage/Drought

a) Location and Extent

Drought is a recurring phenomenon that affects regions across diverse climates, regardless of their typical rainfall patterns. It arises due to a lack of precipitation and can be exacerbated by factors such as high temperatures, strong winds, and low humidity. Droughts manifest in

[105] Ryan Dickstein. "Disaster Declaration Approved for Maryland Counties Impacted by Ida." WMAR 2 News Baltimore, October 19, 2021. https://www.wmar2news.com/news/local-news/disaster-declaration-approved-for-maryland-counties-impacted-by-ida.
[106] Katie Griffith. "Hurricane Sandy Lands in Montgomery County But Severe Damage Avoided." Potomac, MD Patch, October 30, 2012. https://patch.com/maryland/potomac/hurricane-sandy-tuesday-montgomery-county-lands-punch.
[107] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=135917.
[108] Charles Babington. "TAKE A WALK TO THE WILD SIDE." The Washington Post, July 16, 1992. https://www.washingtonpost.com/archive/local/1992/07/16/take-a-walk-to-the-wild-side/7eee3732-85d9-4c57-8c8c-d9c78e0acac0/.

several categories, including meteorological, hydrologic, agricultural, and socioeconomic, each with distinct characteristics:

- **Meteorological Drought**: This type of drought is defined solely by the extent of dryness, quantified by deviations in actual precipitation from the expected average or norm, observed over monthly, seasonal, or annual timeframes.
- **Hydrologic Drought**: Hydrologic drought relates to the impact of reduced precipitation on stream flows, as well as the levels of reservoirs, lakes, and groundwater.
- **Agricultural Drought**: Agricultural drought primarily focuses on soil moisture deficits concerning the water requirements of plant life, especially crops.
- **Socioeconomic Drought**: Socioeconomic drought links the supply and demand of economic goods and services with elements of meteorological, hydrologic, and agricultural drought. It occurs when the demand for water surpasses the available supply due to weather-related deficiencies. Instances of socioeconomic drought can arise from changes in rainfall patterns, shifts in societal water demands, or increased vulnerability to water shortages, or a combination thereof.

The Maryland Department of the Environment adopts the U.S. Army Corps of Engineers' definition of drought, which characterizes droughts as periods when natural or managed water systems fail to provide adequate water to meet established human and environmental needs due to deficiencies in precipitation or stream flow. Consequently, the state actively monitors key indicators, including precipitation levels, stream flows, groundwater levels, and reservoir storage, to effectively manage water resources for the well-being of communities, the environment, and wildlife.

b) Range of Magnitude

The Standardized Precipitation Index (SPI) is a drought assessment tool that gauges the likelihood of an observed precipitation deficit occurring within various preceding timeframes, spanning from 1 to 36 months. This adaptability in assessment periods empowers the SPI to depict drought conditions relevant to a wide spectrum of meteorological, agricultural, and hydrological applications. For instance, soil moisture conditions primarily react to short-term precipitation shortfalls, while groundwater levels, stream flows, and reservoir storage are influenced by precipitation deficits stretching over several months.

In contrast, the Palmer Drought Severity Index (PDSI), devised by Wayne Palmer in the 1960s, employs a formula that incorporates temperature and rainfall data to determine dryness levels. The PDSI has emerged as a semi-official drought index, particularly effective in discerning prolonged drought episodes, typically spanning several months. However, its effectiveness in short-term forecasting, covering a matter of weeks, is relatively limited. The PDSI employs a

baseline of 0 to signify normal conditions, with drought severity expressed as negative values. For instance, a value of minus 2 denotes moderate drought, minus 3 indicates severe drought, and minus 4 signifies extreme drought.

Table 27: Drought Severity Classifications

Drought Severity	Return Period (Years)	Description of Possible Impacts	Drought Monitoring Indices		
			Standardized Precipitation Index (SPI)	NDMC	Palmer Drought Index
Minor Drought	3 to 4	Going into drought; short-term dryness slowing growth of crops or pastures; fire risk above average. Coming out of drought; some lingering water deficits; pastures or crops not fully recovered.	-0.5 to -0.7	D0	-1.0 to –1.9
Moderate Drought	5 to 9	Some damage to crops or pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing, or imminent, voluntary water use restrictions requested.	-0.8 to -1.2	D1	-2.0 to -2.9
Severe Drought	10 to 17	Crop or pasture losses likely; fire risk very high; water shortages common water restrictions imposed	-1.3 to -1.5	D2	-3.0 to -3.9
Extreme Drought	18 to 43	Major crop and pasture losses; extreme fire danger; widespread water shortages or restrictions	-1.6 to -1.9	D3	-4.0 to -4.9
Exceptional Drought	44+	Exceptional and widespread crop and pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells creating water emergencies	Less than -2	D4	-5.0 or less

Assessing the risk associated with droughts poses a challenge due to the diverse array of drought types and indices available. Drought risk encompasses multiple dimensions, including the frequency, severity, and spatial extent (the geographical scope of drought), in addition to the susceptibility of a population or activity to drought impacts. The vulnerability of Montgomery County to drought hinges on a complex interplay of environmental and social factors, gauged by its capacity to predict, manage, withstand, and recover from drought events.

Drought is typically regarded as a regional hazard, and thus, County-level mapping does not significantly enhance or facilitate its analysis. Within Montgomery County, all jurisdictions are generally presumed to share a comparable level of risk concerning drought events.

c) Past Occurrence

The 2016 Maryland State Hazard Mitigation Plan identifies historical drought occurrences for the State. According to the National Climate Data Center's U.S. Storm Events Database, there were 16 drought events between August 7, 1995 and November 1, 2016. Crop damages from

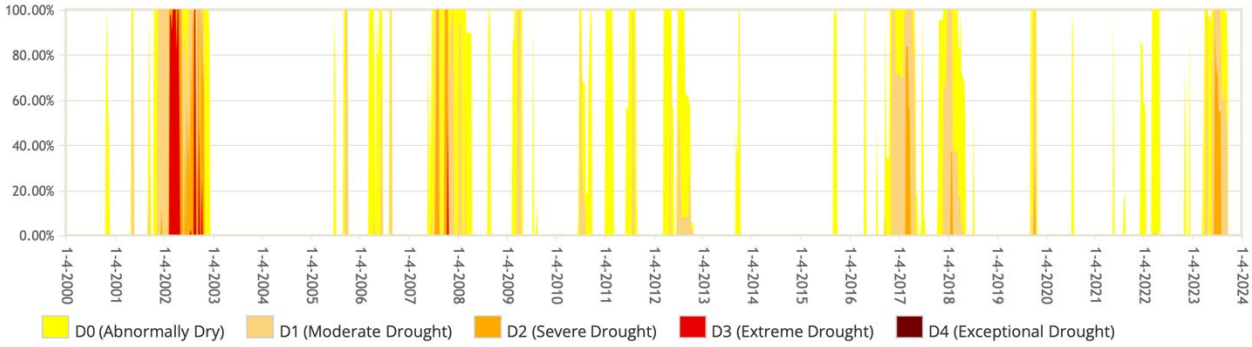
these events totaled $7.36 million for an average damage assessment of $460,000 per event. The table below provides information for some of the more significant drought events in Montgomery County.

Table 28: Significant Drought Events in Montgomery County

Event	Description
1930 -1932	Probably the most severe agricultural drought ever recorded in Maryland and the District of Columbia. Rainfall was about 40 percent less than average, and crop losses for 1930 alone were estimated at $40 million.
1953 - 1956	Affected almost all of Maryland and the District of Columbia. Drought recurrence intervals exceeded 25 years for those areas of Maryland west of Baltimore. For the remaining parts of Maryland and the District of Columbia, the drought had recurrence intervals of 10-25 years, except for the area north and east of Baltimore where recurrence intervals were less than 10 years.
1958 - 1971	This drought lasted the longest of any drought since 1930 and was the most severe in terms of annual departure from average stream flow. Rainfall was sufficient to prevent major agricultural losses. Stream flow in the Potomac declined to record lows, with withdrawals accounting for 80 percent of the available water flow.
1980 - 1983	Affected all but the westernmost part of Maryland. Recurrence interval of the drought was about 10 to 25 years throughout the affected area. The extent to which stream flow decreased during this drought is similar to that during the 1958-71 drought. No major agricultural drought developed, and water supplies were adequate for public supply use.
Fall 1984 – Summer 1988	This drought affected Maryland east and south of Frederick and Washington D.C. Many counties were declared disaster areas because of large agricultural losses. These losses for 1986-1988 were estimated at $302 million. Water supplies for municipalities did not become critically low, although water use was restricted in several areas during summers. Crop damages for Montgomery County amounted to over $2.0 million. No injuries, fatalities, or properties were lost or damaged.
August-September 1995	Dry weather, combined with periods of excessive heat, caused substantial damage to several crops, and limited the production of healthy livestock, during a month-long period that extended through mid-September. Montgomery County crop damages amounted to $100. No injuries, fatalities, or properties were lost or damaged.
July 1997	A very dry month, containing one 7-day heat wave, exacerbated drought-like conditions across much of the fertile farmland of Maryland. The weather in July proved to be the death knell for much of the crop yield, including corn, hay, alfalfa, and soybeans. Agricultural states of emergency were declared in many areas west of the Chesapeake Bay. Hardest-hit counties included Carroll, Frederick, Howard, Montgomery, and Washington. Total crop damages were estimated at $43.7 million for the State; crop damages for Montgomery County amounted to $4.6 million. No injuries, fatalities, or properties were lost or damaged.
September 1998	Crop damages for Montgomery County amounted to over $1.4 million. No injuries, fatalities, or properties were lost or damaged.
November 1998	Crop damages for Montgomery County amounted to over $1.8 million. No injuries, fatalities, or properties were lost or damaged.
August 1999	High pressure was the dominant weather feature across Maryland through the 24th of August. Most rain producing storm systems steered north of the region through the period. This resulted in the continuation of the climatological, meteorological, and hydrological drought which plagued the area. By the third week of August the Palmer Drought Index, a measure of long-term drought conditions, indicated Maryland was in an extreme drought. Washington County reported the lowest groundwater levels in history

Event	Description
	on the 4th. Nineteen Maryland counties were declared federal drought disaster areas on the 11th. The agricultural drought in Maryland continued to devastate farmers, who suffered crop damages of $30 million. An official drought declaration was declared by the Governor of Maryland. Montgomery County crop damage resulting from this drought event amounted to over $2.3 million. The County approved $1.0 million to distribute to 94 farmers covering 35,590 acres. No injuries, fatalities, or properties were lost or damaged.
September 2001	These months were the driest on record since record keeping began in 1871. Groundwater levels, reservoirs, and stream levels fell below record lows. Much of the state was under mandatory water-use restrictions, and wildfires were abundant. Precipitation amounts during this time were only about 57 percent of normal levels. An official drought declaration was declared by the Governor of Maryland.
August 2007	The U.S. Department of Agriculture Secretary declared a drought disaster for the entire State of Maryland. County losses were projected to exceed $13 million. The County approved $1.5 million for distribution to impacted farmers.
November 2008	This was the fifth month in a row that drought conditions were seen across Central and Northern Maryland. Persistent high pressure over the Southeast U.S. forced most rain producing low pressure systems to steer north of the region. The 5-month rainfall total at BWI Airport was only 5.79 inches, compared to the normal of over 17 inches. The drought contributed to a six-fold increase in the amount of brush fires seen across Maryland this November. The agricultural community continued to be hard hit by the persistent drought. By November 20th, 80 percent of topsoil moisture across the state was rated short or very short. The persistent drought contributed $40 million in damage to the fall harvest.
June – August 2010	Drought/Excessive Hear Economic Injury Disaster (#12386) declared by US Small Business Administration in Maryland, including Montgomery County.

Figure 42: Montgomery County Percent of Area in Drought 2000 – 2023[109]



[109] U.S. Drought Monitor – Time Series. Retrieved on 09/29/2023 from: https://droughtmonitor.unl.edu/dmData/Timeseries.aspx

d) Future Occurrence

Predicting the severity and frequency of future drought events in Montgomery County poses a significant challenge. Drought, occurring sporadically, is a natural phenomenon in virtually every climate across the United States. However, the specter of climate change looms large, potentially amplifying the risk of extreme drought events, even if they remain relatively rare. Historical data reveals a slight downward trend in the Palmer Drought Severity Index (PDSI) over the past seven decades, signaling an increased potential for drought risks in the future.

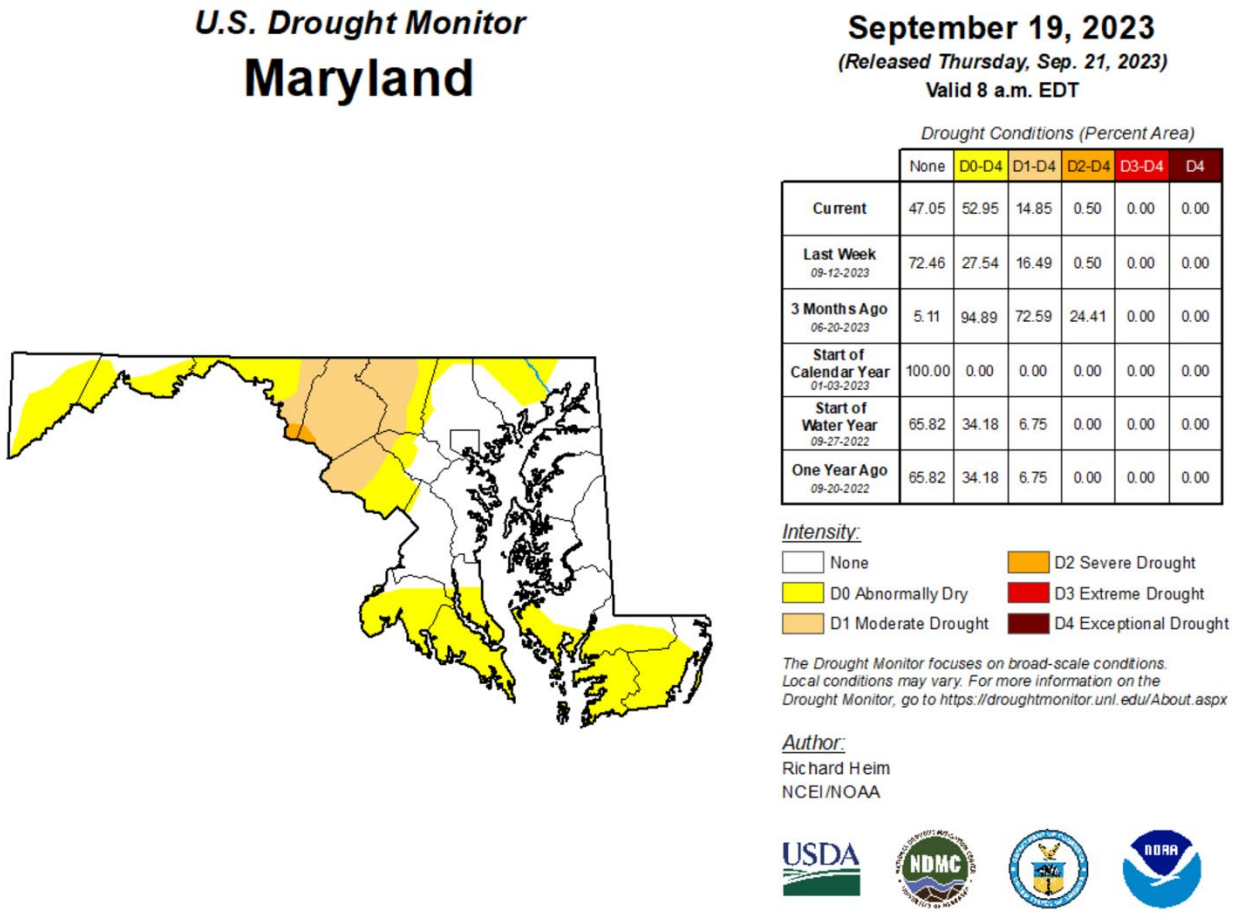
Unlike other natural events, such as floods with commonly accepted return periods or non-exceedance probabilities like the '100-year flood,' drought risk is challenging to define. Instead, drought magnitude is typically assessed in terms of its duration and the severity of the associated hydrologic deficit. Fortunately, various resources are available for evaluating drought conditions and projecting near-future expectations. The National Integrated Drought Information System (NIDIS) Act of 2006 (Public Law 109-430) outlines a collaborative approach to drought monitoring, forecasting, and early warning (NIDIS, 2007). NIDIS maintains the U.S. Drought Portal, a web-based hub offering access to a plethora of drought-related resources, including the U.S. Drought Monitor (USDM) and the U.S. Seasonal Drought Outlook (USSDO).

The USDM, as of September 19, 2023, provides the current weekly drought status for Maryland and is developed and maintained by the National Drought Mitigation Center. On the other hand, the USSDO projects potential drought conditions for September through December 2023, as developed by the National Weather Service's Climate Prediction Center. Several indices gauge how much precipitation for a specific period deviate from historical norms. The widely used Palmer Drought Severity Index (PDSI), for example, plays a pivotal role in determining when to grant emergency drought assistance, particularly in agriculture and water resource management. The PDSI is calculated from observed temperature and precipitation data and estimates soil moisture. While it excels in assessing long-term drought conditions spanning several months, its efficacy diminishes for shorter-term forecasts, measured in weeks. The index uses a scale with 0 representing normal conditions, while drought is indicated by negative values; for instance, -2 signifies moderate drought, -3 represents severe drought, and -4 indicates extreme drought. Over the period from 1895 to 2010, the average annual PDSI value for Montgomery County stood at -0.32, suggesting near-normal moisture conditions.

Looking ahead, future droughts may become more frequent, attributed in part to the rising incidence of extreme heat events stemming from a warming climate. Long-term climate models project changes in precipitation distribution and an increase in both the frequency and severity of drought in specific regions of the country. Despite projections indicating moderate increases in annual precipitation in Maryland, rising temperatures associated with climate change models are expected to reduce soil moisture throughout the year. According to the Intergovernmental

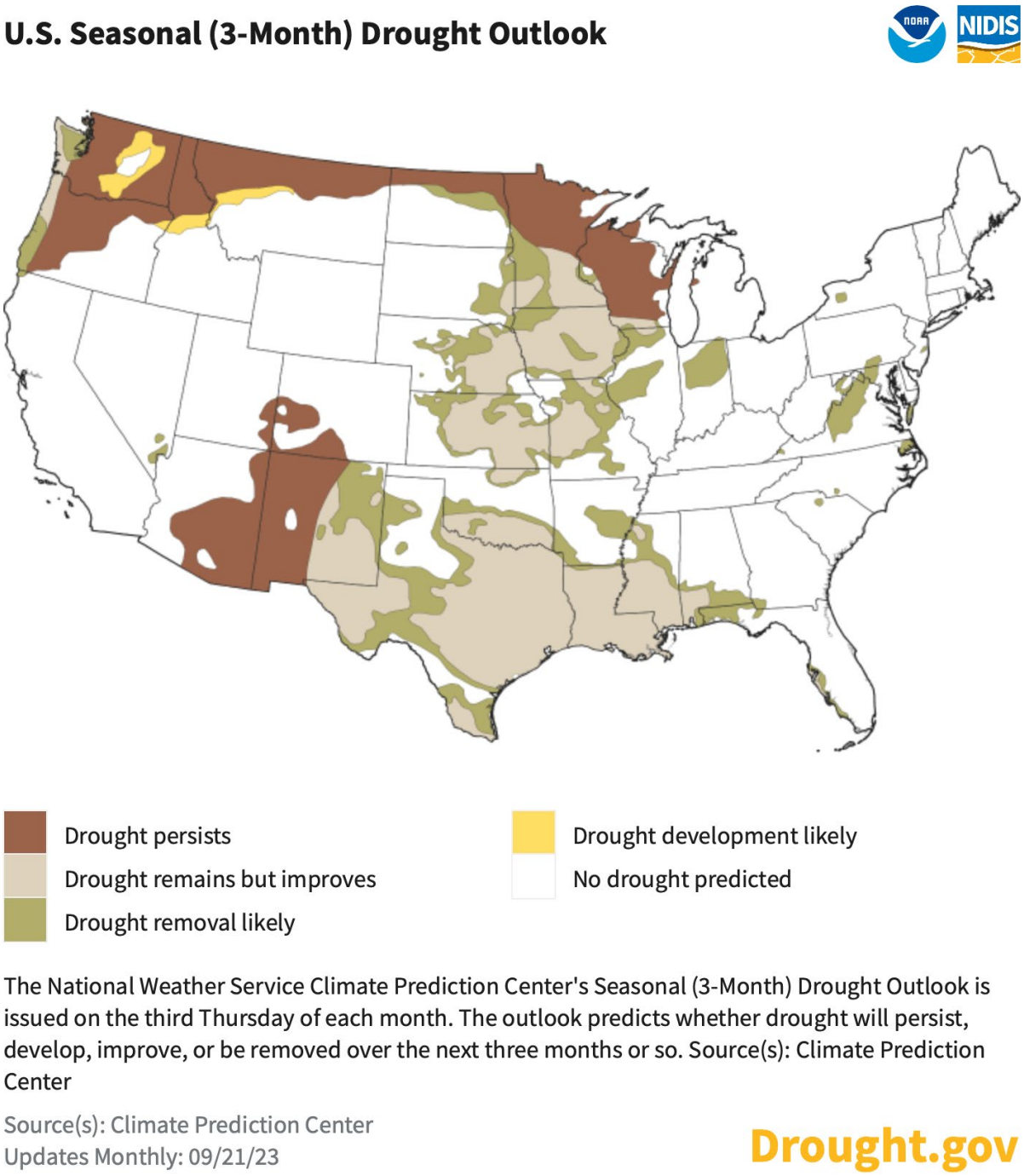
Panel on Climate Change (IPCC) Fourth Assessment Report, there's a high likelihood of more frequent hot extremes and heatwaves as the Earth continues to warm. In Maryland, the number of days with temperatures exceeding 90°F is anticipated to more than double under a lower greenhouse gas emissions scenario and nearly triple under a higher emissions scenario by the end of the century. Extended heatwaves, characterized by temperatures above 90°F for at least three consecutive days, are also expected to become more commonplace and enduring, particularly under higher emissions scenarios.

Figure 43: U.S. Drought Monitor for Maryland, September 2023



Recent droughts in both developing and developed countries and the resulting economic and environmental impacts and personal hardships have underscored the vulnerability of all societies to this “natural” hazard. Droughts may cause a shortage of water for human and industrial consumption, hydroelectric power, recreation, and navigation. Water quality may also decline and the number and severity of wildfires may increase. Severe droughts may result in the loss of agricultural crops and forest products, undernourished wildlife and livestock, lower land values, and higher unemployment.

Figure 44: U.S. Seasonal Drought Outlook



e) Vulnerability Assessment

(1) 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.

According to the 2015 Washington Metropolitan Area Water Supply Study by ICPRB/CO-OP evaluated future water demand and resource adequacy for the period 2015 – 2040. This study concluded that, under a repeat of conditions similar to severe historic droughts and without including potential impacts from climate change, …"by 2035 the current water supply system will experience considerable stress, with mandatory water use restrictions required in the WMA. By 2040 there is likelihood that storage in the Little Seneca Reservoir will become exhausted."[110]

(2) Systems & Structures

In order to provide regional service during drought conditions and ensure that there is adequate flow in the river to meet the environmental flow-by, the Cooperative (CO-OP) Section of the Interstate Commission of the Potomac River Basin (ICPRB) coordinates releases from the Jennings Randolph Reservoir, located near Bloomington, Maryland, on the North Branch of the Potomac River, and the Little Seneca Lake in the County on Little Seneca Creek. These two sources of water augment the Potomac River during periods of extreme low flow in the Washington Metropolitan area. The agencies that have intakes in Montgomery County and which are considered the Regional Water Supply system during a drought are:

- The Washington Suburban Sanitary Commission,
- The Fairfax County Water Authority (FCWA), and
- The Washington Aqueduct Division (WAD) of the Corps of Engineers that serve the District of Columbia, Arlington, Falls Church, and a small portion of Fairfax County. The

[110] Montgomery County Ten-Year Comprehensive Water Supply & Sewerage Systems Plan 2022-2031 pg.3-14

City of Rockville, the Town of Leesburg, and Loudoun County Sanitation Authority also draw their water from the Metropolitan area of the Potomac River.

The following figure depicts the major water supply reservoirs that serves the Washington Region, including several reservoirs located in Montgomery County.

Figure 45: Major Water Supply Reservoirs Serving the Washington Region[111]

These are just a few examples of direct impacts, but it's important to recognize that these direct impacts often have far-reaching consequences, which can be termed indirect impacts. Take, for instance, the reduction in crop yields, diminished productivity of rangelands, and

[111] Montgomery County Ten-Year Comprehensive Water Supply & Sewerage Systems Plan 2022-2031

decreased forest output. These outcomes can set off a chain reaction of consequences that ripple through various sectors of society.

For instance, reduced agricultural productivity can lead to lower income levels for farmers and agribusinesses, which, in turn, can result in several interrelated effects. These effects may include increased prices for essential food items and timber products, which can burden consumers and the wider economy. The decrease in income for farmers can trigger unemployment in rural areas, leading to a rise in joblessness and potentially more people relying on government assistance programs. Moreover, when farmers and businesses earn less, local tax revenues can decline due to reduced spending, impacting public services. In economically stressed communities, crime rates may surge, and foreclosure rates on bank loans to farmers and businesses could rise as well. This economic strain can even prompt migration as individuals seek better opportunities elsewhere.

Direct or primary impacts of drought are typically associated with biophysical factors, such as reduced water availability or changes in weather patterns. As impacts become increasingly removed from their initial causes, the links to the root causes become more complex. In fact, when we examine the web of impacts extending from the primary cause, it becomes exceedingly challenging to quantify the financial extent of damages.

Drought impacts can be broadly categorized into three major groups: economic, environmental, and social. Each of these categories encapsulates a multitude of direct and indirect consequences, highlighting the intricate and multifaceted nature of the impact pathways associated with drought.

Prolonged droughts can also lead to saltwater intrusion. Saltwater can move into freshwater aquifers, reducing the availability of freshwater for drinking and other uses. This is especially a concern for regions that rely heavily on groundwater as a primary source of drinking water.

(3) Natural, Cultural, & Historical Resources

Drought exerts a significant economic toll, particularly in the agriculture sector, which includes related industries like forestry and fisheries. These sectors heavily rely on both surface and subsurface water supplies for their operations. The economic impacts of drought are multifaceted and extend beyond just reduced crop and livestock yields. They encompass a range of challenges, including heightened vulnerability to insect infestations, increased susceptibility to plant diseases, and elevated risk of wind erosion. Black Hill Regional Park located in Montgomery County has more than 2,000 acres of land for outdoor recreation and family gatherings. Black Hill Regional Park is home to the Little Seneca Reservoir which is operated by the Maryland National Capital Park and Planning Commission (M-NCPPC), the Little Seneca Reservoir was built from 1983-1986. This reservoir is part of the Washington

Metropolitan Regional Water Supply, with water supply use and costs shared cooperatively by WSSC Water, Washington Aqueduct and Fairfax Water. The Little Seneca Reservoir holds four billion gallons of water and serves as an emergency raw-water supply during droughts. The reservoir supplements the Potomac River flow via discharge to Little Seneca Creek.[112]

In the realm of agriculture, drought-induced yield losses are apparent and directly affect the livelihoods of farmers. Beyond yield reductions, drought conditions create a favorable environment for insect pests and the proliferation of plant diseases. These adverse conditions can lead to further losses in crop and livestock production, compounding the economic impact.

Forests, too, bear the brunt of drought-related hardships. Drought stress weakens trees, making them more susceptible to insect infestations and diseases. As a result, forest health deteriorates, and growth rates diminish. Extended periods of drought significantly elevate the incidence of forest and range fires, posing heightened risks to both human and wildlife populations. Moreover, these wildfires also jeopardize buildings, infrastructure, and critical facilities in their path.

It's important to note, however, that drought conditions, by themselves, are not typically expected to directly impact general building stock, critical facilities, and infrastructure. These elements of the built environment are designed to withstand a variety of environmental stressors, including drought. The primary focus of drought-related impacts remains centered on the agricultural and natural resource sectors, where surface and subsurface water supplies play a vital role in sustaining livelihoods and ecosystems.

(4) Community Activities

Income loss serves as another vital indicator when assessing the far-reaching impacts of drought, given its widespread effects across various sectors. The repercussions of reduced income for farmers reverberate through the broader economy. Retailers and service providers catering to the agricultural sector experience diminished business, triggering a chain reaction of economic challenges.

This chain reaction includes increased unemployment as businesses reduce their workforce to cope with declining revenues. It also elevates credit risk for financial institutions due to potential loan defaults from struggling businesses. Furthermore, there can be capital shortfalls, affecting investment and growth opportunities. Reduced business activities translate into a loss

[112] WSSC Water - https://www.wsscwater.com/littleseneca

of tax revenue at local, state, and federal levels of government, which can hamper public services and infrastructure development.

The impact of reduced income extends beyond the agricultural sector. It has a noticeable effect on the recreation and tourism industries as discretionary income dwindles, limiting people's ability to engage in leisure activities and travel. The broader economy experiences inflationary pressure, leading to higher prices for essential goods like food and energy as supplies shrink. In some instances, local shortages of specific goods necessitate their import from regions unaffected by drought, further straining economic resources.

Moreover, the diminished water 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.

Table 29: Notable Assets in Montgomery County Damaged by Water Shortages and Drought

Approximate Date of Event	Asset(s)	Category	Description of Damage
August 2007	Farmland/ crops	Natural, historic, cultural	2007 was one of the driest years on record in Montgomery County. The low volume of rain in the County led to an estimated crop loss of $13 million. Drought conditions in 2007 prompted the Montgomery County Office of Agriculture to enact the Agricultural Emergency Assistance Program for the third time in the program's history.[113]
August 1999	Farmland/ crops	Natural, historic, cultural	Between September 1998 and August 1999, the area experienced 12 to 16 inches of rain less than average. This resulted in severe drought

[113] Montgomery County Office of Agriculture. "Agricultural Emergency Assistance Program." montgomerycountymd.gov. Accessed September 28, 2023. https://www.montgomerycountymd.gov/agservices/programs/Ag-Emergency-Assistance-Program.html.

Approximate Date of Event	Asset(s)	Category	Description of Damage
			conditions which led to crop loss costing an estimated $11 million.[114]
July 1997	Farmland/ crops	Natural, historic, cultural	Drought conditions in Montgomery County resulted in extensive loss of crops. The County lost an estimated $2.1 million of soybeans and $2.5 million of grain corn.[115]

10. Tornado

a) Location and Extent

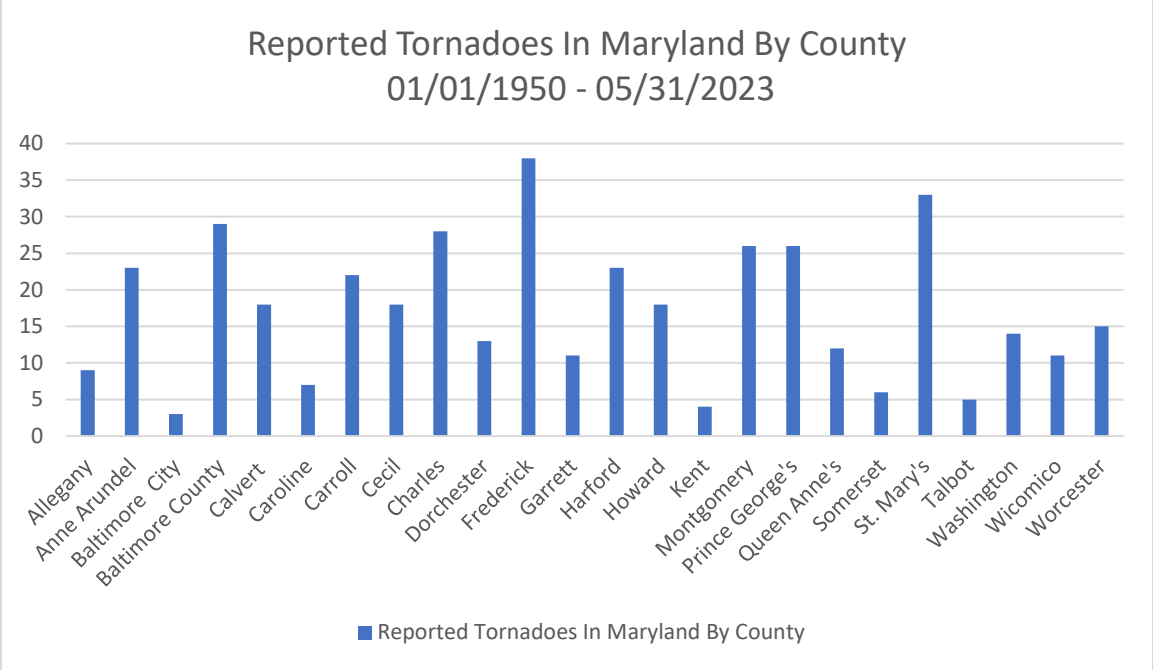
Tornadoes are frequently associated with a specific region in the United States colloquially known as "Tornado Alley." While there's no universally agreed-upon definition of its boundaries, Tornado Alley typically encompasses states known for their susceptibility to tornadoes, including Texas, Oklahoma, Kansas, and Nebraska. Some interpretations of Tornado Alley also extend to nearby states such as South Dakota, Iowa, and Missouri. Additionally, southeastern states like Mississippi, Alabama, and Georgia witness a significant number of tornadoes annually, and this region is commonly referred to as "Dixie Alley." Both Tornado Alley and Dixie Alley are recognized as tornado hotspots due to the regular convergence of meteorological conditions conducive to tornado formation.

However, it's important to note that tornadoes aren't exclusive to these areas. Most states in the U.S. experience tornadoes each year, with all 50 states having recorded at least one tornado since 1950. According to data from the National Oceanic and Atmospheric Administration (NOAA), Maryland has documented 412 tornadoes between January 1, 1950, and May 31, 2023. While it's highly likely that tornadoes occurred in the state prior to 1950, NOAA's tornado reporting data doesn't extend that far back.

[114] National Centers for Environmental Information. “Storm Events Database - Event Details.” ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5718876.
[115] National Centers for Environmental Information. “Storm Events Database - Event Details.” ncdc.noaa.gov. Accessed September 28, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5611210.

Of the 412 documented tornadoes in Maryland, 26 of them affected Montgomery County, tying it with Prince George's County for the fifth-highest number of tornadoes among Maryland's counties. Frederick County, situated immediately northwest of Montgomery County, recorded the highest number of tornadoes among all Maryland counties, with 38 reported occurrences.

Figure 46: Historical Record of Tornadoes in Maryland



The United States experiences a peak in tornado activity during late spring and early summer, with roughly 70% of tornadoes occurring between March and July. This timeframe is commonly referred to as 'tornado season,' although it's essential to dispel the misconception that tornadoes cannot happen during other months. Tornadoes are indeed possible throughout the entire year, although their occurrence becomes less frequent and severe during the fall and winter.

b) Range of Magnitude

Tornadoes are capable of unleashing catastrophic damage whenever they occur. Historically, tornadoes in the U.S. were rated according to the Fujita scale, but this system was replaced in February 2007 by the Enhanced Fujita scale. Both the Fujita (F) and Enhanced Fujita (EF) scale rate the severity of tornadoes on a scale from 0-5, with a higher number indicating a more severe and powerful event. The intensity of a tornado will fluctuate over the duration of its existence, and the rating given to a tornado is meant to convey the event at its strongest point. F-0 and EF-0 tornadoes are the most common and least destructive, while F-5 and EF-5

tornadoes are exceptionally rare and destructive. The U.S. experienced 1,376 tornadoes in 2022, and 75% of these were rated either EF-0 or EF-1. As of 2023, the most recent EF-5 tornado occurred in 2013 in Moore, Oklahoma.

Although the majority of tornadoes in the U.S. are rated as either EF-0 or EF-1, these events can still generate wind speeds of 85-110 mph.[116] At the high end of the scale, EF-5 tornadoes are among the most violent meteorological events on the planet, and winds produced by an F-5 in 1999 were recorded at 302 mph by a nearby doppler radar station. Although the validity of the 1999 measurement has occasionally been questioned, it is well established that EF-5 tornadoes can produce windspeeds well above 200 mph. In comparison, the highest recorded windspeed produced by a hurricane is 190 mph.

Table 30: Enhanced Fujita (EF) Scale Wind Speeds

EF Rating[117]	3 Second Gust (mph)	Description of Event
EF-0	65-85	Gale
EF-1	86-110	Moderate
EF-2	111-135	Significant
EF-3	136-165	Severe
EF-4	166-200	Devastating
EF-5	Over 200	Incredible

The width of tornadoes, the duration a tornado is on the ground, and speed of at which they move varies by event. According to NOAA's National Severe Storm Laboratory (NSSL), tornadoes typically move at 10-20 mph, although past occurrences have been documented moving at nearly 60 mph.[118] The NSSL also states that some long-lasting tornadoes can be on the ground for hours, but the average tornado is only on the ground for about 5 minutes.[119] Determining the width of a tornado can be difficult as they this tends to fluctuate, and the width of the visible funnel cloud may be different than the width of their damage. FEMA

[116] US Department of Commerce, NOAA. "The Enhanced Fujita Scale (EF Scale)." NOAA's National Weather Service. Accessed September 12, 2023. https://www.weather.gov/oun/efscale.
[117] US Department of Commerce, NOAA. "The Enhanced Fujita Scale (EF Scale)." NOAA's National Weather Service. Accessed September 12, 2023. https://www.weather.gov/oun/efscale.
[118] National Oceanic and Atmospheric Administration, and National Severe Storm Laboratory. "Tornado FAQ." Text. nssl.noaa.gov. Accessed September 13, 2023. https://www.nssl.noaa.gov/education/svrwx101/tornadoes/faq/.
[119] National Oceanic and Atmospheric Administration, and National Severe Storm Laboratory. "Tornado FAQ." Text. nssl.noaa.gov. Accessed September 13, 2023. https://www.nssl.noaa.gov/education/svrwx101/tornadoes/faq/.

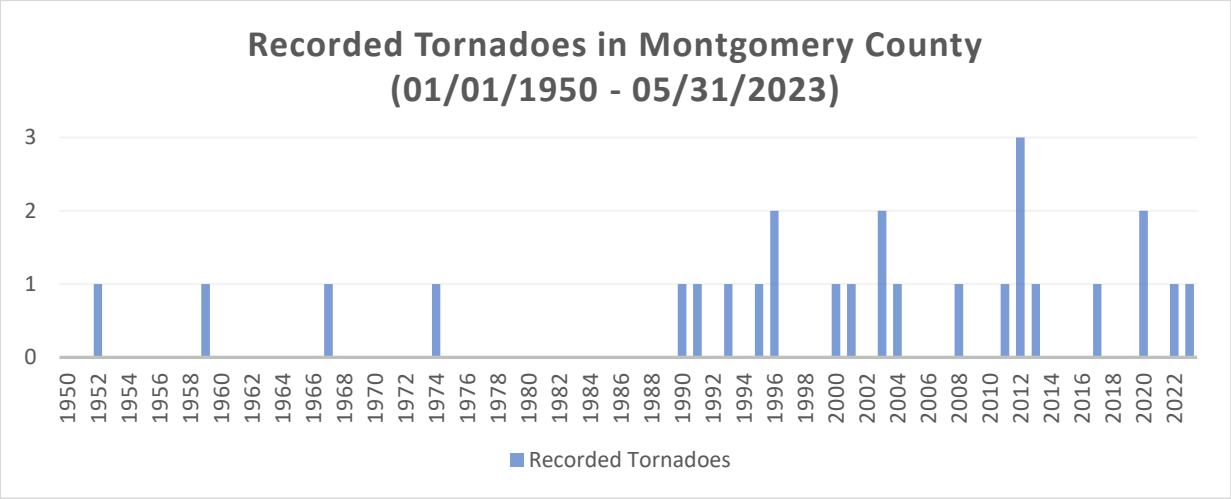
estimates the average width of tornadoes is 300 – 500 yards, whereas National Geographic claims the average width of tornadoes is 660 feet.[120] There is a statistical correlation between size and severity, as wider tornadoes tend to receive higher ratings on the EF-scale.

c) Past Occurrences

Tornadoes have impacted Montgomery County in the past, but they are relatively uncommon events. Since 1950, there have been 26 officially recorded tornadoes in Montgomery County, which is a rate of approximately one tornado every 3 years. However, one tornado every 3 years is just the average rate over a 73-year span, and the number of tornadoes which occur in any given year can vary. This is illustrated by the fact that there have been 4 years since 1950 when Montgomery County has had multiple tornadoes: 1996 (2), 2003 (2), 2012 (3), and 2020 (2). At the other end of the spectrum, Montgomery County's longest stretch without a tornado is 16 years (1974-1990). Of the 26 tornadoes reported in Montgomery County since 1950, 4 occurred between 1950 and 1990, 12 occurred between 1990 and 2010, and 10 have occurred since 2010. The apparently increasing frequency of reported tornadoes in Montgomery County may be the result of several factors like more accurate reporting and changing weather patterns.

[120] National Geographic Staff. "Tornadoes, Explained." nationalgeographic.com, August 28, 2019. www.nationalgeographic.com/environment/article/tornadoes.

Figure 47: Historical Tornadoes in Montgomery County



Among the 26 tornadoes recorded in Montgomery County since 1950, 12 have been rated F/EF-0 and 14 have been rated F/EF-1. Thankfully, all the tornadoes which have impacted the County to-date have been relatively harmless in terms of injuries and deaths. In total, these 26 tornadoes caused only a single reported injury and no fatalities. According to data from the National Centers for Environmental Information (NCEI), the total property damage caused by

the 26 tornadoes in Montgomery County is $5,133,000.[121] Nearly half of the total property damage came from a single F-1 tornado which occurred on 10/18/1990, and this occurrence also caused the single tornado-related injury to have been reported in Montgomery County.

Table 31: Table 18: Tornadoes in Maryland and Montgomery County by Rating

Fujita/Enhanced Fujita Rating[122] [123]	Occurrences in Maryland	Occurrences in Montgomery County
F/EF-0	187	12
F/EF-1	177	14
F/EF-2	35	0
F/EF-3	8	0
F/EF-4	2	0
F/EF-5	0	0

Montgomery County has not experienced a tornado rated F/EF-2 or greater, although some of these events have occurred elsewhere in Maryland. The state has not experienced any F/EF-5 tornadoes, but there have been two recorded F-4 tornadoes in Maryland. The first occurred in 1998 and the second in 2002, and these two tornadoes resulted in 1 fatality and 127 injuries. These two tornadoes also caused a combined $119 million in property damages, which is greater than the total property damage caused by all 399 F/EF-0, F/EF-1, and F/EF-2 tornadoes recorded in Maryland to-date.[124]

d) Future Occurrences

Montgomery County – and Maryland overall – is not within Tornado Alley, Dixie Alley, or other regions traditionally associated with frequent tornadoes. However, the threat of tornado impacts in Montgomery County remains a possibility, and there are more than two dozen documented occurrences of tornadoes in the County. While the overall rate of tornado

[121] National Centers for Environmental Information. "Storm Events Database." ncdc.noaa.gov. Accessed September 13, 2023. https://www.ncdc.noaa.gov/stormevents/.
[122] National Weather Service, and National Oceanic and Atmospheric Administration. "Storm Prediction Center." spc.noaa.gov. Accessed September 12, 2023. https://www.spc.noaa.gov/climo/summary/.
[123] Note: NOAA official data lists three additional tornadic events in Maryland which were not given an F/EF rating.
[124] National Centers for Environmental Information. "Storm Events Database." ncdc.noaa.gov. Accessed September 13, 2023. https://www.ncdc.noaa.gov/stormevents/.

occurrences in Montgomery County since 1950 is relatively low, there are several points which suggest that it may be wise for the County to prepare for more tornadoes in the future.

First, the data on past tornadoes in Montgomery County reveals that nearly 85% of the reported tornadoes occurred since 1990, with only 4 events being recorded between 1950 and 1990. In the last 20 years (2003 – 2023), more tornadoes were reported in Montgomery County than during previous 53 years of record keeping. Additionally, the first year when multiple tornadoes were reported in Montgomery County was 1996, and since then the County has had another 3 years with multiple tornadoes. One possible theory for the increasing frequency of recorded tornadoes in Montgomery County is an overall improvement in documentation. Superior weather radars, the spread of smart phones, and better trained spotters could all result in more accurate documentation of tornadoes. This theory suggests that tornadoes in Montgomery County have long occurred with the same frequency seen since 1990 but were underreported in previous decades. If true, any hazard mitigation and/or emergency operations planning which is based on overall tornado data since 1950 may be underappreciating the risk of tornadoes in Montgomery County.

Second, recent studies have identified trends which suggest that the Tornado Alley hotspot may be gradually shifting to the east. In 2018, the journal *Nature* published research which found that the number of days with meteorological conditions conducive to tornado formation (tornado days) had increased significantly east of the Mississippi River.[125] Conversely, the number of tornado days in the traditional Tornado Alley region decreased. Additionally, a different study in 2022 conducted a special analysis of large tornado outbreaks (LTO) and concluded that the nucleus of LTOs has gradually been shifting south and east since 1989.[126] If these trends continue, it will be critical for eastern communities – including Montgomery County – to be prepared for more frequent and intense tornadic events.

The probability of a tornado occurring in any given year in Montgomery County is assessed as "possible" with between 1% and 49.9% annual probability. This assessment is based on NCEI data for all recorded tornadoes to have occurred within Montgomery County since 1950. However, it is worth noting that a significant majority of these events occurred within the last

[125] Gensini, Vittorio A., and Harold E. Brooks. "Spatial Trends in United States Tornado Frequency." *Npj Climate and Atmospheric Science* 1, no. 1 (October 17, 2018): 1–5. https://doi.org/10.1038/s41612-018-0048-2.
[126] Nouri, Niloufar, and Naresh Devineni. "Examining the Changes in the Spatial Manifestation and the Rate of Arrival of Large Tornado Outbreaks." *Environmental Research Communications* 4, no. 2 (February 2022): 021001. https://doi.org/10.1088/2515-7620/ac50c1.

30 years, and this may be due to improved radar technology, more trained spotters, and the ease of documenting events with smart phones. When looking at tornado events since 1990, the assess probability is "likely" with between 50% and 90% annual probability.

e) Vulnerability Assessment

Official tornado data provided by the National Centers for Environmental Information reveals that the statistical likelihood of tornadoes in Montgomery County is relatively low. However, the County is no stranger to tornado occurrences and has experienced one as recently as 2023. Furthermore, while the County has not experienced a tornado rated above an F/EF-1, there is precedent for tornadoes rated as high as F/EF-4 impacting communities in Maryland. In 2002, an F-4 tornado touched down in western Charles County, MD and traveled nearly 38 miles; at their closest point, Montgomery County is less than 20 miles away from Charles County. Therefore, Montgomery County should continue to take steps that help ensure the public is aware of the possibility of tornadoes in the County and educated on the actions to take when they occur.

One particularly dangerous aspect of tornadoes is the lack of lead time usually afforded to those in their paths. Unlike hurricanes, tornadoes cannot be tracked days ahead of their expected impact, and the exact mechanisms responsible for producing them are still not fully understood. When the National Weather Service assesses that the conditions are right for tornado formation, they will issue tornado watches covering the relevant area. Unfortunately, the systems which bring the necessary conditions for tornadoes are oftentimes far larger than any tornado they ultimately produce, and the Storm Prediction Center acknowledges that typical watches cover about 25,000 square miles.[127]

Tornado warnings are far smaller in size than watches, but they are much more serious as they indicate the presence of an actual tornado rather than conducive conditions. Because tornado warnings are often issued during or after the formation of a tornado, tornado warnings typically provide a relatively short window of time for those in the path of a tornado to act. According to FEMA, the lead time of tornado warnings is usually only 10-15 minutes, but this can be even shorter if the conditions are unfavorable. While it may seem reasonable to simply lower the standards for issuing tornado warnings to attempt to increase lead time, the reality is that this can be counterproductive. Several studies have found evidence that warnings *more* than 15

[127] Storm Prediction Center. "Storm Prediction Center Frequently Asked Questions (FAQ)." spc.noaa.gov. Accessed September 13, 2023. https://www.spc.noaa.gov/faq/.

minutes in advance can increase fatalities compared to no warning at all, and other variables such as repeated false alarms may decrease the public's reaction time when a warning is issued.[128]

(1) People

Tornadoes threaten virtually all individuals in Montgomery County to some extent. However, the current inability to precisely predict when and where tornadoes will form means that the hazard is particularly threatening to individuals who have difficulty receiving (or understanding) issued warnings, as well as those who are unable to adequately shelter in a timely manner. A selection of populations which can broadly be considered as more vulnerable to tornado impacts are identified and discussed in the chart below. It should be noted that the following chart is not an exhaustive list of vulnerable populations.

Table 32: Populations at Elevated Risk from Tornado Impacts in Montgomery County

Population	Potential Vulnerabilities	Scope in Montgomery County
Elderly	Older individuals may have limited mobility, as well as limited hearing and vision. These factors can make it more difficult to notice alerts (sirens, phone alerts, etc) and reach shelter in a timely manner.	Per 2021 ACS 1-year estimates, 16.6% of the total population in Montgomery County is 65 years or older. The same data shows that 7 of 215 census tracks in the County have more than 32.6% of their population 65 years or older. Communities in these census tracks include Silver Spring, Gaithersburg, and Calverton.
Disabled	Individuals with physical or mental disabilities may have difficulty understanding traditional weather alerts, and individuals with disabilities may require assistance with reaching a shelter.	Per 2021 ACS 1-year estimates, 8.7% of Montgomery County's noninstitutionalized population have a disability. The same data shows that 2.5% have a hearing disability, 1.5% have vision difficulty, 3.5% have a cognitive disability, and 3.9% have an ambulatory difficulty. Individuals may have more than one disability.
Low Income	Individuals considered to be disadvantaged due to low income	Per 2021 ACS 1-year estimates, 188,783 individuals in Montgomery

[128] Black, Alan W., and Walker S. Ashley. "The Relationship between Tornadic and Nontornadic Convective Wind Fatalities and Warnings." *Weather, Climate, and Society* 3, no. 1 (January 1, 2011): 31–47. https://doi.org/10.1175/2010WCAS1094.1.

Population	Potential Vulnerabilities	Scope in Montgomery County
	(income <200% below federal poverty level) may lack access to cell phones, televisions, and/or weather radios which help alert individuals of an oncoming tornado. These individuals may also lack access to study structures or shelters which save lives.	County in 2021 earned less than 200% below the federal poverty level. These individuals are not centered in any one portion of the County and broadly match the overall population distribution in the County.
Limited English proficiency	Individuals who do not speak English or only have limited English skills may have difficulty understanding emergency alerts. This issue may be exacerbated if the emergency alerts use meteorological terms which are not commonly encountered. Additionally, spoken alerts may be difficult to hear clearly if the signal reception is bad or the weather generates significant background noise. Individuals who are unable to understand the emergency alerts may not take appropriate action or act at all.	Per 2021 ACS 1-year estimates, 16% of the population in Montgomery County spoke English at a level below "very well" or not at all. Additionally, the Climate and Economic Justice Screening tool identifies 17 of 215 census tracks in the County as being "linguistically isolated." This is defined as being in or above the 90th percentile for the share of households where no one over age 14 speaks English "Very well." A cluster of 5 such census tracks are along Connecticut Avenue between North Kensington and Aspen Hill.

(2) Structures

In terms of the built environment, mobile homes are consistently identified as structures which are especially vulnerable to tornadoes (and high winds in general). Although it is not uncommon for these structures to utilize lightweight construction, mobile homes are vulnerable to tornadoes mainly because they lack the robust anchoring used for permanent structures.[129] Furthermore, mobile homes typically do not have attached basements which can serve as shelters in the event of a tornado. According to the National Weather Service (NWS), approximately 40% of all tornado-related fatalities occur in mobile homes. Additionally,

[129] National Weather Service. "Severe Weather Preparedness Week." www.weather.gov. Accessed September 15, 2023. https://www.weather.gov/jan/swpw_mhsafety.

individuals are 15-20 times more likely to lose their life in a tornado compared to individuals in permanent structures hit by tornadoes.[130] Due to the vulnerability of mobile homes, the NWS does not recommend that mobile home residents stay in their home during a tornado. Instead, the NWS recommends that these individuals take shelter in the community storm shelters which are usually found in mobile home parks. These community shelters are key assets for protecting the public from tornadoes. Therefore, it is highly recommended that appropriate entities ensure these storm shelters are capable of sufficiently holding the number of people who will rely on them for protection in the event of a tornado.

Table 33: Notable Assets in Montgomery County Damaged by Tornadoes

Approximate Date of Event	Asset(s)	Category	Description of Damage
November 5, 2003	Homes, businesses	Structures	A tornado crossed into Maryland from Northern Virginia and produced scattered damage in rural areas between the Potomac River and Germantown. Numerous farm buildings were destroyed, and the total cost of the tornado damage was estimated to be $1.2 million.[131]
May 27, 2001	Homes, businesses	Structures	An F1 tornado stayed on the ground for approximately 3.5 miles while seriously damaging homes and businesses. A multi-screen cinema had its roof stripped off, and a mall had to be evacuated and condemned until later repairs could restore the structural integrity of the building.[132]
July 19, 1996	C&O Canal, White's Ferry	Natural, historic, cultural	An F1 briefly touched down 2 miles north of the historic Whites Ferry. The Ferry was established in 1786 to cross the Potomac between Virginia and Maryland. The tornado uprooted trees along

[130] National Weather Service. "Severe Weather Preparedness Week." www.weather.gov. Accessed September 15, 2023. https://www.weather.gov/jan/swpw_mhsafety.
[131] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 29, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5379733.
[132] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 29, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5248119.

Approximate Date of Event	Asset(s)	Category	Description of Damage
			the access road to White's Ferry, as well as along the Chesapeake and Ohio Canal. Crop losses of $30,000 was also reported.[133]
October 18, 1990	Homes, businesses	Structures	According to data from NCEI, the F1 tornado that plowed through 40 structures in Kensington in October 1990 caused more damage than any other tornado recorded in Montgomery County. The damage from the tornado was estimated at $2.5 million.[134]

11. Earthquake

An earthquake is a powerful geological event characterized by the vigorous shaking or oscillation of the Earth's surface, brought about by the abrupt movement of rocks, typically occurring within the upper 10-20 miles of the Earth's crust. These seismic phenomena are the consequence of various natural processes, including crustal stress, volcanic activity, mass movements like landslides, or the structural collapse of subterranean chambers. Earthquakes, as extraordinary and often catastrophic events, encompass a vast array of implications.

These seismic disturbances can extend their influence across extensive regions, sometimes spanning hundreds of thousands of square miles. Their impacts are both far-reaching and profound, transcending mere geological significance. Earthquakes can exact an immense toll on both the physical and human aspects of our world. They can inflict colossal property damage, racking up losses in the tens of billions of dollars, while also exacting a grim human cost in terms of lives lost and injuries sustained by hundreds of thousands of individuals.

Moreover, the ramifications of an earthquake extend beyond the immediate and tangible. They reverberate through the social and economic fabric of the afflicted area, causing disruptions of

[133] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 29, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5568062.
[134] National Centers for Environmental Information. "Storm Events Database - Event Details." ncdc.noaa.gov. Accessed September 29, 2023. https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=10041387.

monumental proportions. Communities are shaken, livelihoods are disrupted, and infrastructures vital for daily life are often rendered inoperative. The aftermath of a significant earthquake represents a Herculean challenge, demanding extensive resources and coordinated efforts to rebuild shattered lives and communities.

In essence, earthquakes are not merely geological phenomena; they are awe-inspiring and sobering events that remind us of the immense forces at play within our planet. Their consequences are multi-faceted, encompassing physical destruction, human suffering, and societal upheaval, making them a pivotal focus of scientific study, preparedness, and disaster mitigation efforts.

a) Location & Extent

Earthquakes wield far-reaching impacts, extending their grasp across vast expanses, often spanning hundreds of thousands of square miles. Their consequences are dire, encompassing the tragic loss of lives, injuries, extensive property damage, and the disruption of both social and economic functions. The primary driver of this devastation is the violent shaking of the ground during an earthquake, a phenomenon whose severity hinges on the amplitude and duration of the seismic event.

These seismic upheavals most frequently originate at fault lines, where tectonic plates interact, and stress accumulates over time. Maryland, however, finds itself situated on the North American plate, a considerable distance away from any plate boundary. In fact, the nearest plate boundary lies approximately 2,000 miles to the east, beneath the waters of the Atlantic Ocean. Closer to home, in Montgomery County, the most relevant geological feature is the Ramapo Fault, a component of a broader system of faults that trend northeastward and dip to the southeast. These intricate geological formations traverse the landscape from southeastern New York to eastern Pennsylvania.

The Ramapo Fault and its associated fault system have a storied history, having played a role in the geological evolution of the Appalachian Mountains some 200 million years ago. While Maryland may not be perched on a plate boundary, the Ramapo Fault system serves as a reminder of the Earth's complex geological history, underlining the ongoing potential for seismic activity in regions far removed from active plate boundaries[135]. The best predictor of the distribution of earthquakes is the distribution of past earthquakes. Earthquake events in

[135] Columbia University, 2012

Pennsylvania typically do not impact areas greater than 100 km from the epicenter, and earthquake epicenters in Philadelphia are not common. Due to zones of weakness or deep fault lines within the North American plate, earthquakes are a possible hazard within Montgomery County.

b) Range of Magnitude

More substantial earthquakes can trigger a range of destructive phenomena, including subsidence, soil liquefaction, and landslides. Conversely, milder earthquakes may pass by unnoticed, their tremors escaping human perception. The intensity of an earthquake is contingent on several factors, primarily the amount of energy discharged at its epicenter, the distance from that epicenter, and the nature of the underlying soil.

To gauge and categorize the severity of earthquakes, the United States Geological Survey (USGS) relies on specialized measurement tools that factor in both magnitude and intensity. The Richter scale, an open-ended logarithmic scale, plays a central role in quantifying the magnitude of earthquakes, essentially measuring the energy released at the earthquake's source. In this logarithmic scale, each incremental increase in Richter scale magnitude corresponds to a tenfold augmentation in the magnitude of the seismic event and a thirtyfold escalation in the energy unleashed. Consequently, while a 2.0 magnitude quake might go nearly unnoticed, an 8.0 magnitude earthquake can inflict substantial damage over a considerable area.

To provide a clearer understanding of earthquake effects relative to Richter Magnitude, a detailed table is presented below for reference:

Table 34: Richter Scale Magnitudes & Associated Earthquake Size Effects

Richter Magnitude	Earthquake Effects
Less than 3.5	Generally felt but recorded.
3.5-5.4	Often felt, but rarely causes damage.
Under 6.0	At most, slight damage to well-designed buildings; can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive up to about 100 km from epicenter.
7.0-7.9	Major earthquake, can cause serious damage over large areas.
8.0 or greater	Great earthquake; can cause serious damage in areas several hundred km across.

The Richter Scale does not give an indication of the intensity or damage of an earthquake, although it can be inferred that higher magnitudes cause more damage. The impact of an earthquake is measured in intensity. The Modified Mercalli Intensity (MMI) scale measures earthquake intensity as shown below.

Table 35: Modified Mercalli Intensity Scale & Associated Impacts

Scale	Intensity	Description of Effects	Corresponding Richter Scale Magnitude
I	Instrumental	Detected only on seismographs	< 4.2
II	Feeble	Some people feel it	
III	Slight	Felt by people resting; like a truck rumbling by	
IV	Moderate	Felt by people walking	
V	Slightly Strong	Sleepers awake; church bells ring	< 4.8
VI	Strong	Trees sway; suspended objects swing; objects fall off shelves	< 5.4
VII	Very Strong	Mild alarm, walls crack, plaster falls	<6.1
VIII	Destructive	Moving cars uncontrollable, masonry fractures, poorly constructed buildings damaged	<6.9
IX	Ruinous	Some houses collapse, ground cracks, pipes break open	
X	Disastrous	Ground cracks profusely, many buildings destroyed, liquefaction and landslides widespread	<7.3
XI	Very Disastrous	Most buildings and bridges collapse, roads, railways, pipes and cables destroyed, general triggering of other hazards	<8.1
XII	Catastrophic	Total destruction, trees fall, ground rises and falls in waves	>8.1

The USGS further evaluates the intensity of earthquakes through Peak Ground Acceleration (PGA) and Spectral Acceleration (SA). PGA expresses the severity of an earthquake and measures how hard the earth shakes or accelerates in each geographic area. The figure below depicts seismic design categories, which reflect the likelihood of experiencing earthquake shaking intensities. Montgomery County is in Category A, a very small probability of experiencing damaging earth-quake effects.

Figure 48: Earthquake Hazard Map, Eastern US

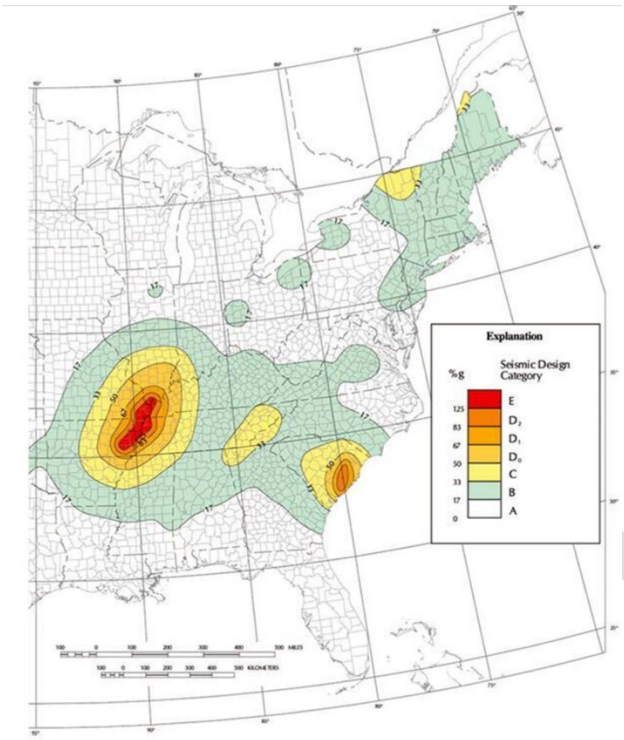
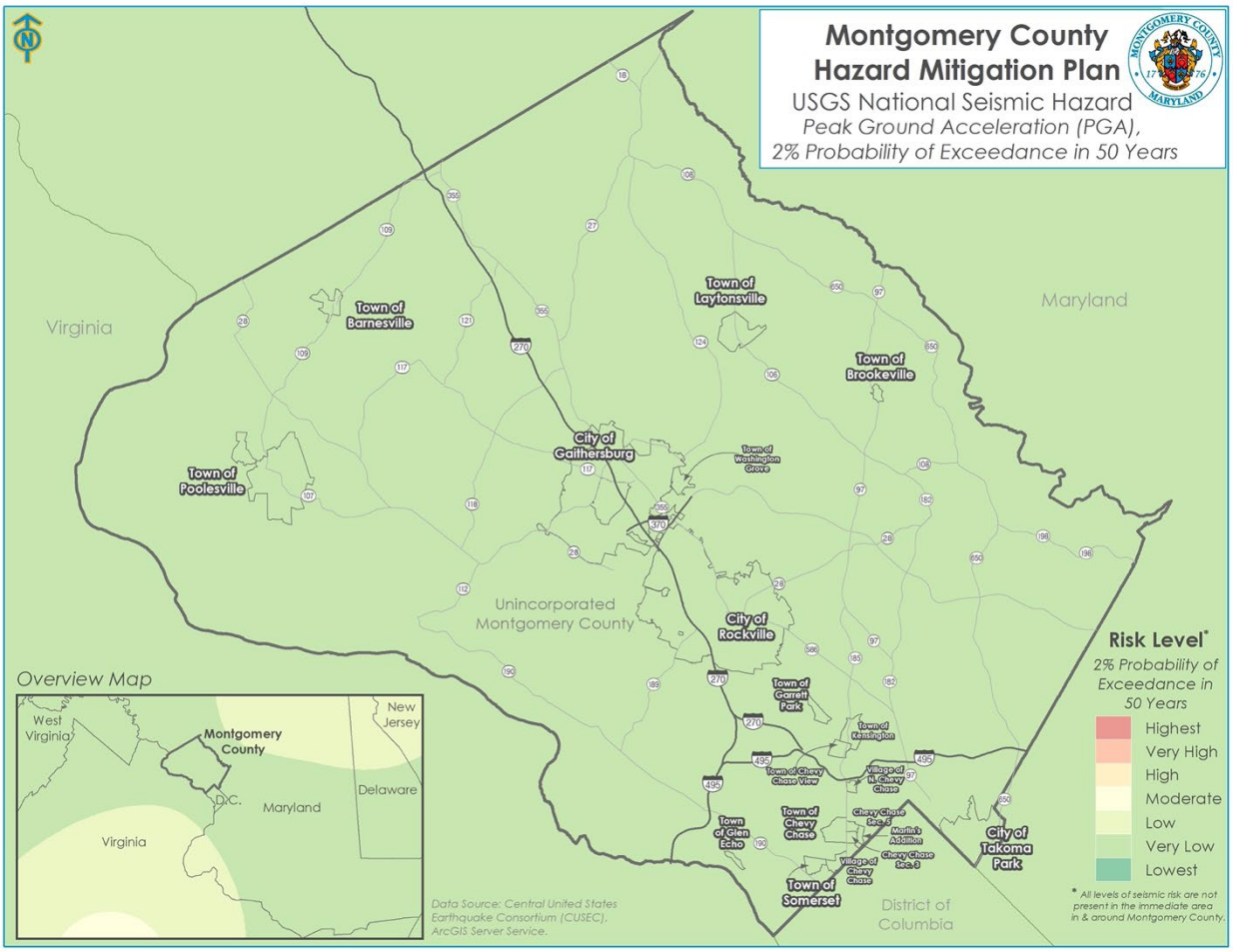


Figure 49: Peak Ground Acceleration in Montgomery County

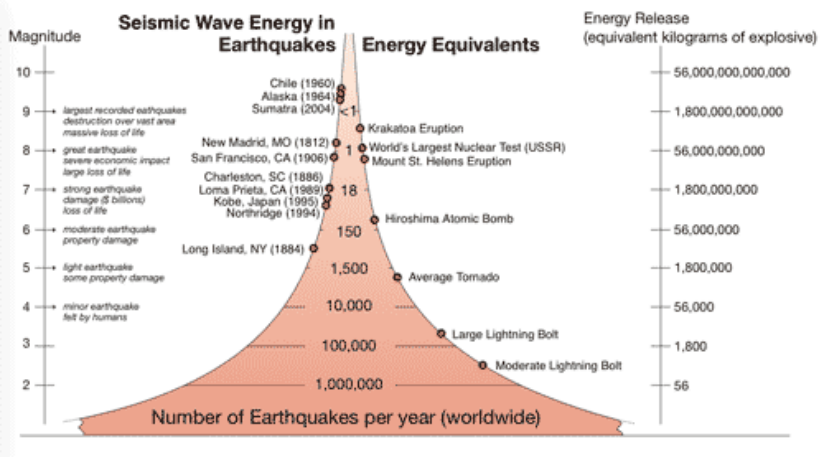


The most concerning scenario for the County would involve a moderately intense earthquake striking the region, registering a notable level on the MMI (Modified Mercalli Intensity) scale, ensuring that virtually everyone within the vicinity would be acutely aware of the seismic event. In such a situation, structural damage to buildings would become apparent, with signs like shattered windows and fissures in the masonry particularly affecting poorly constructed residences.

Inside homes, household items would be displaced, potentially causing breakages and, unfortunately, injuries to occupants. The immediate aftermath of this seismic event would necessitate a swift response from emergency services, and the 9-1-1 call center would likely become inundated with concerned citizens seeking assistance and guidance in the face of this unexpected crisis.

The figure below depicts magnitude in relation to energy equivalents and historical earthquake occurrences.

Figure 50: Seismic Wave Energy in Earthquakes

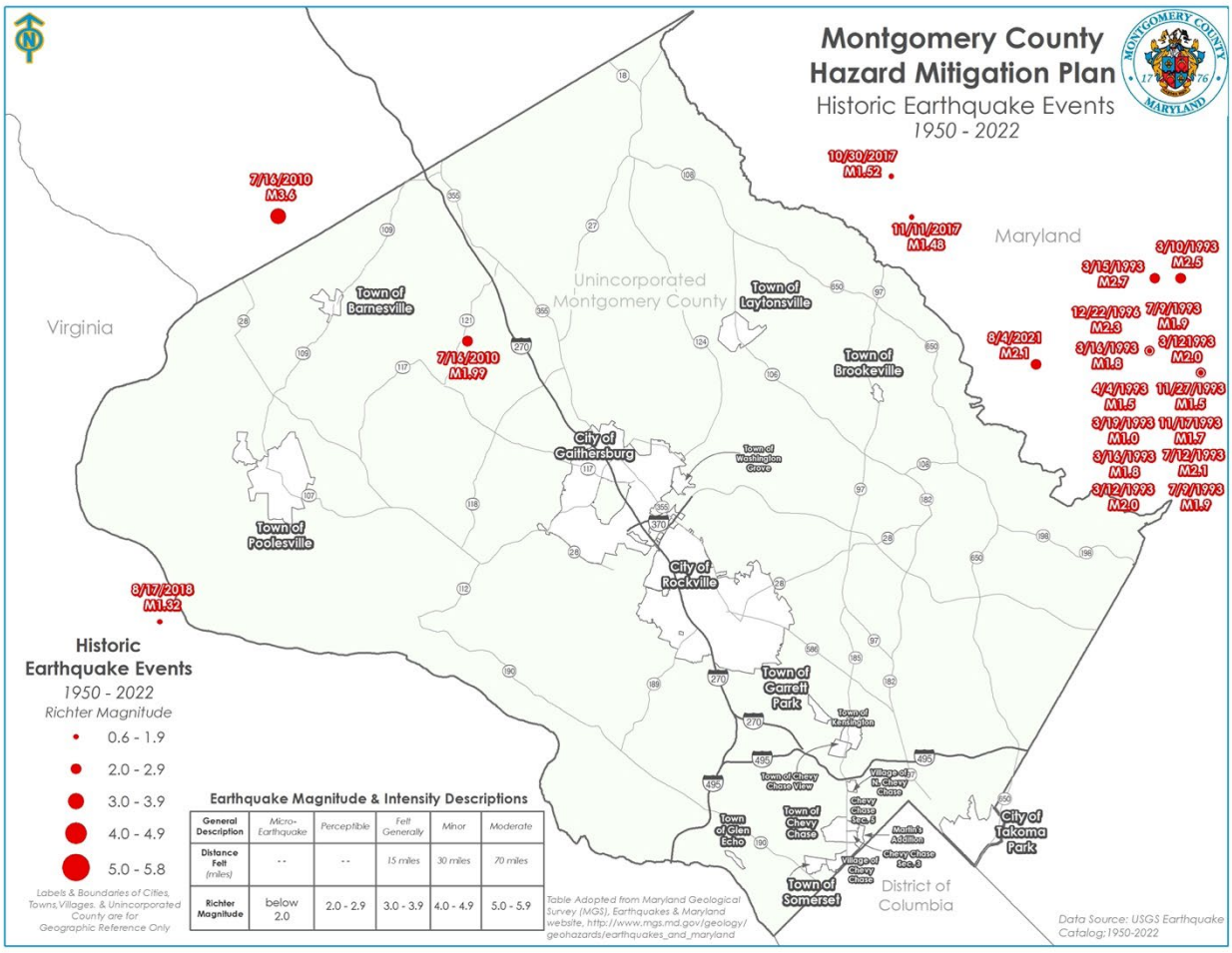


c) Past Occurrence

Maryland's seismic history dates to the earliest recorded earthquake, which jolted Annapolis on April 24, 1758, registering between 3.5 and 3.7 on the Richter Scale. Over two centuries later, on August 23, 2011, the most recent significant seismic event occurred, measuring 5.8 on the Richter Scale. This earthquake's epicenter was situated in Louisa County, Virginia, but its impact reverberated for hundreds of miles, including in Montgomery County. Remarkably, despite its wide reach, this seismic event did not result in substantial damage in Montgomery County. Minor consequences included the temporary closure of some public facilities within the county's borders and structural damage to the National Cathedral, which stands just a stone's throw from the county line.

Since 1758, Maryland has logged a total of 68 earthquakes, none of which have been reported to cause major damage or loss of life. Geologists specializing in this field tend to predict that the largest magnitude earthquake that could potentially occur in the state of Maryland would fall within the range of 4 to 4.5 on the Richter Scale. Consequently, Maryland maintains a notably low probability of experiencing a destructive earthquake within a 50-year timeframe.
For a visual depiction of the historical occurrences of earthquakes in Montgomery County, please refer to the figure below.

Figure 51: Historical Occurrences of Earthquakes Near Montgomery County 1950 - 2022

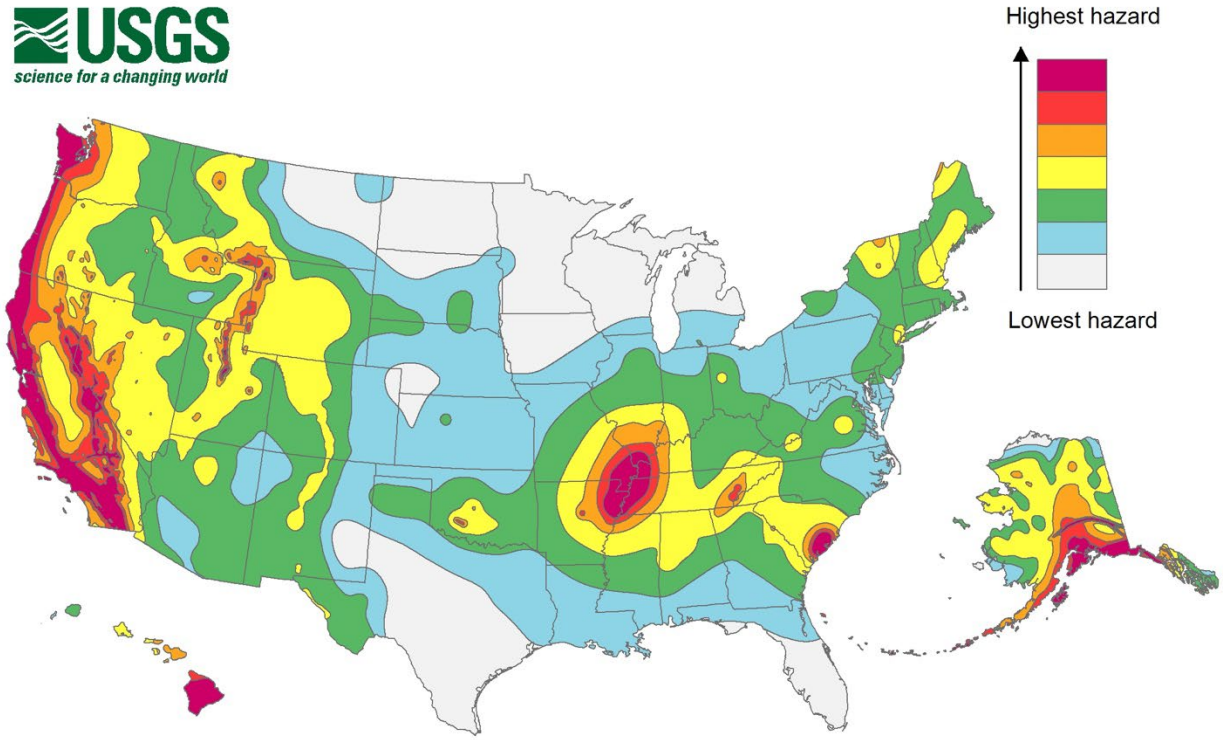


d) Future Occurrence

The best available guides to the magnitude and frequency of seismic hazards are the probabilistic ground motion maps produced by USGS. The latest available maps are the 2018 USGS National Seismic Hazard Maps.

The figure below shows relative seismic hazard zones in the U.S. as determined by the USGS National Seismic Hazard Mapping Project. The map of hazard zones is based on peak ground acceleration (PGA) for the US with a recurrence interval of 2,500 years (2% probability of exceedance in 50 years). PGA is expressed as a percentage of the force of gravity, or %g. Damage to buildings of poor construction generally begin at a PGA of 10% g.

Figure 52: Long-term National Seismic Hazard Map[136]



e) Vulnerability Assessment

Overlooking the low probability, if a strong earthquake with an epicenter located in the County were to occur, it would cause extensive critical services disruptions, financial losses, and casualties. The following table lists earthquake-induced direct or indirect impacts that would affect Montgomery County's economy, environment, and residents. In the event of an earthquake, the magnitude and location in the County would determine the possible loss of life and infrastructure affected.

(1) People

The impacts of a large-scale earthquake in Montgomery County would disproportionately effect the County's socially vulnerable populations. While absolute losses are more likely to occur among wealthier groups or property and business owners in densely populated areas, the relative impact of an earthquake on low-income households' economic stability and resilience

[136] USGS, 2018

would be far greater in the long term. Socially vulnerable households are less likely to have strong financial safety nets or insurance to recover from disasters such as earthquakes. Additionally, housing is often the principal economic asset of lower income urban households which a large-scale earthquake might damage irreparably (UNDRR).

Earthquakes can have particularly severe and disproportionate impacts on socially disadvantaged populations. Socially disadvantaged populations often reside in older, poorly constructed, or substandard housing. These structures are more likely to suffer extensive damage or even collapse during an earthquake, putting residents at greater risk of injury or homelessness. Lower-income individuals and families may lack the financial means to prepare for or recover from earthquake-related losses. They may not have insurance coverage or savings to repair or replace damaged property, making it harder for them to regain stability after a disaster.

Vulnerable populations may have limited access to healthcare facilities or face barriers to seeking medical attention after an earthquake. Injuries sustained during the quake may go untreated, leading to long-term health issues. Socially disadvantaged communities rely more heavily on public services, such as emergency shelters, food assistance, and transportation. When these services are disrupted or overwhelmed by the earthquake, those who depend on them can face additional hardships.

Disadvantaged populations typically experience social isolation, discrimination, or lack of social support networks, which can exacerbate the emotional and psychological trauma caused by an earthquake. Loss of employment or livelihood due to earthquake-related disruptions can have a more profound impact on low-income individuals and families, pushing them deeper into poverty. Post-earthquake recovery efforts can sometimes inadvertently exacerbate existing inequalities. Gentrification, for example, may lead to the displacement of low-income residents from their neighborhoods as areas are rebuilt and property values rise.

(2) Systems

An earthquake in Montgomery County, Maryland, has the potential to disrupt critical systems and infrastructure in several ways, posing significant challenges to the region's response and recovery efforts. Here are some of the key critical systems that could be affected:

Transportation Infrastructure:

- Roads and bridges may experience structural damage or become blocked by debris, impeding emergency response and evacuation efforts.
- Public transportation systems, including buses and trains, may be halted or delayed due to damage to tracks, stations, or power supply systems.

Utility Services:

- Electrical power lines and substations can be damaged or disrupted, leading to widespread power outages.
- Gas and water pipelines may rupture, potentially causing fires, leaks, or water supply issues.

Communications:

- Telecommunication networks, including cell towers and landline infrastructure, may suffer damage or overload, making it difficult for residents to reach emergency services or communicate with loved ones.
- Internet services may be disrupted, affecting access to critical information and emergency alerts.

Emergency Services:

- Fire stations, police stations, and hospitals could sustain damage, affecting their ability to respond to emergencies effectively.
- Emergency response personnel and equipment may be overwhelmed by the volume of calls and the extent of damage.

Education and Public Facilities:

- Schools, government buildings, and community centers may be damaged or rendered unsafe for use, impacting public services and shelter availability.

Water Supply and Sanitation:

- Earthquakes can damage water treatment plants and sewage systems, potentially causing water contamination or shortages.

Business and Economy:

- Local businesses may suffer damage or disruption, leading to economic losses and potential job layoffs.
- Supply chains may be interrupted, affecting the availability of goods and services.

(3) Structures

Most property damage and earthquake-related injuries and deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size,

distance from the fault, site, and regional geology. Other damaging earthquake effects include landslides, the down-slope movement of soil and rock (mountain regions and along hillsides), and liquefaction, in which ground soil loses shear strength and the ability to support foundation loads. In the case of liquefaction, anything relying on the substrata for support can shift, tilt, rupture, or collapse.

(4) Natural, Cultural, & Historical Resources

An earthquake in Montgomery County, Maryland, has the potential to damage or endanger several important cultural resources in the area. These resources hold historical, artistic, and cultural significance and are integral to the county's heritage and identity. Here are some examples of the types of cultural resources that could be at risk:

Historic Buildings and Structures:

- Historic homes, churches, and other buildings may suffer structural damage, including cracks in walls, ceilings, and foundations.
- Architectural details, such as ornate facades, stained glass windows, and decorative interiors, may be at risk of damage or loss.

Museums and Art Galleries:

- Artifacts, artwork, and museum exhibits may be dislodged or damaged due to shaking, potentially resulting in the loss of irreplaceable cultural and historical items.
- Fragile items, such as sculptures, paintings, and delicate textiles, may be particularly vulnerable.

Libraries and Archives:

- Libraries and archival repositories may experience damage to rare books, manuscripts, and historical documents.
- Shelves and storage areas may become disorganized or collapse, making it challenging to access and preserve valuable materials.

(5) Community Activities

An earthquake has the potential to disrupt community events across Montgomery County in various ways, depending on its magnitude and proximity to the event location. In the immediate aftermath of a significant earthquake, event organizers may opt to cancel or postpone gatherings to ensure the safety of participants. This decision can be made to assess damage, address safety concerns, and allow time for recovery efforts. Earthquakes can also cause structural damage to event venues, such as Maryland SoccerPlex, community centers, parks, and outdoor spaces. This damage may render the venue unsafe for use and necessitate

repairs or reconstruction. Concerns about safety and the aftermath of an earthquake may lead to lower attendance at community events, affecting their overall success and participation levels.

12. Land Subsidence/Karst

a) Hazard Identification

Land subsidence refers to the sinking or downward settling of the ground's surface. It can occur over large areas or be localized to small patches of land. A common and recognizable form of land subsidence is sinkholes. Land subsidence and sinkholes most commonly occur in regions called "karst terrain,"[137] which is typically formed in areas with abundant soluble rocks like limestone and dolomite. In these areas, the natural dissolution of the soluble rocks leads to features like caves and underground drainage systems. It is not uncommon for karst areas to contain natural springs and aquifers, and according to the United States Geological Survey (USGS), about 40% of groundwater used for drinking comes from karst aquifers.[138] Over time, sub-surface dissolution reduces the volume of material supporting the overlying weight and leads to land subsidence at the surface. The size and impact can vary dramatically depending on the specific conditions of land subsidence. For sinkholes, there are three categories which are generally used to describe the common sinkhole characteristics:

Dissolution sinkholes

These sinkholes form slowly over time as water dissolves the soluble bedrock at the surface. Because dissolution sinkholes form gradually, they can go unnoticed for a long time. Generally, these sinkholes tend to be shallower than the other types, and it is not uncommon for them to fill with water or sediment which naturally gathers in the depression. Additionally, dissolution sinkholes usually lack the underground cavity which is commonly associated with cover-subsidence and cover-collapse sinkholes.

Cover-collapse sinkholes

These sinkholes occur suddenly when the loose material covering a cavity becomes too thin to support its own weight or the weight of what's above it (e.g., buildings, roads, etc.). Of the

[137] United States Geological Survey. "What Is a Sinkhole?" usgs.gov. Accessed September 1, 2023. https://www.usgs.gov/faqs/what-a-sinkhole.
[138] United States Geological Survey. "Karst Aquifers." usgs.gov. Accessed September 1, 2023. https://www.usgs.gov/mission-areas/water-resources/science/karst-aquifers.

three categories, cover-collapse sinkholes tend to be the most dramatic-looking and dangerous. The primary factor which makes these sinkholes particularly dangerous is the speed at which they can develop, often leaving very little time for people to react. Additionally, it can be difficult to avoid these sinkholes because the underground cavities that eventually collapse to form them may not be visible or easily detectable from the surface. Cover-collapse sinkholes can cause significant economic damage and be fatal for anyone caught in them.

Cover-subsidence sinkholes

Cover-subsidence sinkholes are similar to cover-collapse sinkholes in that they are typically caused by an underground cavity. However, cover-subsidence sinkholes are generally smaller than cover-collapse sinkholes and form more gradually. These sinkholes form as loose material covering a cavity that is slowly washed into the cavity below, causing the ground surface to subside or sink. Rather than caving in all at once, a cover-subsidence sinkhole is more akin to the sand flowing from the top of an hourglass to the bottom.

b) *Location and Extent*

In the United States, states like Florida, Texas, and Missouri are commonly associated with karst landscapes and sinkholes. This is primarily due to the relatively high concentrations of soluble rocks such as limestone present in these areas. In Maryland, geology favorable for the development of sinkholes is primarily found in the western and northern parts of the state, with Washington, Carroll, and Frederick Counties being the most affected.[139] Geologically, Montgomery County is largely situated on the Piedmont Plateau. The Piedmont Plateau is characterized by bedrock consisting of hard, crystallin minerals such as schist and gneiss, which is generally not conducive to the natural formation of sinkholes. However, data from USGS does indicate that the western portion of the County may have concentrations of clastic geology. While not generally associated with sinkholes, clay can gradually compact under the weight of new construction or heavy rain.

Figure 53: Sinkhole Hotspots

[139] Western Maryland Resource Conservation & Development Council, Inc. "A User's Guide to Karst and Sinkholes in Western Maryland," 2004. http://www.mgs.md.gov/reports/Karst_in_Maryland.pdf.

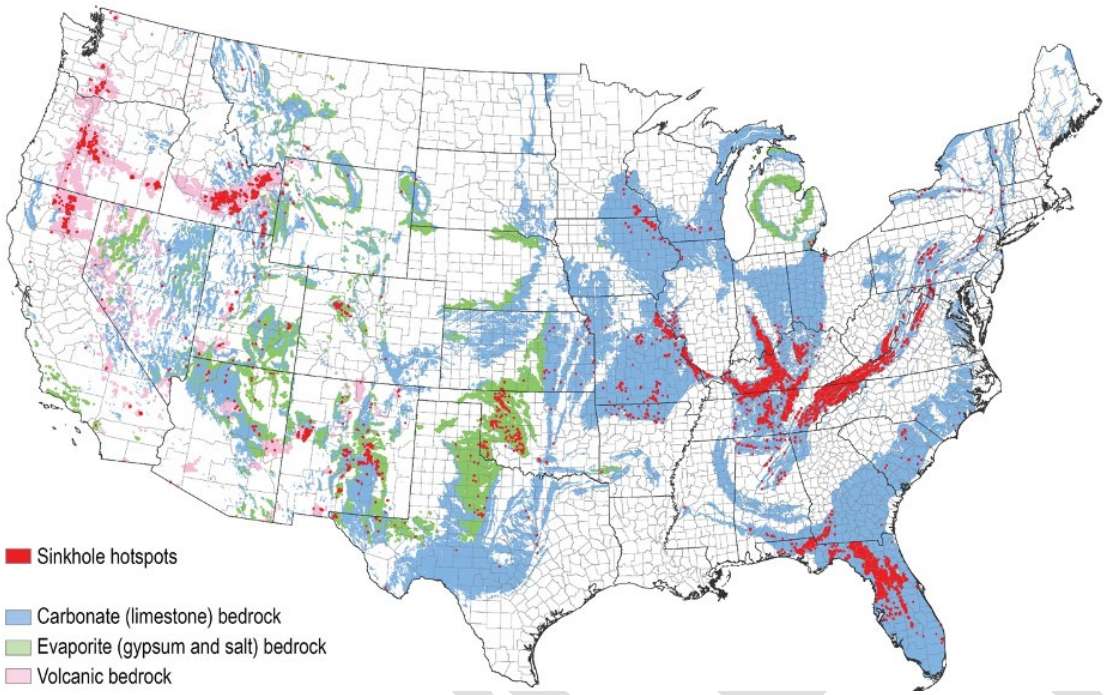
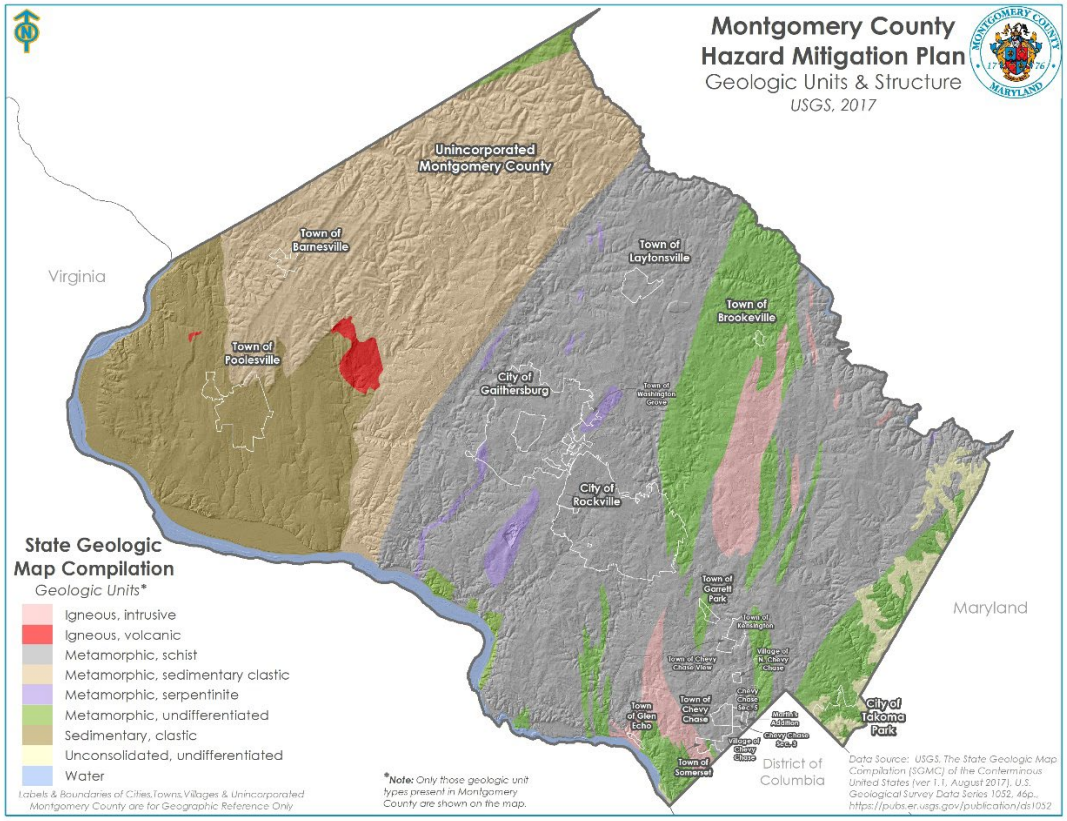

Sinkhole hotspots
Carbonate (limestone) bedrock
Evaporite (gypsum and salt) bedrock
Volcanic bedrock

Figure 54: Geologic Units & Structures in Montgomery County[140]



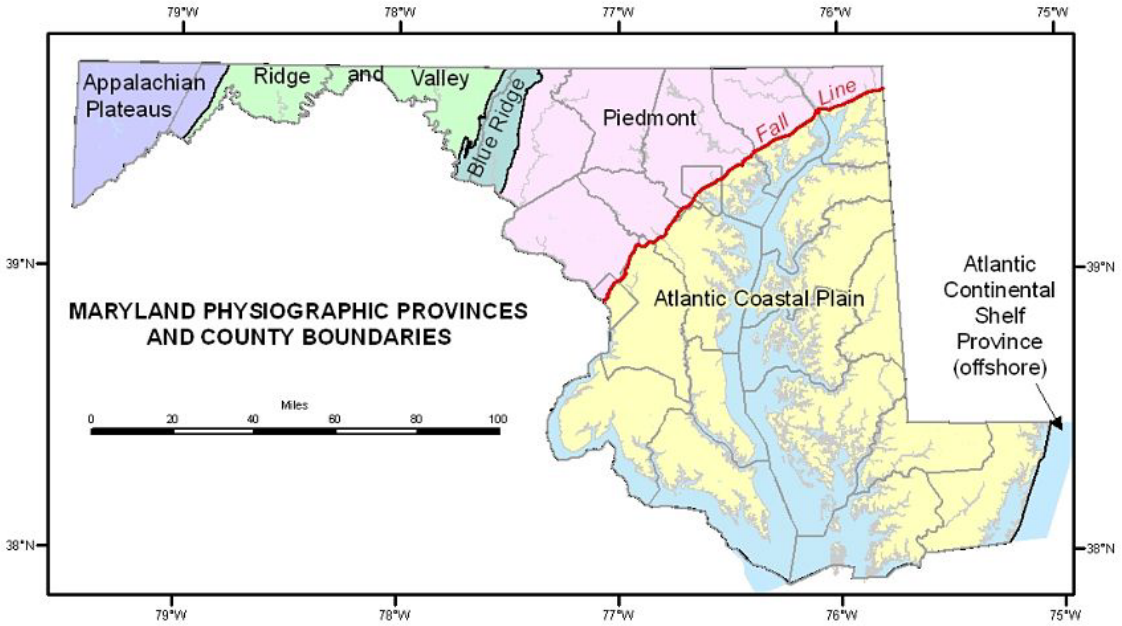
The threat of sinkholes is not solely limited to the northern and western portions of Montgomery County, as human activity can lead to the formation of sinkholes in areas which lack the geology typically associated with sinkhole formation. According to the USGS, human activity which alters the local hydrology and/or sub-surface mineral composition has been correlated to sinkhole formation.[141] Examples of such activities include mining and agriculture. Additionally, urban development can contribute to land subsidence by reshaping local water-drainage patterns. In some instances, sinkholes have developed as a result of leaky or burst pipelines. Sinkholes caused by human activity may be particularly concerning as they are inherently more likely to occur in populated areas where human activity occurs. Overall, the

[140] Doctor, Daniel, Jeanne Jones, Nathan Wood, Jeff Falgout, and Natalya Rapstine. "Progress toward a Preliminary Karst Depression Density Map for the Conterminous United States." In *Proceedings Of The 16th Multidisciplinary Conference On Sinkholes And The Engineering And Environmental Impacts Of Karst*. Puerto Rico: National Cave and Karst Research Institute, 2020. https://doi.org/10.5038/9781733375313.1003.

[141] U.S. Geological Survey. "Sinkholes." usgs.gov, June 9, 2018. https://www.usgs.gov/special-topics/water-science-school/science/sinkholes#overview.

parts of Montgomery County which are most vulnerable to land subsidence and sinkholes are locations with both concentrations of soluble minerals and human activity which alters the local hydrology.

Figure 55: Maryland Physiographic Provinces



c) *Range of Magnitude*

Due to its geology, sinkholes which occur in Montgomery County are more likely to be cover-collapse and cover-subsidence sinkholes. Sinkholes of all types can vary in size; according to the USGS, the diameter of a sinkhole can range from a few feet to hundreds of acres, and it is not uncommon for them to approach depths of 100 feet.[142] While sinkholes in unpopulated and undeveloped areas pose little to no danger, they can cause significant damages in urban settings. In extreme cases, individuals above or near a cover-collapse sinkhole can get caught in the shifting earth, which can be fatal.

While cover-collapse sinkholes are generally the most dramatic-looking and dangerous, other forms of land subsidence can have significant financial impacts that affect individuals, businesses, and governments. Even when the effect is gradual, land subsidence can cause building foundations to shift and place additional stress on the structure. This can jeopardize

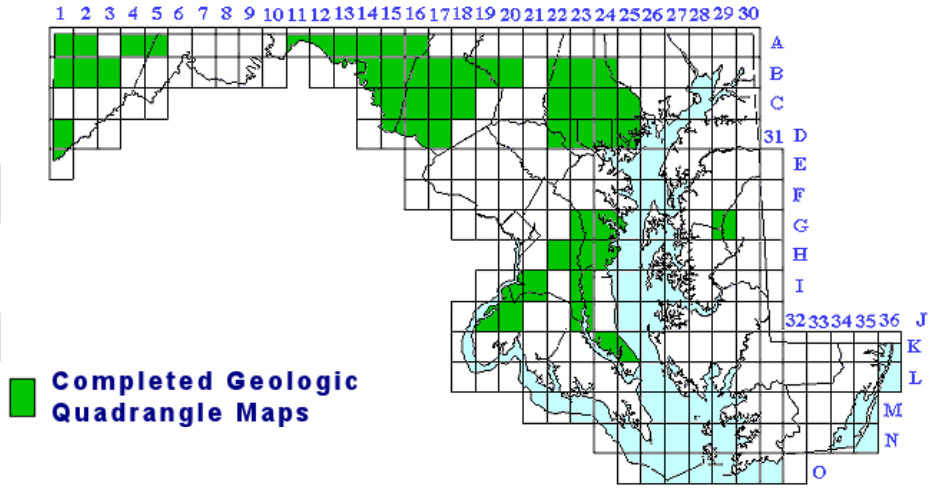
[142] United States Geological Survey. "What Is a Sinkhole?" usgs.gov. Accessed September 1, 2023. https://www.usgs.gov/faqs/what-a-sinkhole.

the overall structural integrity of buildings which are not designed to handle such stress. Remedying the impact of land subsidence on structures can be time consuming and expensive; although there is no national tracking of land subsidence damage costs, the USGS estimates that over the last 15 years, sinkholes have cost an average of $300 million per year.[143]

Past Occurrences

As recognized by the USGS, cataloging and examining past occurrences of land subsidence and sinkholes is a very difficult task. There is no national database of sinkhole collapses, and only a few states attempt to track sinkholes within their own jurisdiction. While there is not a database for sinkholes in Maryland, the Maryland Geological Survey has completed several geologic maps which help determine the likelihood of sinkholes by examining multiple geologic factors which contribute to the formation of sinkholes. Unfortunately, the Maryland Geological Survey has not yet completed a geologic map for Montgomery County. The map below is available on the Maryland geological Survey website and shows the sections of Maryland which have been mapped in green.

Figure 56. Graphic from MGS showing the geologic quadrangle maps which have been completed in Maryland.



Even if Montgomery County and/or Maryland produced a comprehensive list of the reported ground collapses, it would likely be an incomplete list. This is because many sinkhole collapses

[143] U.S. Geological Survey. "How Much Does Sinkhole Damage Cost Each Year in the United States?" usgs.gov. Accessed September 5, 2023. https://www.usgs.gov/faqs/how-much-does-sinkhole-damage-cost-each-year-united-states.

are not reported to authorities or news organizations, and many occur in rural areas where they are unobserved.[144] Although the full scale of past sinkholes in Montgomery County is difficult to ascertain, several occurrences have been documented since 2000:

- In 2004, a sinkhole emerged in the community of Bethesda. This occurrence required the temporary relocation of a nearby statue due to the risk posed to it. The cause of the sinkhole was identified as a water main break.
- In 2007, a sinkhole formed near the bridge on Randolph Road over Rock Creek. Damage from the sinkhole meant that repairs were required to restore the road.
- In 2010, a sinkhole which emerged in Chevy Chase was large enough to swallow a resident's car. An investigation found that a local water main break had created the void which eventually became too weak to support the overlying weight.
- In 2018, a metal pipe in the median of Father Hurley Boulevard designed to drain water into an adjacent creek rusted and collapsed. This allowed runoff from heavy rains to erode the berm underneath the road causing a 20-by-20-foot sinkhole.
- In 2022, a 20-by-30-foot sinkhole formed under the southbound lanes of I-270 in Gaithersburg. According to the Maryland State Highway Administration, the sinkhole formed after a drainage pipe underneath the road burst. The reduction of available lanes along the affected stretch of I-270 created a temporary traffic headache for Montgomery County transportation officials.

d) *Future Occurrences*

Montgomery County is likely to continue experiencing infrequent land subsidence and sinkholes in the near future. While the County doesn't have large stretches of karst terrain like what can be found in Washington and Carroll Counties, pockets of soluble minerals conducive to the formation of sinkholes can be found. In these areas, the natural formation of sinkholes will remain a possibility. Montgomery County may also continue to experience sinkholes which form as a result of human activity, particularly in the more urban settings found in the central and southern regions of the County. These areas are more likely to have a higher volume of both underground pipes and impermeable surfaces which, if not properly monitored and managed, may alter the local hydrology and lead to the formation of sinkholes.

[144] U.S. Geological Survey. "How Many Sinkholes Open up in a Year?" usgs.gov. Accessed September 6, 2023. https://www.usgs.gov/faqs/how-many-sinkholes-open-a-year.

Determining the probability of land subsidence events occurring in Montgomery County is limited by the available data. A conservative assessment of "possible" with between 1% and 49.9% annual probability has been determined after review of news reports of sinkholes in the County. However, it should be noted that many sinkholes occur in areas where they go unnoticed and unreported, and certain types of sinkholes can develop slowly over multiple years. As a result, the probability of land subsidence events in Montgomery County *may* be higher than currently assessed.

e) Vulnerability Assessment

Fortunately for Montgomery County, the overall geology within its jurisdictional boundaries is not karst terrain conducive to the formation of sinkholes. This geology means that Montgomery County is not likely to experience frequent and widespread occurrences of land subsidence and sinkholes. Infrequent sinkholes will remain a possibility, and this is mainly due to the possibility of small pockets of soluble geology conducive to the formation of sinkholes, as well as the potential for sinkholes which emerge as a result of human activity. It is notable that many of the sinkholes which have been reported in Montgomery County since 2000 were determined to be the result of burst pipes. While there are multiple factors which can lead to burst pipes, the reoccurring nature of this phenomena since 2000 may indicate a deteriorating underground pipeline network which may be susceptible to future breaks.

The deterioration of underground pipelines In Montgomery County would also be consistent with findings from the American Society of Civil Engineers (ASCE), which produces statewide infrastructure "report cards." In the 2020 Maryland Report Card, the ASCE reviewed Maryland's overall drinking water infrastructure and assigned it a "C" grade. In their summary of Maryland's drinking water infrastructure, the ASCE identifies that "the leading issue related to drinking water is aging infrastructure, which negatively affects the reliability of the water system."[145] The report further states that Baltimore City alone has averaged nearly 1,000 breaks each year, and the issue exists in many of Maryland's cities and towns. Although the report does not specifically mention Montgomery County, it is reasonable to assume that the County's water infrastructure is in a similar condition to that of the state.

Fortunately for Montgomery County, the sinkholes reported since 2000 have not resulted in any fatalities, and the infrastructure damage has mostly involved roadways. However, the

[145] American Society of Civil Engineers. "2020 Mayland Infrastructure Report Card." infrastructurereportcard.org, 2020. https://infrastructurereportcard.org/state-item/maryland/.

threat of sinkholes in Montgomery County – particularly as a result of burst pipes – is likely to persist. Additionally, the 2022 sinkhole which damaged I-270 demonstrated that even roadways which are generally considered well-built are not immune to damage from sinkholes. The possibility of a future sinkhole developing underneath heavily trafficked roadways cannot be eliminated, and a cover-collapse sinkhole occurring underneath a major roadway during morning or evening rush hours could result in multiple injuries and/or fatalities. Sinkholes in an urban setting can also disrupt businesses and displace residents if the structural integrity of buildings is jeopardized.

Table 36: Notable Assets in Montgomery County Damaged by Land Subsidence

Approximate Date of Event	Asset(s)	Category	Description of Damage
June 15, 2022	I-270	Systems	

13. Sea Level Rise

a) Location and Extent

Montgomery County is not located directly on the coast, but it is situated near the Chesapeake Bay and Potomac River, which are influenced by sea level rise. While the county is not as vulnerable to sea level rise as coastal areas, it can still experience indirect impacts from rising sea levels in the following ways:

- **Flooding along Waterways**: Higher Sea levels can contribute to an increased risk of coastal and riverine flooding. This can affect areas adjacent to the Potomac River and the Chesapeake Bay, including parts of Montgomery County.
- **Tidal Flooding**: During extreme high tides or storm events, sea level rise can exacerbate tidal flooding along the Potomac River and its tributaries, potentially affecting low-lying areas within the county.
- **Water Quality**: Changes in sea level can impact the water quality of the Potomac River and the Chesapeake Bay. Saltwater intrusion, for example, can affect the availability of freshwater resources and harm aquatic ecosystems.

- **Infrastructure Vulnerability**: Rising sea levels can put pressure on infrastructure such as bridges, sewage systems, and roads that cross or run along water bodies. Increased flooding can lead to maintenance challenges and increased costs.
- **Economic Impacts**: While not as directly impacted as coastal regions, Montgomery County can still experience economic consequences from sea level rise, such as disruptions to transportation, increased infrastructure maintenance costs, and potential impacts on property values.

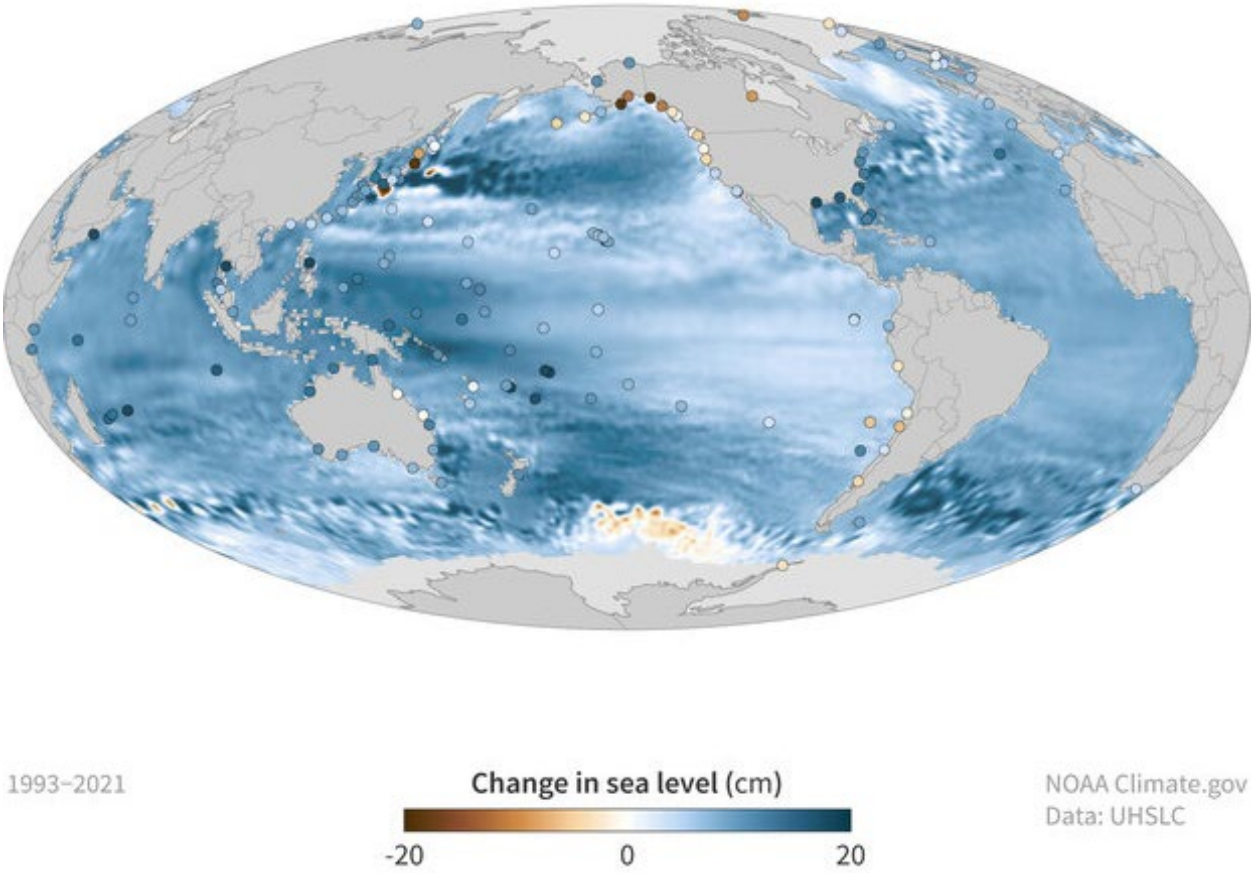
Because Montgomery County isn't located directly on the coast, some materials and studies were drawn from the nearest coastal areas near Baltimore.

b) Range of Magnitude

Global mean sea level rise has been observed over the last century in tide station data from around the world and, more recently, in satellite-based ocean height measurements. Between 1993 and 2021 mean sea level has risen across most of the world ocean (blue colors). In some ocean basins, sea level has risen 6-8 inches (15-20 centimeters). Rates of local sea level (dots) on the coast can be larger than the global average due to geological processes like ground settling or smaller than the global average due to processes like the centuries-long rebound of land masses from the loss of ice-age glaciers.[146]

Figure 57: Sea Level Change 1993 – 2021

[146] Map by NOAA Climate.gov based on data provided by Philip Thompson, University of Hawaii.



In the United States, almost 30 percent of the population lives in relatively high population-density coastal areas, where sea level plays a role in flooding, shoreline erosion, and hazards from storms. Globally, 8 of the world's 10 largest cities are near a coast, according to the U.N. Atlas of the Oceans. While Montgomery County isn't located on the coast, parts of its critical infrastructure is including the Blue Plaints Wastewater Treatment Plan in Washington, DC.

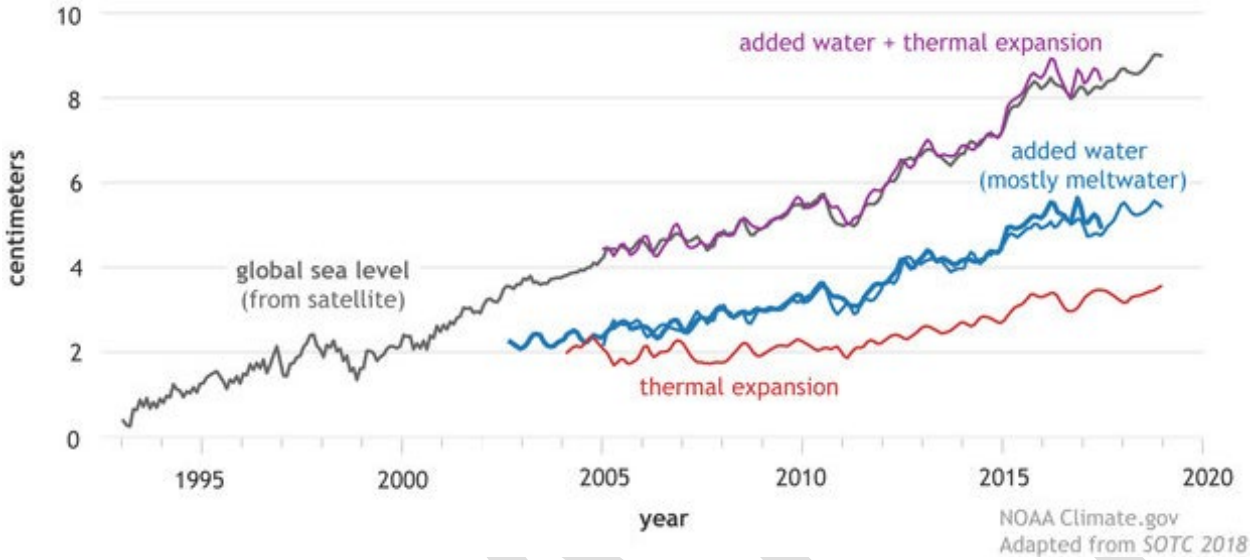
c) Past Occurrence

Sea level measurement relies on two primary methodologies: tide gauges and satellite altimeters. Tide gauge stations, distributed worldwide, have been diligently tracking daily high and low tides for over a century, employing a diverse range of both manual and automated sensors. By compiling data from numerous stations across the globe, scientists can derive a comprehensive global average, accounting for seasonal variations.

Since the early 1990s, the measurement of sea level has expanded into the realm of space technology, utilizing radar altimeters. These advanced instruments gauge the height of the sea surface by assessing the speed and intensity of radar pulses directed at the ocean. The principle is simple: the higher the sea level, the more rapid and robust the return signal. This innovative

approach has greatly enhanced our ability to monitor and understand changes in sea levels on a global scale.

Figure 58: Contributors to Global Sea Level Rise 1993 - 2018



To assess the contributions of thermal expansion and actual mass transfer to observed sea level rise, scientists employ a multifaceted approach. They gauge sea surface temperature through an array of tools, including moored and drifting buoys, satellites, and ship-collected water samples. Additionally, the upper portion of the ocean's temperature is scrutinized through a global network of aquatic robots, while deeper temperatures are monitored via instruments deployed from oceanographic research vessels.

For estimating the portion of rising sea levels attributed to actual mass transfer — the movement of water from land to ocean — scientists combine direct measurements from field surveys, which include melt rate and glacier elevation assessments, with satellite-derived data that reveals minuscule variations in Earth's gravity field. When water relocates from land to ocean, this transition increases the gravitational pull over oceans by a slight degree. Scientists leverage these gravity shifts to estimate the quantity of newly added water.

d) Future Occurrence

Since the year 1900, the global average sea level has experienced an increase of approximately 7–8 inches. Projections indicate that by the year 2100, sea levels could rise by another 1–8 feet, with a probable range of 1–4 feet. This escalation is attributed to emissions stemming from human activities, both historical and anticipated (figure below).

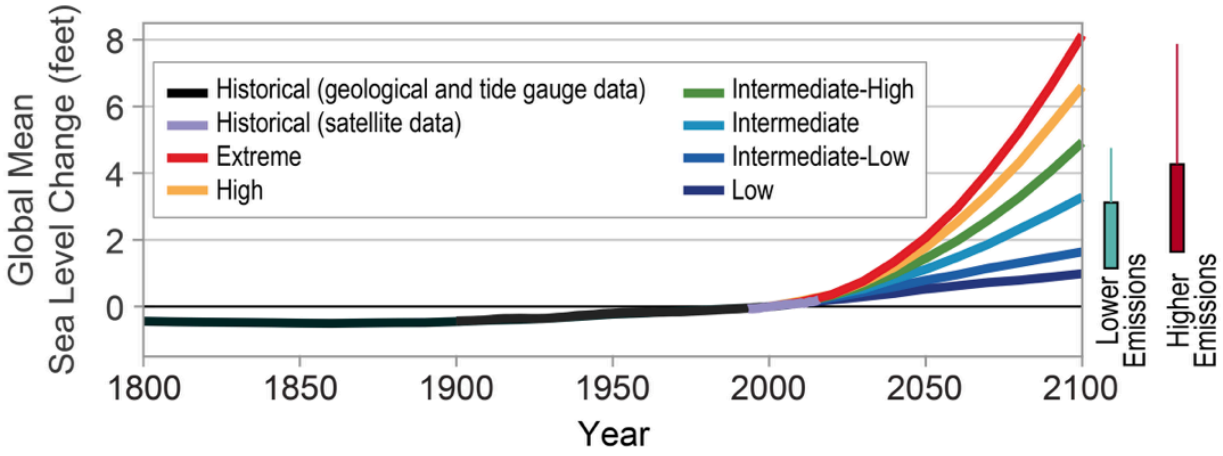
Of note, the Chesapeake Bay area ranks as the third most susceptible region in the United States to sea level rise (SLR), following only Louisiana and South Florida in vulnerability. The

primary repercussions of SLR on the state encompass a heightened frequency and severity of coastal flood events, increased erosion along the shoreline, inundation of wetlands and low-lying terrains, and the intrusion of saltwater into groundwater sources.

Tide-gauge records reveal that sea levels within the Chesapeake Bay have exhibited an average annual increase of 1.3 to 1.5 inches over the past century, surpassing the global historical average observed during the same period by 50%. In the case of the Chesapeake Bay, the challenge of global SLR is further compounded by considerable rates of land subsidence, with an average rate of 3.1 mm per year identified between 2006 and 2011. This subsidence results from a combination of factors, including groundwater extraction and natural geologic adjustments linked to post-glacial phenomena.

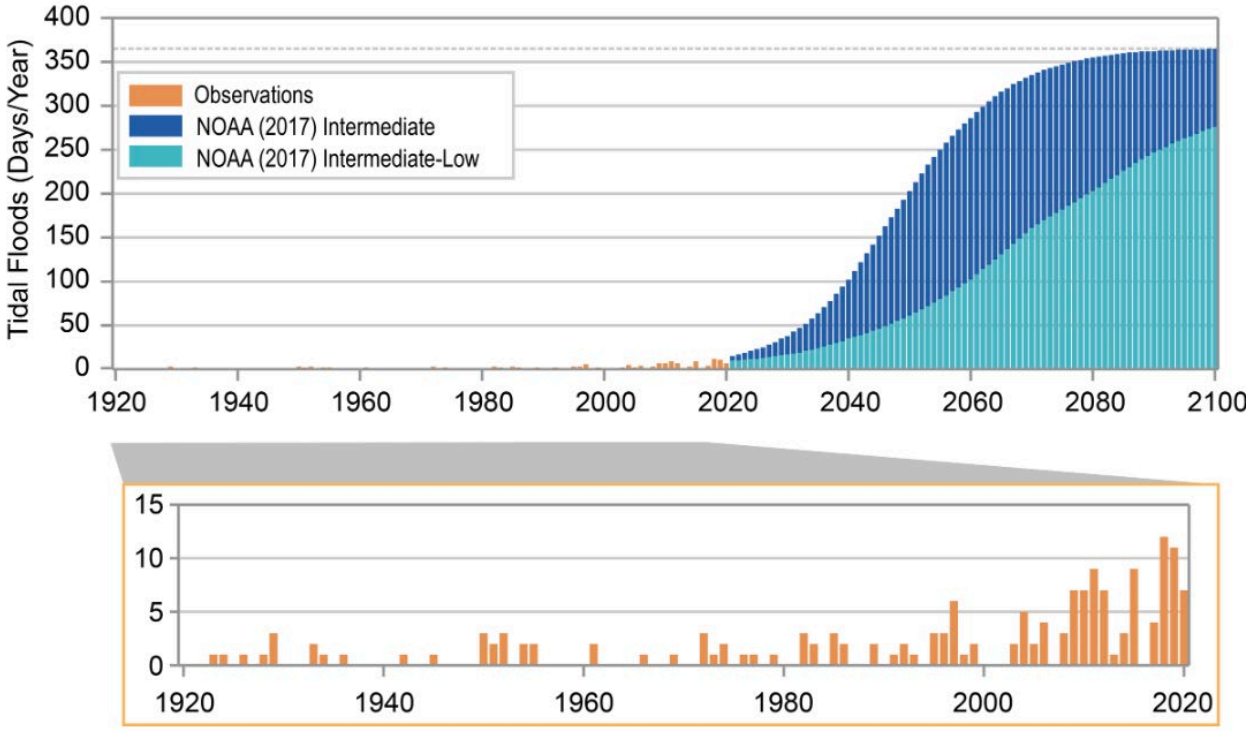
Recent studies specific to Maryland indicate that, with a 66% probability, the likely range of SLR between 2000 and 2050 falls within 0.8 to 1.6 feet. Should emissions continue their upward trajectory, the anticipated range of SLR over the course of this century extends to 2.0 to 4.2 feet.

Figure 59: Observed & Projected Changes in Global Sea Level



The rise in sea levels has led to a surge in tidal floods, often associated with disruptive but non-catastrophic consequences. These are commonly referred to as nuisance floods, characterized by water levels surpassing the local threshold established by NOAA's National Weather Service for minor impacts. These events can inflict damage on infrastructure, necessitate road closures, and strain stormwater drainage systems. Over time, as sea levels along Maryland's coastline have continued to climb, there has been a notable uptick in the frequency of tidal flood days, encompassing all days where water levels exceed the nuisance-level threshold. The pinnacle of such occurrences was observed in the year 2018.

Figure 60: Observed & Projected Annual Number of Tidal Floods for Baltimore, MD



As our planet's temperatures continue to rise due to global warming, an inevitable consequence is the ongoing increase in sea levels. The extent of this rise and the timeline it follows largely hinge on two critical factors: the rate of future greenhouse gas emissions and the behavior of massive ice sheets in Antarctica and Greenland. The latter introduces a degree of uncertainty, as it remains unclear whether these colossal ice sheets will undergo a gradual, predictable melting process as the Earth warms or whether they might reach a tipping point, resulting in swift and catastrophic collapse.

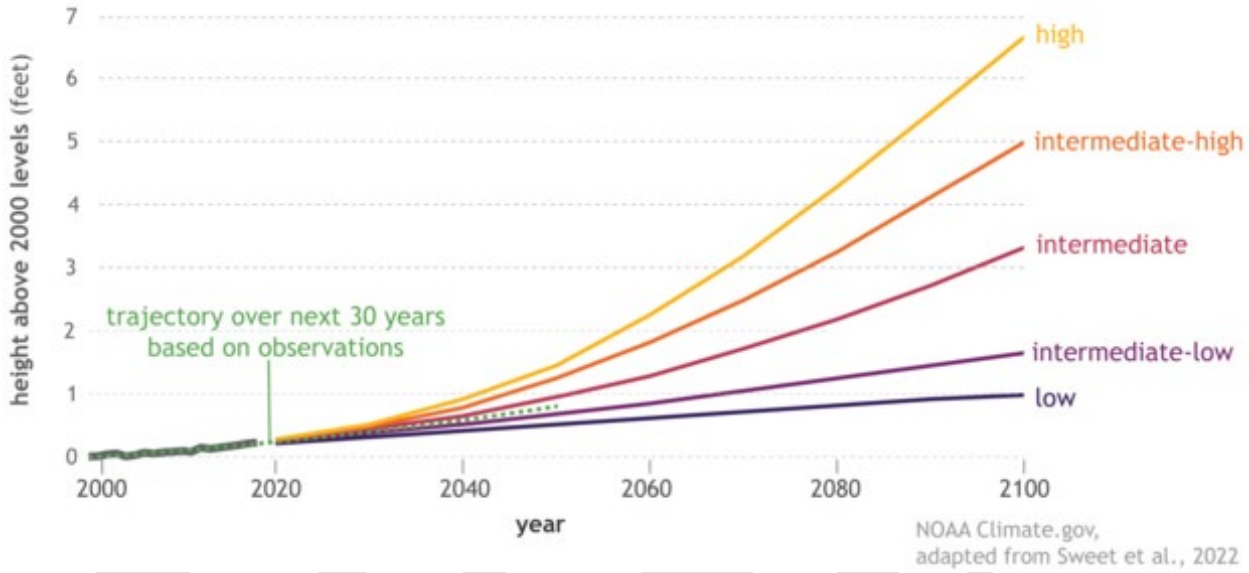
To provide updated insights into this complex issue, the National Oceanic and Atmospheric Administration (NOAA) spearheads an interagency task force, convening every four to five years. This collaborative effort reviews the most recent research on sea level rise and publishes a comprehensive report outlining projections for future sea level changes under various scenarios, including those considered "likely" and those deemed "unlikely but plausible."

In their 2022 report, the task force arrived at a sobering conclusion: Even under the most optimistic scenario featuring the lowest greenhouse gas emissions and warming levels (1.5 degrees Celsius), global mean sea levels are anticipated to rise by a minimum of 0.3 meters (equivalent to 1 foot) above 2000 levels by the year 2100. However, in a scenario marked by exceptionally high emissions rates that could trigger rapid ice sheet collapse, the sea level could surge as much as 2 meters (equivalent to 6.6 feet) higher by 2100 compared to the year 2000.

These findings underscore the urgent need for concerted global efforts to mitigate greenhouse gas emissions and address the profound implications of rising sea levels on our planet.

The following figure depicts Observed Sea level from 2000-2018, with future sea level through 2100 for six future pathways (colored lines). The pathways differ based on future rates of greenhouse gas emissions and global warming and differences in the plausible rates of glacier and ice sheet loss.[147]

Figure 61: Possible Pathways for Future Sea Level Rise[148]



e) Vulnerability Assessment

(1) People

Sea-level rise can have significant impacts on Montgomery County's population in several ways. Flooding and saltwater intrusion resulting from sea-level rise can pose health risks, including waterborne diseases and contamination of drinking water supplies. Vulnerable populations, such as the elderly and those with preexisting health conditions, may face greater health risks.

(2) Systems & Structures

Rising sea levels can damage critical infrastructure such as roads, bridges, water treatment plants, and power facilities. This can disrupt essential services and create hardships for

[147] NOAA Climate.gov graph, adapted from Sweet et al., 2022.

[148] NOAA Center for Operational Oceanographic Products and Services. (n.d.) Sea level trends.

residents, potentially prompting some to relocate. While Montgomery County isn't located on the coast, the Blue Plains Wastewater Treatment Plan is located on the Potomac River in Washington, D.C. This facility is susceptible to rising sea levels.

14. Dam Failure

a) Location and Extent

A dam is defined as a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water. Dams typically are constructed of earth, rock, or concrete. A levee is a man-made barrier constructed of soil along a water course for the primary purpose of providing flood protection.

A dam failure is the catastrophic collapse, breach, or other failure, often resulting in downstream flooding. The image to the right depicts an example of a concrete buttress dam 23 ft in height near White Oak, Maryland.

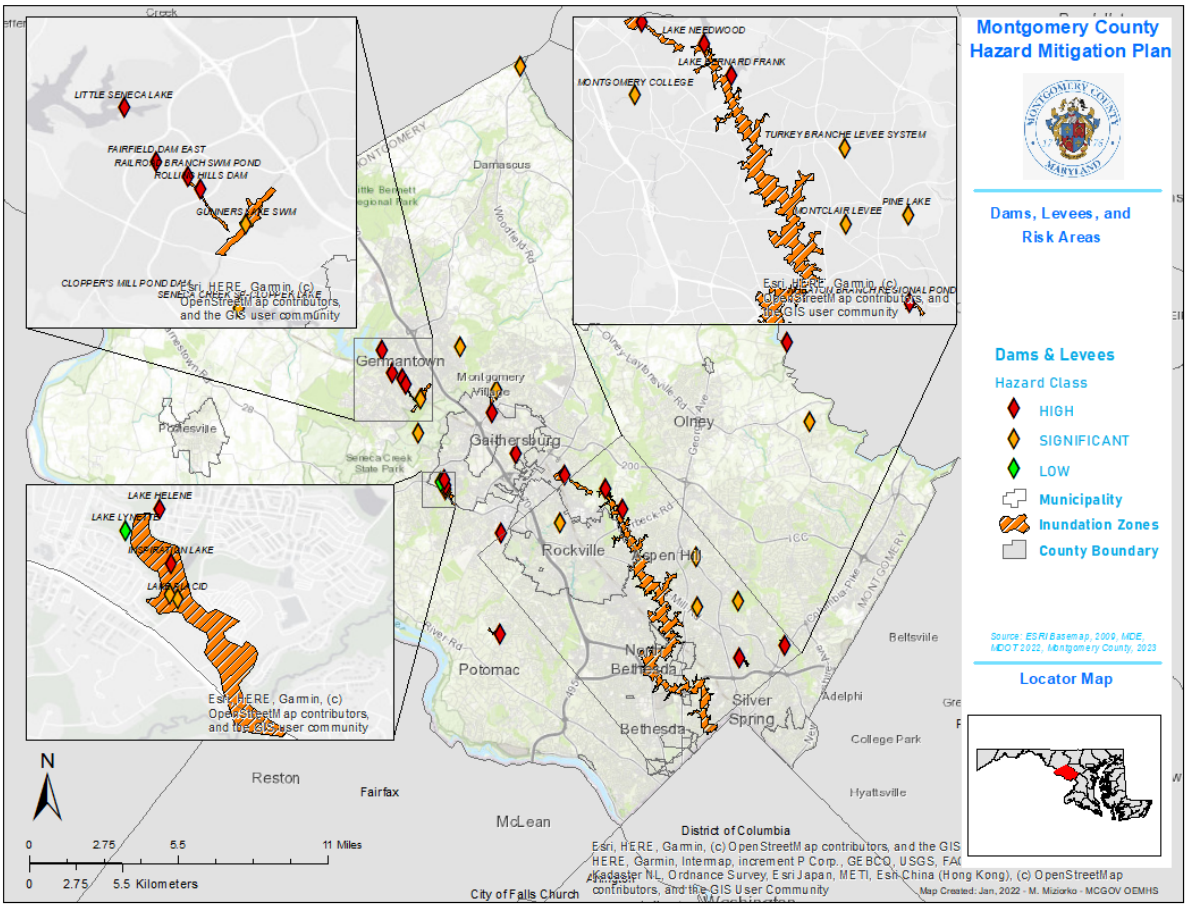
Figure 62: Example of Concrete Buttress Dam

Dam failures typically occur during extreme flood events, or when internal erosion (piping) through the dam or foundation occurs. Complete failure occurs if internal erosion or overtopping results in a complete structural breach, releasing a high-velocity wall of debris-laden water that rushes downstream.

The dams represent the greatest risk to the people who live below the dam In the area designated as the "inundation zone" for overflow or catastrophic failure. possible inundation zone location, the dams in Maryland are classified in three categories:

- **High Hazard Dams**: Probable loss of life; major increases in existing flood levels at houses, buildings, railroads, major interstates, and state roads with more than 6 lives in jeopardy.
- **Significant Hazard Dams**: Possible loss of life, significant increased flood risks to roads and buildings with no more than 2 houses or 6 lives in jeopardy.
- **Low Hazard Dams**: Unlikely loss of life; minor increases to existing flood levels at road and buildings.

Figure 63: Dams, Levees, & Risk Areas in Montgomery County



Of the 41 dams or impoundments located in Montgomery County, there are currently 15 dams that are classified as high hazard dams. Of these 15 designated high hazard dams, 4 are owned and operated by Montgomery County's Department of Environmental Protection (DEP). Beyond the county, other major owners of dams include Washington Suburban Sanitary Commission (WSSC), Maryland National Capital Park and Planning Commission (M-NCPPC), and the City of Gaithersburg.

Montgomery County is experiencing sustained population growth, which is causing hazard creep, particularly across the northern portion of the county. This will result in other dams, currently classified as Low hazard, to become Significant or High hazard in the coming ten to twenty years. As of 2022, a total of 7,988 structures currently resides in the Probably Maximum Flood (PMF) zones of these Significant and high hazard dams. Of these 7,988 parcels, a total of 7101 occupied residential dwellings are at risk. The estimated land value as of the year 2022 is roughly $98 million.

Each Significant and High hazard dam is required by COMAR 26 to have an Emergency Action Plan (EAP) developed. The EAP is reviewed annually by the owner/operator of the structure and the Office of Emergency Management & Homeland Security (OEMHS). The EAPs are exercised on a three-year cycle.

Table 37: Dams within Montgomery County

DAM NAME	HAZARD CLASS	EAP	OWNER/OPERATOR
Brighton Dam	HIGH	Yes	WSSC
Lake Needwood	HIGH	Yes	MNCPPC-Upper Rock Creek
Lake Frank	HIGH	Yes	MNCPPC-Upper Rock Creek
Lake Walker Dam – Pond 1	HIGH	Yes	Lake Forest Associates
Wheaton Branch Storm Water Management	HIGH	Yes	Montgomery County DEP
Inspiration Lake	HIGH	Yes	City of Gaithersburg
Crabbs Branch SWM Facility	HIGH	yes	Montgomery County DEP
Little Seneca Dam	HIGH	Yes	WSSC
Lake Helene Dam	HIGH	Yes	City of Gaithersburg
Summit Hall Park Dam	HIGH	Yes	City of Gaithersburg
Railroad Branch SWM Pond	HIGH	Yes	Montgomery County DEP
Burnt Mills Dam	HIGH	Yes	MNCPPC-Burnt Mills
Falls Road Golf Course	HIGH	Yes	Montgomery County Revenue Authority
Gudelsky Pond	HIGH	Yes	Montgomery County DEP
Fairfield East Dam	HIGH	Yes	F.F. Development, L.P.
Chadswood	SIGNIFICANT	Yes	Chadswood Homeowner's Association, Inc./Mo Co DEP
Manchester	SIGNIFICANT	Yes	Manchester Farm Community Association. Inc./ Mo Co DEP
Seneca State Park Dam	SIGNIFICANT	Yes	MD DNR-Public Lands, Engineering & Constr-Central
Gunners Lake	SIGNIFICANT	Yes	Montgomery County DEP
Lake Whetstone	SIGNIFICANT	Yes	Montgomery Village Found., Inc.
Lake Nirvana Dam	SIGNIFICANT	Yes	City of Gaithersburg
Lake Placid Dam	SIGNIFICANT	Yes	City of Gaithersburg
Wheaton Regional Park Dam	SIGNIFICANT	Yes	MNCPPC Montgomery Parks
Rattlewood Golf Course	SIGNIFICANT	Yes	Montgomery County Revenue Authority
Cloppers Mill West Pond F	SIGNIFICANT		Montgomery County DEP
Ashton Pond Dam	SIGNIFICANT		Ashton Pond Community Association (APCA)
Montgomery College (Rockville Campus) SWM Dam	SIGNIFICANT		
Lake Lynette	LOW	Yes	City of Gaithersburg

b) Range of Magnitude

Dams built in Montgomery County are built for a variety of uses. Uses include stormwater management, flood protection, power generation, recreation, and water supply. Dam failure can occur with little warning and can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding;
- Inadequate spillway capacity, resulting in excess overtopping flows;
- Internal erosion of embankment or foundation due to seepage or piping;
- Improper maintenance, including failure to remove trees, repair internal seepage problems, replace lost material from the cross section of the dam and abutments, or maintain gates, valves, and other operational components;
- Improper design or construction, including the use of improper construction materials and construction practices;
- Negligent operation, including the failure to remove or open gates or valves during high flow periods;
- Failure of upstream dams on the same waterway;
- Landslides into reservoirs, which cause surges that result in overtopping;
- High winds, which can cause significant wave action and result in substantial erosion;
- Earthquakes, which typically cause longitudinal cracks at the tops of the embankments, which can weaken entire structures;
- Debris blockages of spillways; and
- Sabotage or vandalism.

The two most common modes of dam failure for embankment dams are internal erosion (piping) and over-topping. High and significant hazard dams are designed to prevent over-topping during most storm events occurring in the County. The high hazard structures are designed to prevent over-topping during a Probable Maximum Flood (PMF), an extreme event well in excess of a 100-year storm. The PMF for this area is approximately 27” of rain in 6 hours.

Dam failures due to piping may occur at any time. Piping is internal erosion inside the dam embankment. This condition may take years to develop and may be difficult to detect. Piping failure may be prevented through proper inspection and maintenance. The Maryland Department of the Environment (MDE) requires regular inspections of all dams and corrective actions to be taken if conditions are observed through inspections.

Dams are considered to be localized hazards and are most likely to affect inundation areas downstream and immediate areas around a particular dam or levee in Montgomery County.

Discharge from a dam breach is usually several times the 1% chance flood and, therefore, typical flood studies are of limited use in estimating the extent of flooding. Typical design of high and significant hazard dams includes Dam Breach Analysis which considers instantaneous release of the reservoir during the dam breach.

There are other downstream risks from dam failure:

- **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 after overtopping, or undergo component malfunction or mis operation, where the consequences considered are over and above those that would occur without dam breach. The consequences typically are due to downstream inundation, but loss of the pool can result in significant consequences in the pool area upstream of the dam.
- **Non-Breach Risk**: The risk in the reservoir pool area and affected downstream floodplain due to 'normal' dam operation of the dam (e.g., large spillway flows within the design capacity that exceed channel capacity) or 'overtopping of the dam without breaching' scenarios.
- **Residual Risk**: The risk that remains after all mitigation actions and risk reduction actions have been completed. With respect to dams, FEMA defines residual risk as "risk remaining at any time" (FEMA, 2015, p A-2). It is the risk that remains after decisions related to a specific dam safety issue are made and prudent actions have been taken to address the risk. It is the remote risk associated with a condition that was judged to not be a credible dam safety issue[149].

Currently, there is a lack of sufficient information available to conduct a comprehensive analysis of non-breach and residual risks associated with high hazard potential dams in Montgomery County. Nevertheless, it is important to acknowledge and define specific aspects of risk related to dam safety:

- Incremental risk refers to the added risk, encompassing both the likelihood and potential consequences, posed to the pool area and downstream floodplain occupants due to the presence of a dam. This risk factors in scenarios such as dam breaches,

[149] FEMA, 2020 Rehabilitation of High Hazard Potential Dams Grant Program Guidance

overtopping, component malfunctions, or mis operations. It considers consequences that go beyond those occurring without a dam breach.

- Non-breach risk pertains to the risk within the reservoir pool area and the downstream floodplain that arises from the routine operation of the dam. This includes scenarios where the dam operates normally, such as the release of large spillway flows within design capacity that exceed the channel's capacity, or situations where overtopping occurs without resulting in a breach.
- Residual risk signifies the risk that remains after specific decisions regarding dam safety concerns have been addressed, and prudent actions have been taken to mitigate the risk. This residual risk is associated with conditions that have been deemed non-credible dam safety issues.

The oversight of dams and levees in Maryland falls under the jurisdiction of the Maryland Department of the Environment Dam Safety Division (MDE). MDE defines a dam as any structure, obstruction, wall, or embankment, along with its associated features, constructed with the intent of temporarily or permanently storing water. In Montgomery County, most dams consist of earthen embankments in conjunction with spillways, and many are designed as stormwater management structures.

c) Past Occurrence

Heavy rain volumes in Maryland starting on June 25, 2006, yielded 10 to 15 inches in less than 12 hours in some parts of the state. These precipitation levels correspond to approximately 500 to 1,000-year storm based on the National Weather Service latest rainfall charts.

Even with these dramatic rainfall totals, dams in Maryland performed well. During the June 2006 storms (which eventually led to a FEMA declared disaster), the only failures in Maryland were to five low hazard dams, all located on the Eastern Shore. When storms exceed the 100-year storm (1% probability any given year), some low hazard dam failure can be expected to occur. The cost of repairs from these failures tends to be less than the increased cost of improving the design and construction required of greater hazard dams.

However, on June 27, 2006, conditions at both Lake Frank and Lake Needwood in Rockville, Montgomery County made it necessary to activate their Emergency Action Plans (EAPs). Montgomery County's Lake Needwood had swelled to 25 feet above normal water surface elevations. Concerns over the stability of the Lake Needwood Dam as a result of discovery of major seepage on the downstream embankment forced safety officials to evacuate more than 2200 people from their homes downstream. Multi-million-dollar repairs on the dam have been made since the potential failure incident. The two lakes are owned by MNCPPC. The figures below exhibits the swelling of Lake Needwood.

Figure 64: Lake Needwood Dam

Figure 65: Water flows at record levels from Montgomery County's Lake Needwood into Rock Creek.

d) Future Occurrence

There are two flood control levees in Montgomery County, Montclair Manor and Turkey Branch, both built by Montgomery County and regulated by MDE.

Montclair Manor levee is located near a townhouse development located on Veirs Mill Road (MD Rt. 586) between Valleywood Drive and Claridge Road in Wheaton, MD. The levee was constructed in 2008 by Montgomery County Department of Environmental Protection to protect 12 townhouses from flooding. The facility is being maintained by DEP.

Turkey Branch levee is located along Turkey Branch north of the intersection of Georgia Avenue (MD Rte. 97) and Hewitt Avenue in Aspen Hill, MD. The levee was constructed in 1988 by DEP to protect two apartment complexes and a church from flooding. The levee is comprised of three distinct sections running along both sides of the stream. The maintenance responsibly is shared by the property owners and the County.

In 2022, Montgomery County entered a partnership with the U.S. Department of Homeland Security, Science & Technology Directorate (DHS S&T) to deploy flood monitoring capabilities at several significant and high hazard dams. This technology mitigates flood risk to dam owners and operators by providing continuous monitoring of water levels and sends email and text

notifications to contacts listed in the EAPs. This project makes significant progress in addressing Mitigation Action 1.5 and 1.6.

e) Vulnerability Assessment

(1) People

Determining the impact of flooding is difficult to accomplish, especially for estimating loss of life. Loss of life is a function of the time of day, warning time, awareness of those affected and failure scenarios. Many dam safety agencies have used "population at risk", a more quantifiable measurement of the impact to human life, rather than "loss of life". Population at risk is the number of people in structures within the inundation area that would be subject to significant personal danger if they took no action to evacuate. The impacts of a dam failure are contingent on many factors and, therefore, cannot be concisely described.

The fifteen high hazard dams within the county have the potential to threaten more than 48,000 persons. Montgomery County 2018 population data from the U.S. Census Bureau was aggregated by census block and GIS was used to estimate populations within each danger reach zone. According to the GIS analysis, a catastrophic failure of any of these dams could cause major flooding in populated areas and have a significant impact on Montgomery County. The potential magnitude of a dam failure depends on the time of year and the base flow of the river when the failure occurs. During the winter months, when river flows are higher, the impact to the area would be much greater and evacuation times much less.

(2) Systems & Structures

The MDE requires dam owners to develop an Emergency Action Plan (EAP) for each high and significant hazard dam. The purpose of the EAP is to provide the Dam Operator with procedures to follow to safeguard the lives and property of the citizens living downstream and predict the dam inundation path to allow for proper evacuation.[150]

As a part of the State of Maryland requirements, dam owners and operators must provide danger reach maps for all high and significant hazard dams delineating the areas downstream that would be impacted because of potential dam breach. These maps are included in the EAPs and include extent of the dam inundation zone, wave arrival times, and depth of water at time

[150] ***Note: Inundation maps prepared by dam owners are on file with the County, and for national security purposes, can only be accessed through the Montgomery County OEMHS. The dam owners within the county have developed an evacuation plan that specifies emergency procedures for evacuation, control, and re-entry of areas that are at risk for possible dam inundation.***

of wave arrival. This assists emergency personnel to understand the population, county facilities and critical facilities at risk when planning for a localized hazard incident such as dam failure.

Dam failure inundation zones can also be used to run exposure analysis for population, value, and critical infrastructure at risk. Critical facilities are those community components that are most needed to withstand the impacts of disaster as previously described.

Dam failures can result in ecological disruptions, including damage to natural habitats and landscapes. Cultural resources situated in outdoor settings, such as historic gardens and sculptures, may be impacted by changes to the environment.

Infrastructure, such as roads, bridges, and utilities, may be affected by dam failures, hindering access to cultural resources and making recovery efforts challenging.

(3) Natural, Cultural, & Historical Resources

A dam failure could have a significant and potentially devastating impact on Montgomery County's cultural resources. The extent of the impact would depend on several factors, including the size of the dam, its proximity to cultural resources, the volume of water it holds, and the effectiveness of emergency response and preparedness efforts.

Cultural resources, including historic buildings, museums, archives, and artworks, could be directly damaged or destroyed by the force of the rushing water. Water can be destructive, causing structural damage and eroding or displacing artifacts and documents. Cultural institutions and historical sites located downstream from a dam may experience severe flooding in the event of a failure. Floodwaters can inundate buildings, causing damage to structures and contents.

Many cultural resources house irreplaceable artifacts, manuscripts, and artwork that are vulnerable to water damage. Dam failures can lead to the loss of these items, which often hold significant historical and cultural value. Cultural institutions often contribute to the local economy through tourism and cultural events. Dam failures can disrupt these activities, leading to economic losses for the community. Evacuations and emergency response efforts related to a dam failure can disrupt the community, impacting the operation and accessibility of cultural resources. Public safety concerns may limit access to these sites.

Land Use and Development Trends

Land use and new development in or near the danger reach of a dam can be de-conflicted through proper preparedness and mitigation planning. Montgomery County Department of Permitting Services regulates construction near the floodplains in the county. MDE Dam Safety Division provides permitting for construction and reconstruction of dams. A dam breach analysis required as part of this process is needed to delineate the area potentially impacted

should a dam fail. These maps are used to aid dam classification for any existing and proposed facilities. A dam breach analysis may be required for:

- Any proposed pond construction that could potentially affect the downstream properties or right of way.
- Any existing upstream pond embankment that could potentially affect proposed downstream construction.
- Establishment of a dam hazard class for embankments as part of the development.
- Existing and proposed roadway embankment that may act as a dam.

Most of the safety analysis is done through modeling a dam failure scenario and mapping the "danger reach" in the form of an inundation zone. To minimize loss of life and property damage the land use and development restrictions can be implemented by local legislation.

Staff from the County Office of Emergency Management and Homeland Security annually work with dam operators and owners to update the EAPs and operators are required to submit the updated EAPs to OEMHS.

Dam failure flooding can occur as the result of partial or complete dam collapse and release of an impoundment. Embankment dam failures often result from prolonged rainfall and flooding, and internal erosion. The primary danger associated with dam failure is the high flow depth and velocity flooding of those properties downstream of the dam. Secondary losses would include loss of the multi-use functions of the facility and associated revenues that accompany those functions.

B. Future Considerations for Climate Change

Montgomery County, like many regions around the world, should take several future considerations into account in the context of climate change. These considerations are vital for adapting to the changing climate and mitigating its impacts on the community. Here are some key considerations:

- **Climate Resilience Planning**: Montgomery County should continue to develop and update comprehensive climate resilience plans that address both short-term and long-term climate impacts. These plans should consider vulnerabilities in infrastructure, housing, public health, and natural resources.
- **Extreme Heat Preparedness**: As extreme heat events become more frequent and intense, the county should invest in heat action plans that include cooling centers, public awareness campaigns, and support for vulnerable populations, such as the elderly and low-income residents.
- **Flood Risk Management**: With the potential for increased rainfall and more frequent flooding due to climate change, the county should enhance its flood risk management

strategies. This includes infrastructure improvements, early warning systems, and floodplain management.

- **Water Resources Management**: Montgomery County should plan for changes in precipitation patterns and the availability of water resources. This may involve implementing water conservation measures, improving water storage and distribution systems, and ensuring the sustainability of water sources.
- **Green Infrastructure**: Investing in green infrastructure like parks, green roofs, and tree canopy expansion can help mitigate the urban heat island effect, improve air quality, and provide climate-resilient green spaces for communities.
- **Transportation and Energy**: Encouraging sustainable transportation options, such as public transit, biking, and walking, can help reduce greenhouse gas emissions. Additionally, transitioning to clean and renewable energy sources for both public and private sectors can contribute to emissions reduction.
- **Community Engagement**: Engaging the community in climate action initiatives is crucial. Public awareness campaigns, educational programs, and involving residents in decision-making processes can foster a sense of collective responsibility and drive local climate action.
- **Local Agriculture and Food Security**: Climate change can impact local agriculture. The county can support sustainable farming practices, local food production, and food security initiatives to ensure a stable food supply.
- **Economic Resilience**: Preparing the local economy for climate change includes fostering businesses that are resilient to climate impacts, encouraging green job growth, and exploring economic diversification strategies.
- **Emergency Preparedness**: Strengthening emergency response and preparedness plans is essential. This includes preparing for extreme weather events, natural disasters, and ensuring that vulnerable populations have access to emergency services and resources.
- **Monitoring and Data Collection**: Continuously monitoring climate data, assessing the effectiveness of adaptation measures, and adjusting plans based on new information are critical aspects of climate change preparedness.
- **Collaboration**: Collaboration with neighboring jurisdictions, state agencies, and regional organizations can enhance the county's capacity to address climate change effectively, as climate impacts often transcend administrative boundaries.

1. Severe Storms, Thunderstorms, & High Wind, Tornadoes

There is a complex relationship between high wind events and climate change, and this relationship can vary depending on geographic location and specific wind-related phenomena.

As global temperatures rise, the atmosphere retains more moisture, leading to increased chances of intense precipitation events. For Montgomery County, this can translate to more frequent and severe thunderstorms. With intense storms comes the potential for hail, high

winds, and lightning—each carrying its own set of risks such as property damage, power outages, and forest fires. A consistent increase in severe storms could strain the county's infrastructure, especially older buildings and power lines, leading to costly repairs and upgrades. Furthermore, disruptions from these events could have cascading impacts on transportation, agriculture, and local economies.

Climate change can influence large-scale atmospheric circulation patterns, which, in turn, affect regional and local wind patterns. While the overall impact on wind patterns is complex and can vary by region, some areas may experience changes in the frequency, intensity, or direction of high winds. One of the most direct links between climate change and high winds is through the intensification of severe weather events. As the planet warms, there is evidence to suggest that certain types of storms, such as tropical cyclones (hurricanes and typhoons), can become more powerful and produce stronger winds. These intensified storms can lead to more frequent and severe high wind events. The relationship between tornadoes and climate change is less straightforward. While there is ongoing research into this area, it's challenging to attribute individual tornadoes or changes in tornado frequency directly to climate change. However, some studies suggest that climate change may influence the environmental conditions that can favor tornado formation.

Climate change has also led to increased interest in renewable energy sources like wind power. As a result, there has been a growth in wind farms and wind turbines in many regions. Changes in wind patterns can affect the availability and consistency of wind as an energy source, which can have implications for wind energy production and efficiency.

It's important to note that while climate change can influence the conditions that give rise to high wind events, attributing individual wind events solely to climate change is challenging. These events are influenced by a complex interplay of atmospheric conditions, and their specific causes can vary widely.

2. Extreme Temperatures

Montgomery County is likely to experience both hotter summers and milder winters because of climate change. Hotter summers imply more frequent and longer-lasting heatwaves. These extreme temperatures can exacerbate health issues, especially among vulnerable populations such as the elderly, children, and those with chronic illnesses. High temperatures can also strain energy resources, with increased demand for cooling potentially leading to power outages. Conversely, milder winters can disrupt ecosystems, with certain pests not experiencing die-offs and potentially impacting local agriculture.

According to the 2022 Global Climate Report[151] 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[152] 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.

3. Flooding

With the increased frequency of severe storms and rising sea levels, areas in and around Montgomery County are at risk of more frequent and severe flooding events. While the county is not on the coast, its proximity to waterways like the Potomac River means it could still face significant flooding issues. This poses a threat to property, infrastructure, and natural habitats. Additionally, there's a risk of contamination to drinking water supplies and damage to wastewater treatment facilities. Over time, consistent flooding could also alter land use patterns and property values, forcing the county to make substantial adjustments to its urban planning strategies.

Climate change can lead to changes in precipitation patterns, including more intense rainfall events. This can result in higher volumes of water flowing into local rivers and streams, increasing the risk of riverine flooding. As the climate warms, the intensity of storms, including

[151] NOAA – National Centers for Environmental Information (NCEI) – 2022 Annual Global Climate Change Report. Retrieved on 07/06/2023 from: https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202213

[152] 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

tropical storms and hurricanes, may increase. These intense storms can bring heavy rainfall, leading to significant flooding in low-lying areas and along waterways in Montgomery County.

Although Montgomery County is not a coastal area, it is situated near the Chesapeake Bay and Potomac River. Rising sea levels due to climate change can lead to more frequent and severe tidal flooding in areas along the bay and river, impacting properties and infrastructure. Urbanization and the expansion of impervious surfaces in Montgomery County can exacerbate flooding during heavy rainfall events. As climate change brings more intense storms, these surfaces prevent water from being absorbed into the ground, leading to increased runoff and urban flooding. Changes in precipitation patterns and increased storm intensity can lead to erosion and sedimentation in rivers and streams. This can impact water quality and the flow of water, contributing to flood risks. Climate change can alter the timing and magnitude of snowmelt and rain-on-snow events, affecting the spring and winter flood patterns in the county.

Flooding can have a significant impact on communities in the County, including damage to homes, displacement of residents, and disruptions to transportation networks and public services.

By addressing these considerations and actively working to adapt to and mitigate the effects of climate change, Montgomery County can build a more resilient, sustainable, and climate-ready community for its residents. It is important to regularly review and update climate action plans to stay responsive to changing climate conditions and emerging challenges.

4. Hurricanes & Tropical Storms

While Montgomery County is somewhat inland and traditionally has been shielded from the direct impacts of hurricanes, changes in climate patterns may increase the intensity and reach of these storms. Even if hurricanes don't make direct landfall nearby, the county can still experience heavy rainfall, strong winds, and subsequent flooding from such systems. This can result in widespread power outages, road closures, and damage to structures. Additionally, prolonged heavy rains can cause landslides in areas with specific topographical vulnerabilities. The economic and social implications of more frequent or more intense hurricanes could be profound, necessitating improved preparedness and emergency response strategies.

Hurricanes thrive on warm ocean waters as their primary energy source. Climate change has led to increased sea surface temperatures, providing more heat and moisture for hurricane formation and intensification. Warmer oceans can lead to stronger hurricanes and a longer hurricane season. Not only are sea surface temperatures rising, but the heat content of the upper ocean layers is also increasing. This deeper pool of warm water can sustain and fuel hurricanes, allowing them to maintain their strength for longer periods.

Climate change can lead to higher atmospheric moisture levels, providing hurricanes with more moisture to convert into rainfall. This can result in heavier rainfall and increased flooding

associated with hurricanes. Changes in the global climate system can influence atmospheric circulation patterns, including the steering currents that guide hurricanes. These alterations can impact the tracks and paths of hurricanes, potentially leading them to affect different regions or intensify differently.

While there is ongoing research, some studies suggest that climate change may lead to an increase in the frequency of the most powerful hurricanes (Category 4 and 5) in certain regions.[153] Since the 1980s, the hurricane record has shown a more active period in the North Atlantic Ocean. On average, there have been more storms, stronger hurricanes, and an increase in hurricanes that rapidly intensify. Thus far, most of these increases are from natural climate variations. However, one recent study[154] suggests that the latest increase in the proportion of North Atlantic hurricanes undergoing rapid intensification is a bit too large to be explained by natural variability alone. This could be the beginning of detecting the impact of climate change on hurricanes, the paper states. In contrast, the frequency of hurricanes making U.S. landfall (a subset of North Atlantic hurricanes) has not increased since 1900, despite significant global warming and the heating of the tropical Atlantic Ocean.

Climate change can alter the preferred tracks and areas where hurricanes form. For example, some research suggests that hurricanes may move farther poleward, impacting regions that are not typically prone to hurricane activity. It's important to note that while climate change can influence hurricane characteristics, hurricanes are complex phenomena influenced by multiple factors, including natural climate variability. Attribution studies seek to determine the extent to which climate change is contributing to observed changes in hurricane behavior, and research in this area is ongoing.

C. Human Caused Hazards

1. Hazardous Materials

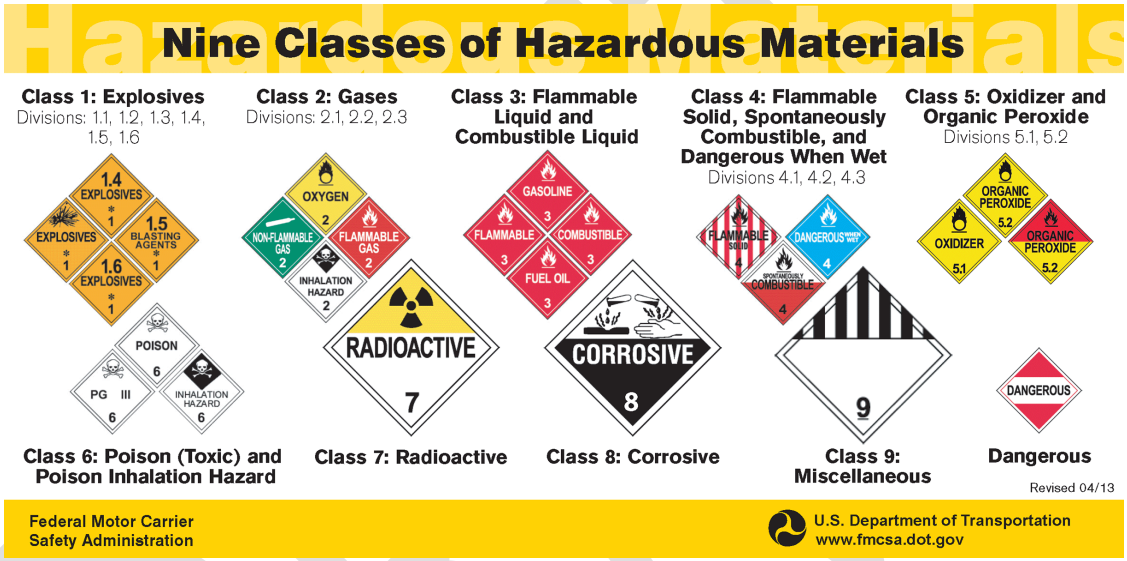
Hazardous materials are more ubiquitous than people may initially think – a quick review of the labels on household cleaning supplies can identify numerous substances which, when used incorrectly, can be harmful to humans. Generally, hazardous materials come with labels and safety features which reduce the risks associated with these materials, but it is often impossible

[153] NASA – A Force of Nature: Hurricanes in a Changing Climate. Retrieved on 09/21/2023 from: https://climate.nasa.gov/news/3184/a-force-of-nature-hurricanes-in-a-changing-climate/

[154] Bhatia, K.T., Vecchi, G.A., Knutson, T.R. *et al.* Recent increases in tropical cyclone intensification rates. *Nat Commun* **10**, 635 (2019). https://doi.org/10.1038/s41467-019-08471-z

to fully guarantee the safety of individuals who use or are around them. While the risks associated with hazardous materials are real and should be acknowledged, it is often impractical to simply eliminate the presence of these materials as many aspects of day-to-day life in the 21st century rely on them in some capacity. For this reason, 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.

Figure 66: Placards used for the nine classes of hazardous materials as defined by US Department of Transportation



a) Location and Extent

An uncontrolled release of hazardous materials can occur at virtually any site where hazardous materials are present. Because hazardous materials are utilized for a wide variety of purposes, it is not uncommon for them to found near residential areas, and concerns about this contributed to the passing of the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986. EPCRA requires any facility which uses or stores hazardous materials to provide a list of the specific substances to their State or Tribal Emergency Response Commission, Local or Tribal Emergency Planning Committee, and local fire department. Additionally, facilities using or storing hazardous materials must share an annual inventory of these substances with the aforementioned entities, and the information must be made available to the public.

Uncontrolled releases of hazardous materials are also possible during transportation. These events are often quite visible, and several high-profile incidents have occurred recently. In 2023, events such as the train derailment in East Palestine, OH and a truck rollover on I-10 in Tucson, AZ prompted shelter-in-place orders and drew national attention. These events

highlight the fact that uncontrolled releases of hazardous materials can occur near communities which may be nowhere near facilities using or storing hazardous materials. As with most U.S. states, Maryland has a large network of roads and railways which may be used to transport hazardous materials. The Maryland highway transportation network consists of 32,269 linear miles of public roadways, and there are currently 16 interstate highways that exist entirely or partially in Maryland. Six of these are primary interstates, while 10 are auxiliary interstates related to one of the primary interstates.

Within Montgomery, the highest traffic volumes are generally found in the southern end of the County near the Washington D.C. metro area. The Capital Beltway and adjoining interchanges see some of the highest volumes of motorists in the County, and sections of I-495 are traveled by hundreds of thousands of vehicles each day.[155] Additionally, the Eisenhower Memorial Highway (Interstate 270 from Frederick to the Capital Beltway) roughly bisects the County and is heavily trafficked. Data made available by the Maryland Department of Transportation (MDOT) shows that nearly 200,000 vehicles travelled on the Eisenhower Memorial Highway each day in 2022.[156] However, lower traffic volumes do not eliminate the risk of transportation accidents, and events leading to an uncontrolled release of hazardous materials can occur along virtually any stretch of road in the County.

Although air traffic is considered safer than other modes of transportation, the possibility of accidents – minor or major – cannot be fully eliminated. Statistically, nearly half of all air accidents occur during takeoff or landing, and less than 15% occur during the "cruising" phase of flight.[157] While air accidents can theoretically impact virtually any part of Montgomery County, the statistics indicate that the people and property in close proximity to airfields are the most exposed to negative impacts from air accidents.

The Montgomery County Airpark is the primary public airport in the County, and it is located in the central part of the County approximately 3 miles northeast of Gaithersburg. The Airpark experiences approximately 67,000 "operations" per year – each aircraft takeoff or landing is

[155] Maryland Department of Transportation. "Internet Traffic Monitoring System (I-TMS)." AADT History, August 7, 2023. https://maps.roads.maryland.gov/itms_public/AADT_AAWDT_Detail.aspx?station_id=B2971.
[156] Maryland Department of Transportation. "Internet Traffic Monitoring System (I-TMS)." AADT History, August 11, 2023. https://maps.roads.maryland.gov/itms_public/AADT_AAWDT_Detail.aspx?station_id=B2971.
[157] Panish | Shea | Boyle | Ravipudi LLP. "Aviation and Plane Crash Statistics (Updated 2023)." Accessed August 11, 2023. https://www.psbr.law/aviation_accident_statistics.html.

counted as a single operation.[158] Montgomery County also has a second, smaller airfield called Davis Airport approximately 2 miles north the community of Laytonsville. According to the Federal Aviation Administration, Davis Airport has approximately 5,100 operations per year, which is less than a tenth of the yearly operations experienced by the Montgomery County Airpark.[159] Considering the number of commercial air traffic flyovers that occur every day, the potential for air transportation accidents exists statewide. However, a 5-mile radius around Montgomery County Airpark and Davis Airport can be considered high-risk areas because most aviation incidents occur near take-off and landing sites.

Much of the rail traffic in Montgomery County travels along a stretch of rail owned by CSX. Heading north from Washington D.C., the railway enters Montgomery County near the Jesup-Blair Local Park in southern Silver Spring. From there, the railway cuts through the County in a generally northwest direction and crosses the Montgomery-Frederick County line just east of the confluence of the Monocacy River and Potomac River. Along the way, the railway passes through multiple towns including Kensington, North Bethesda, Rockville, Gaithersburg, Germantown, and more. There are multiple points along this route where the railway comes within 100 yards of commercial, residential, and educational properties.

This stretch of rail supports both freight and passenger rail services and is utilized by multiple train operators. The trains which most frequently use these rails are Maryland Area Rail Commuter (MARC) trains. MARC, which is administered by the Maryland Transportation Authority (MTA), has three separate lines currently in service. The line which travels through Montgomery County is the Brunswick Line, and 18 trains travel on the railway every weekday to provide the Line's standard service. The line is also used by Amtrak's Capitol Limited line, which runs daily between Washington D.C. and Chicago. CSX also operates their freight trains on the same stretch of rail, and these trains typically carry large volumes of various manufactured goods, products, and commodities.

b) Range of Magnitude

The negative impacts resulting from an uncontrolled release of hazardous materials are generally limited to the immediate vicinity, but the magnitude of an incident increases significantly when hazardous materials are present in volumes commonly used for bulk

[158] The Montgomery County Airpark: Regulatory Framework and Community Impacts. "OLO2022-2.Pdf," January 25, 2022. https://www.montgomerycountyairpark.com/images/documents/OLO2022-2.pdf.
[159] Federal Aviation Administration. "Facility Dashboard - W50." adip.faa.gov, August 10, 2023. https://adip.faa.gov/agis/public/#/simpleAirportMap/W50.

transportation or commercial and industrial operations. Additionally, hazardous materials can have properties which make them unpredictable in an uncontrolled environment, and this can complicate remediation efforts. If a spill is not quickly and properly addressed, hazardous materials can impart wide-reaching and long-lasting consequences on the surrounding populations and environment.

Uncontrolled releases of hazardous materials can be particularly dangerous if the substance is gaseous, as it can easily be lofted into the atmosphere and swept across large areas. Furthermore, hazardous gases can be colorless and odorless, and this can make it difficult to detect an uncontrolled release of these substances. Clouds of hazardous materials can quickly drift over urban areas and envelop large populations. Common symptoms of exposure to hazardous materials include irritation of the eyes and skin as well as respiratory issues which may require hospitalization. Severe events can result in fatalities among the affected population.

Hazardous materials in a liquid or solid state may percolate down into the ground and reach the water table, and they can be carried miles away from the release site by rivers or streams. Land contaminated by hazardous materials may be rendered unusable until the area is properly treated, which can be a resource-intensive process. Many previous remediation projects across the U.S. have cost millions of dollars and taken years to complete, and the sites are typically monitored for a while afterwards to ensure that the work was successful. Hazardous materials – regardless of the state they are in when released – can cause both short-term and long-term health effects, and individuals will likely need to be evacuated from the impacted area(s).

It is not uncommon for hazardous materials to be transported along routes which are highly trafficked and near populated areas. According to the 2022 Transportation Statistics Annual Report, there are about 1 million daily shipments of hazardous materials by land, water, and air transportation modes. Across the U.S. in 2021, approximately 25,000 hazardous materials incidents (excluding pipeline incidents) associated with these shipments were reported to the U.S. Department of Transportation (DOT).[160] Additionally, the Pipeline and Hazardous Materials Safety Administration (PHMSA) acknowledges that accidents involving hazardous materials are

[160] Department of Transportation, Pipeline and Hazardous Materials Safety Administration, and Office of Hazardous Material Study. “10 Year Incident Summary Reports.” portal.phmsa.dot.gov, August 22, 2023. https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages&PortalPath=%252Fshared%252FPublic%2520Website%2520Pages%252F_portal%252F10%2520Year%2520Incident%2520Summary%2520Reports.

more likely to be significant events, and four out of five hazardous materials road accidents led to severe consequences.[161]

For accidents involving an aircraft, the hazardous material most likely to be present is the fuel for the aircraft. However, additional hazardous materials may be present, particularly if the aircraft was carrying freight. The size of an aircraft should not be used to infer the likelihood of hazardous materials present at the site of an accident -- smaller crafts such as spray planes used for agricultural purposes may contain significant quantities of herbicides and pesticides which may be detrimental to human health.

c) Past Occurrences

Data from the EPA's TRI identifies 776 toxic release incidents in Montgomery County between 1987 and 2022.[162] Among these incidents, the 12 largest releases all involve hydrochloric acid in a gaseous state. Across all 776 incidents, the average amount of toxic materials released during each event was 43,139 pounds. Lead compounds are most frequently involved in these releases, being identified in 159 of the 776 toxic release incidents.[163] Additionally, 173 releases involved substances which are known carcinogens. According to the Environmental Protection Agency (EPA), the single largest release of hazardous materials in Montgomery County occurred in 2005 when 3,449,000 pounds of gaseous hydrochloric acid was released from the power generation station near Dickerson. The single largest release of a carcinogen in the County occurred in 1998 when approximately 15,000 pounds of arsenic was released from the same power generation station.

The PHMSA requires individuals to submit a Hazardous Materials Incident Report (Form 5800.1) when a vehicle transporting hazardous materials experiences an event which jeopardizes the safe containment of the materials. These forms must be submitted within 30 days of the event, and the PHMSA received 382 Form 5800.1 submissions for incidents in Montgomery County between January 1990 and June 2023. The DOT divides hazardous materials into 9 "classes," and more than three quarters of the Form 5800.1 submissions from Montgomery County

[161] Zhigerbayeva, Guldana, and Ming Yang. "A Safety Function Deployment Approach to Risk Management of HazMat Highway Transportation." *ACS Chemical Health & Safety* 28, no. 5 (September 27, 2021): 348–57. https://doi.org/10.1021/acs.chas.1c00020.
[162] Environmental Protection Agency. "TRI Search Results." epa.gov, July 12, 2023. https://enviro.epa.gov/enviro/ez_build_sql_v2.get_table.
[163] Environmental Protection Agency. "TRI Search Results." epa.gov, July 12, 2023. https://enviro.epa.gov/enviro/ez_build_sql_v2.get_table.

identify the hazardous materials involved as class 2 (compressed gases) or class 3 (flammable liquids).

Table 38: Hazardous Materials Incident Reports in Montgomery County 01/01/90 – 06/22/23[164]

Department of Transportation Hazardous Materials Classifications	Number of Incidents Reported to PHMSA
CLASS 1: Explosives	0
CLASS 2: Compressed Gases	186
CLASS 3: Flammable Liquids	109
CLASS 4: Flammable Solids	0
CLASS 5: Oxidizers and Organic Peroxides	8
CLASS 6: Poisonous and Infectious Materials	12
CLASS 7: Radioactive Materials	1
CLASS 8: Corrosive Materials	40
CLASS 9: Miscellaneous Dangerous Goods	26

Although incidents involving hazardous materials are relatively uncommon, the threat of such incidents is continually present. On August 4th, 2023, a hazmat incident in Germantown hospitalized five individuals. According to the Montgomery County Fire Assistant Chief, an accidental mix of chemicals occurred in the Bioscience Education Center at Montgomery County College's Germantown Campus. The mixed chemicals produced fumes which caused respiratory irritation among those nearby, and five individuals were transported to the hospital with non-life-threatening injuries. An acting public information officer for the Montgomery County Fire and Rescue Service reported that the noxious fumes were produced by the accidental mixing of floor stripper and sealer chemicals which were being used to clean the floors.[165] Thankfully, the incident did not result in any fatalities, but the structure had to be ventilated before normal operations could resume.

[164] NOTES: Class 9: Miscellaneous Dangerous Goods includes Environmentally Hazardous Substances, Elevated Temperature Material, Hazardous Wastes, and Marine Pollutants. SOURCE: Pipeline and Hazardous Materials Safety Administration 5800.1 Form submissions

[165] Cohn, Courtney. "Chemical Spill at Montgomery College Germantown Campus." MoCo360, August 4, 2023. http://moco360.media/2023/08/04/chemical-spill-at-montgomery-college-germantown-campus-sends-five-to-hospital/.

On the morning of August 10, 2023, a tanker truck carrying pesticide was involved in a multi-vehicle crash on I-270 near the Democracy Boulevard overpass. The truck overturned during the crash, and this led to an uncontrolled release of the pesticide being transported. Montgomery County Fire and Rescue Service classified the crash as a hazmat incident and shut down four of the five I-270 southbound lanes. The County was fortunate that the incident did not cause any serious injuries or deaths, but closure of the southbound lanes created major traffic delays during the morning rush hour.

d) Future Occurrences

The ubiquitousness of hazardous materials in the 21st century likely means that uncontrolled releases of these materials will continue to be a possibility in Montgomery County. The number of individuals potentially exposed to hazardous materials will also increase as the County's population is projected to grow to 1.2 million by 2045.[166] Furthermore, the County's impressive educational system is attractive to families that have – or are planning to have – children, which can be particularly vulnerable to the determinantal effects of hazardous materials. Thankfully, there are some indications that the scale and frequency of these incidents are declining.

Beginning with data from the EPA's TRI, the average number of toxic release incidents per year in Montgomery County has declined from 39.2 to 9.4 between 1997 and 2022.[167] Over the same time span, the average weight of toxic materials released each year has decreased from 2,722,020 lbs to 6,226 lbs. In terms of percent change, between 1997 and 2022, the number of incidents per year decreased by 76%, and the overall weight of toxic materials released per year decreased by 99%.

[166] Maryland-National Capital Park and Planning Commission. "Thrive Montgomery 2050." montgomeryplanning.org, October 2022. https://montgomeryplanning.org/wp-content/uploads/2023/06/THRIVE-Approved-Adopted-Final.pdf.

[167] Environmental Protection Agency. "Toxic Release Inventory Data Montgomery County, MD." epa.gov, July 12, 2023. https://enviro.epa.gov/enviro/ez_build_sql_v2.get_table.

Table 39: Toxic Release Incidents – Montgomery County, MD

Time Period[168]	Number of Toxic Release Incidents[169]	Estimated Sum of Toxic Releases (lbs)	Mean Toxic Release Incidents per Year	Mean Estimated Sum of Toxic Releases per Year (lbs)
1987 – 1997	101	177,621	10.1	17,762
1997 – 2007	392	27,220,196	39.2	2,722,020
2007 – 2017	236	6,047,015	23.6	604,702
2017 – 2022	47	31,130	9.4	6,226

The reasons for the decrease in toxic releases are complex and not explored in depth in this hazard mitigation plan. However, it is rational to assume that stricter regulatory oversight and improvements to storage and handling techniques have contributed to the observed decline in toxic release incidents. Montgomery County should benefit from the 2020 retirement of all three coal-fired power generating units at the power plant near Dickerson. Although the plant still operates natural gas-fired units, the elimination of coal from power generation at the site reduces the overall heavy metal byproducts such as mercury and lead. This appears to already be noticeable, as the location has not reported an uncontrolled release of lead since 2020; prior to 2020, one or more incidents had been reported at the site each year since 2000.

Data made available by the U.S. Pipeline and Hazardous Materials Safety Administration (PHMSA) reveals that, in general, the transportation of hazardous materials via roads, rail, and air is getting safer. However, there is still plenty of progress left to make, and this is evident by reviewing the overall count of incidents involving hazardous materials in transit; an "incident" is defined by 49 CFR 171.15 and 171.16. Between 2017 and 2022, the number of incidents involving hazardous materials increased from 10,696 to 25,148.[170] During this 5-year stretch, the number of incidents per year only dropped in 2020, and this may be related to the impacts from the global pandemic. Interestingly, the overall increase in incidents between 2017 and 2022 is almost entirely attributable to an increase in incidents on the roads. The annual number

[168] Environmental Protection Agency Toxic Release Inventory 1987 – 2022

[169] The number of chemicals covered by the TRI has expanded from 299 in 1988 to 787 in 2022. In 1994 alone, 286 new chemicals were added.

[170] Department of Transportation, Pipeline and Hazardous Materials Safety Administration, and Office of Hazardous Material Study. "10 Year Incident Summary Reports." portal.phmsa.dot.gov, August 22, 2023. https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages&PortalPath=%252Fshared%252FPublic%2520Website%2520Pages%252F_portal%252F10%2520Year%2520Incident%2520Summary%2520Reports.

of incidents on roadways went from 9,197 in 2017 to 23,401 in 2022, which is an increase of 154%. For comparison, hazardous materials incidents involving air transportation increased by 28%, and incidents involving rail transportation decreased by 12% during the same time span.

Figure 67: HazMat Incidents 2013-2022

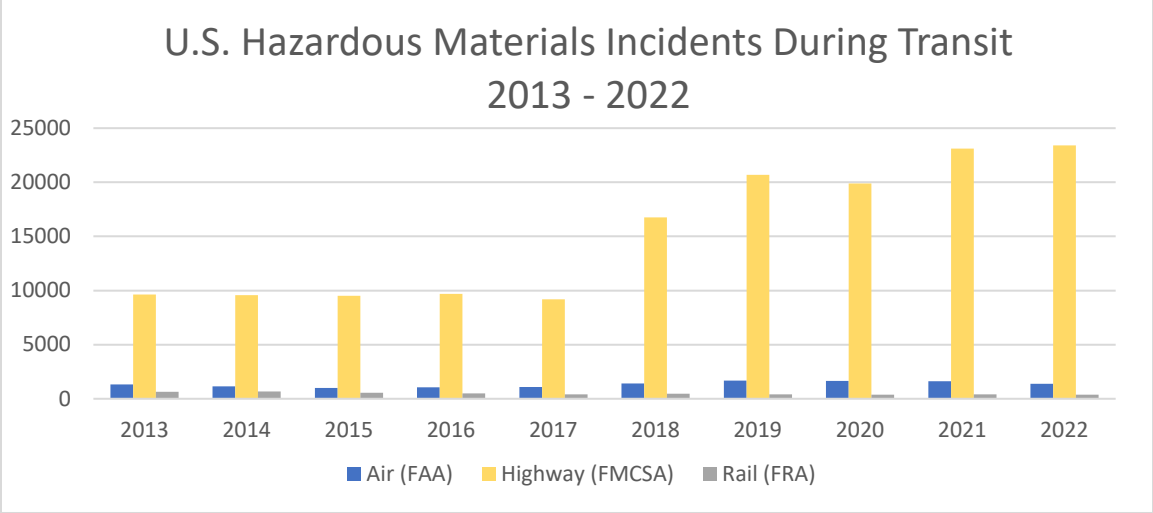
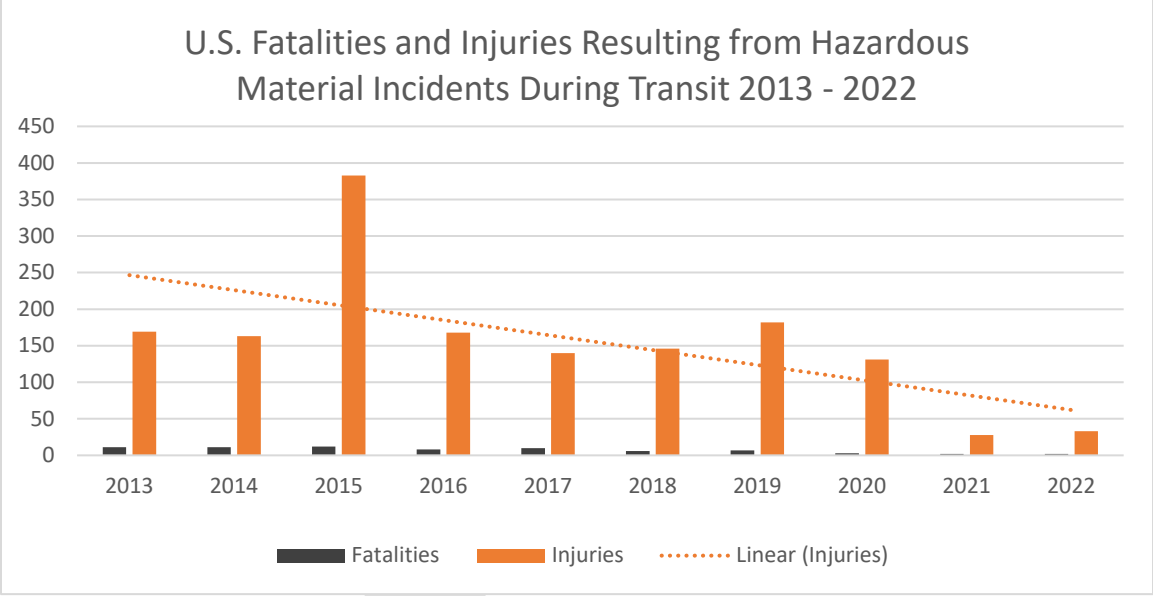


Figure 68: Fatalities & Injuries 2013-2022



While the PHMSA data indicates that the overall number of incidents involving hazardous materials in transit has increased since 2013, the fatalities and injuries which can be connected to these incidents have decreased. Between 2013 and 2022, the annual number of fatalities

decreased from 11 to 2, and the annual number of injuries decreased from 169 to 33.[171] While 0 fatalities should always be the goal, the 2 fatalities in both 2021 and 2022 are the fewest per year in the past 10 years. The 33 injuries recorded in 2022 is a slight increase from the 28 recorded in 2021, but it is still the second fewest of the past 10 years. The significant decrease in yearly injuries and fatalities resulting from hazardous materials incidents between 2020 and 2022 may indicate an increased effectiveness of first responders as well as a wider overall awareness of the risks of hazardous materials.

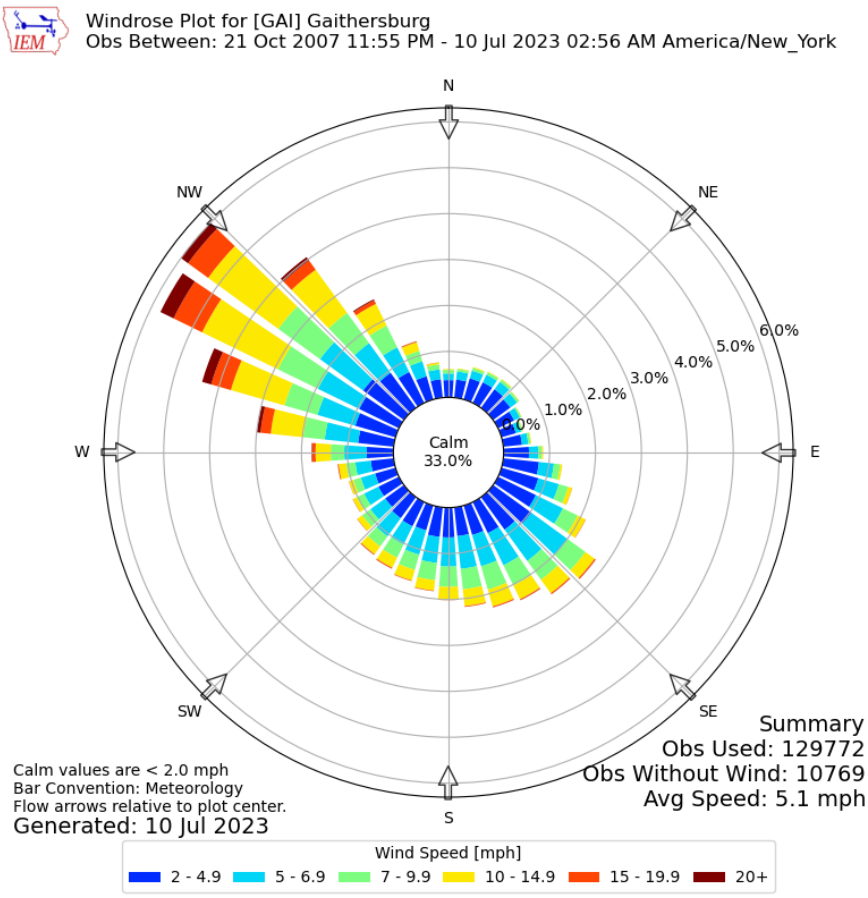
The probability of hazardous materials incidents occurring within Montgomery County in any given year is assessed as ***"highly likely***" with a greater than 90% annual probability. This assessment is based upon previous incidents as documented by both the EPA's TRI and PHMSA data since 1990. This assessment is not *necessarily* indicative of inadequate procedures and regulations – the majority of hazardous materials are transported and utilized without incident.

e) Vulnerability Assessment

Virtually all individuals in Montgomery County are vulnerable to the negative consequences which accompany an uncontrolled release of hazardous materials. Individuals who live closest to the site of an uncontrolled release will generally be the most exposed, but the area impacted by the release is not always a symmetric shape which extends evenly from the release site over time. Hazardous materials in a gaseous state will typically follow atmospheric conditions, and the wind in Montgomery County blows from the northwest on most days. As a result of the wind patterns, the population in the southeast portion of the County may be at an elevated risk of negative consequences resulting from an uncontrolled release of hazardous gases which originate inside the County. Individuals living in the northern part of the County may still be exposed to hazardous materials carried by the wind from a site outside of Montgomery County.

[171] Department of Transportation, Pipeline and Hazardous Materials Safety Administration, and Office of Hazardous Material Study. "10 Year Incident Summary Reports." portal.phmsa.dot.gov, August 22, 2023. https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages&PortalPath=%252Fshared%252FPublic%2520Website%2520Pages%252F_portal%252F10%2520Year%2520Incident%2520Summary%2520Reports.

Figure 69: Windrose plot based on wind measurements taken at Montgomery County Airpark



The area impacted by an uncontrolled release of hazardous material in a liquid state is likely to be different than the area impacted by hazardous gases, even if the releases originate from the same location. The difference in the impacted area is mainly due to liquids following groundwater flows rather than wind patterns. According to the Montgomery County Department of Environmental Protection, groundwater across 88% of the County is naturally funneled west to the Potomac River.[172] In the event of an uncontrolled release of hazardous liquids, the individuals living on the western side of the County are likely to be more vulnerable than those living on the eastern edge.

[172] Montgomery County Department of Environmental Protection. "Watersheds." montgomerycountymd.gov. Accessed August 30, 2023. https://www.montgomerycountymd.gov/water/streams/watershed.html.

The variety of industrial and commercial operations in and around Montgomery County virtually guarantees that hazardous materials will continue to be present in the County. Individuals who live and work near industries which use and store hazardous materials – as well as the railways and roadways which are used to transport them – should be considered more vulnerable to uncontrolled releases of these materials because they will have the smallest window to take action in the event of an incident. As is common with many hazards, a population's vulnerability to hazardous materials incidents is generally elevated if they exhibit one or more of the qualities which are factored into the CDC's Social Vulnerability Index (SVI). These qualities are updated over time, and as of 2020 there are 16 different variables which are used to develop an overall value which illustrates a population's overall ability to prevent human suffering and financial loss in the event of a disaster.[173]

2. Pandemic

a) Location and Extent

It is difficult to anticipate where an epidemic or pandemic may begin or eventually spread. Contact tracing is useful for mapping out the areas and persons infected with a contagious disease. During an epidemic or pandemic, Montgomery County can support the efforts of the Center for Disease Control and Prevention (CDC) and local public health agencies by preparing their staff and operations, as well as providing contract tracing information.

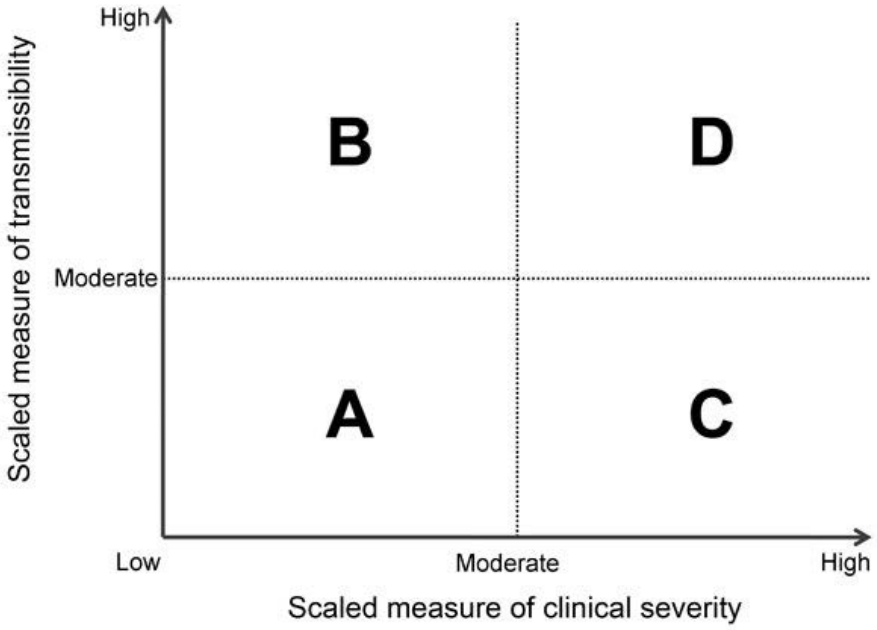
b) Range of Magnitude

The severity of a pandemic, epidemic, or infectious disease is influenced by a multitude of factors and can vary greatly. 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.[174] The PSAF includes two main factors to determine impact: clinical severity (how serious the illness is associated

[173] Center for Disease Control and Prevention. "CDC SVI Documentation 2020 | Place and Health | ATSDR." atsdr.cdc.gov, October 28, 2022. https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2020.html.
[174] 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.

with infection) and transmissibility (how easily the pandemic virus spreads from person-to-person).

Figure 70: Measure of Clinical Severity



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 40: Scaled Measures of Transmissibility and Clinical Severity

Parameter No. and Description[175]	Scale						
	1	2	3	4	5	6	7
Transmissibility							
1. Symptomatic attack rate, community, %	<10	11-15	16-20	21-24	>25	-	-
2. Symptomatic attack rate, school, %	<20	21-25	26-30	31-35	>36	-	-
3. Symptomatic attack rate, workplace, %	<10	11-15	16-20	21-24	>25	-	-
4. Household secondary attack rate, symptomatic, %	<5	6-10	11-15	16-20	>21	-	-
5. R_0: basic reproductive number	<1.1	1.2-1.3	1.4-1.5	1.6-1.7	>1.8	-	-
6. Peak % outpatient visits for influenza-like illness	1-3	1-3	1-3	1-3	1-3	-	-
Clinical Severity							
1. 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
2. Case-hospitalization ratio, %	<0.5	0.5-0.8	0.8-1.5	1.5-3	3-5	5-7	>7
3. Ratio, deaths: hospitalization, %	<3	4-6	7-9	10-12	13-15	16-18	>18

[175] 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.

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 Montgomery County would be a disease with high clinical severity (7) and high transmissibility (5) in the CDC's PSAF.

c) Past Occurrences

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 shows scaled examples of past pandemics and past influenza seasons.

Figure 71: Scaled Measure of Clinical Severity

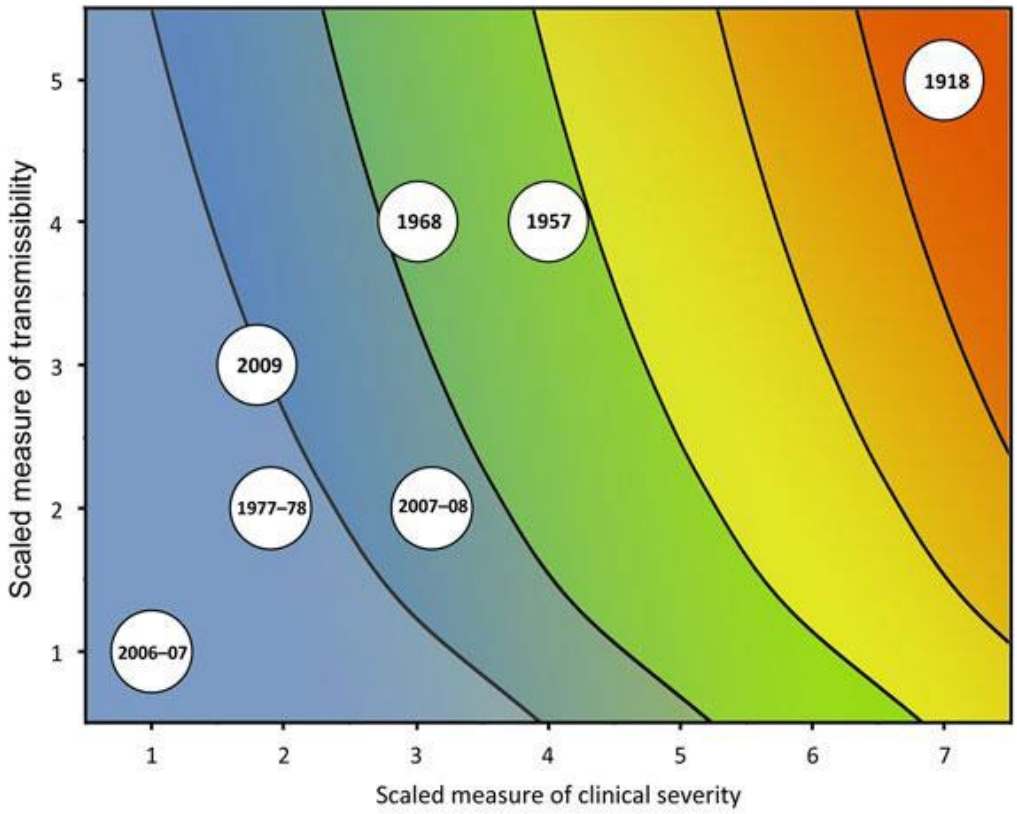


Table 41: Previous Pandemics Transmission & Clinic Severity Scores

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
2007-2007 Flu Season	2	3
2009 Swine Flu Pandemic	3	2

Disease/Flu Season	Transmissibility Score	Clinical Severity Score
2020 COVID-19 Pandemic[176]	5	4-7

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.[177] 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.

Although the exact circumstances of the origin of COVID-19 remain unclear, it is generally accepted that the virus was first detected within the Chinese city of Wuhan in December 2019. By January 21, 2020, the virus was first detected in the U.S. near Seattle, WA – nearly 6,000 miles away from Wuhan, China. The virus quickly spread across the U.S., and the first three cases in Maryland – another 2000 miles away – were confirmed on March 5, 2020, in Montgomery County.

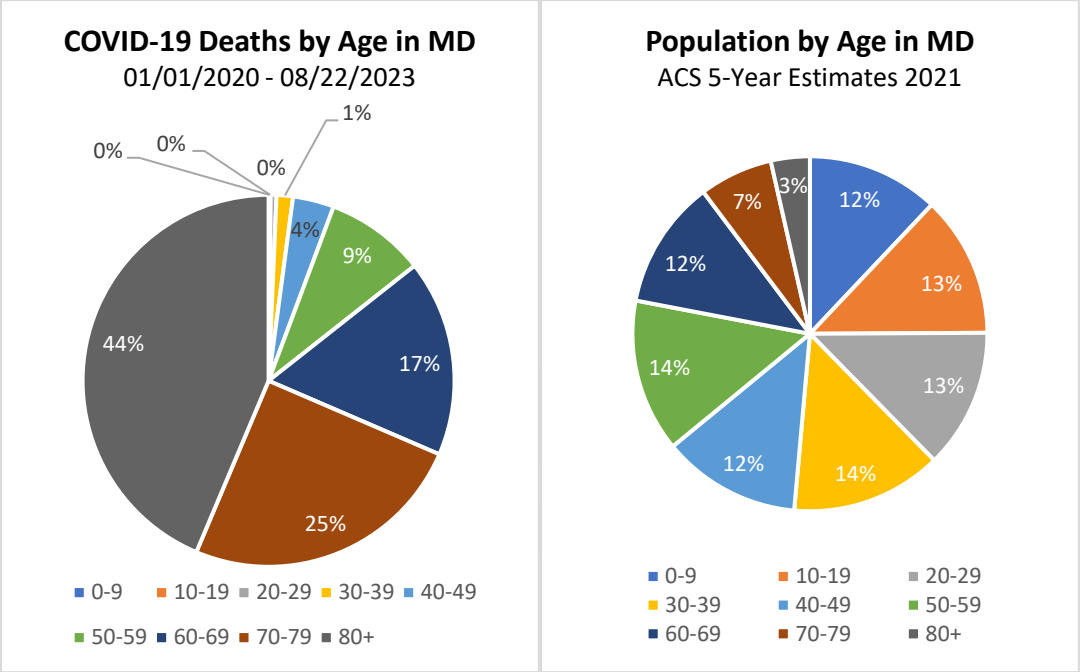
The virus had an unprecedented effect globally and directly influenced critical operations. As of August 22, 2023, Maryland's Department of Health has confirmed 1,390,017 cases of COVID-19 and 16,625 deaths resulting from the disease.[178] Montgomery County has reported 251,391 COVID-19 cases, which is the largest amount reported by any of the counties in Maryland. Montgomery County has also reported 2,389 deaths resulting from COVID-19, which is the second-most among Maryland counties – only Baltimore County has reported more deaths (2,836).

[176] *PSAF scores determined by a team of researchers in Brazil. As of 2023, the CDC has not published an official PSAF rating for the COVID-19 Pandemic.*

[177] 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.

[178] Maryland Department of Health. "Maryland COVID-19 Data." health.maryland.gov, August 22, 2023. https://health.maryland.gov/covid/Pages/default.aspx.

Figure 72: COVID-19 Deaths by Age Comparison



NOTE: values are rounded to the nearest percent. 0% does not equal 0 count.

As with many diseases, COVID-19 is much more likely to be fatal for individuals 60 years of age or older. This is demonstrated by the fact that approximately 10% of the population in Maryland is 70 or older, but nearly 70% of all COVID-19 deaths recorded in Maryland were individuals aged 70 or older.[179] Data from the Maryland Department of Health also suggests that racial minorities may be at an increased risk of dying from COVID-19, which could be indicative of existing socio-economic inequalities between different racial groups.

d) Future Occurrence

Historical events indicate that epidemics and pandemics are happening more frequently and spreading farther over the past century. This increase is likely due to multiple factors, such as increased global travel, economic globalization, urbanization, and increased population growth

[179] Maryland Department of Health. "Maryland COVID-19 Data." health.maryland.gov, August 22, 2023. https://health.maryland.gov/covid/Pages/default.aspx.

in natural environment areas.[180] The Maryland Department of Health (MDH) has published case counts of "reportable diseases" for each county in Maryland. In 2020, which is the latest year which MDH has provided complete data for, chlamydia was the most common reportable disease in Montgomery County, with 3,814 reported cases.[181] Fortunately, the number of reported chlamydia cases in Montgomery County in 2020 was 885 fewer than 2019, although it is nearly 400 more than the number of reported cases in 2016. Of the 5 most common reportable diseases in Montgomery County in 2020, only 2 (animal bites and gonorrhea) had an increase in cases from 2019 to 2020. Additionally, between 2016 and 2020, none of the diseases had continuously increasing case counts – all had at least one year where the case count decreased from the prior year.

Table 42: Top Five Selected Notifiable Diseases Reported in Montgomery County in 2020

Disease Name	Recorded Cases[182]					
	Vector	2016	2017	2018	2019	2020
Chlamydia	Bacteria	3,428	4,029	4,410	4,699	3,814
Animal Bites*	Bacteria	1,051	1,099	940	965	1,066
Gonorrhea	Bacteria	563	726	660	834	936
Mycobacteriosis, Other than TB & Leprosy	Bacteria	216	211	234	249	199
Campylobacteriosis	Bacteria	164	198	261	171	130
*While animal bites are not diseases on their own, they can facilitate the transmission of various diseases which can become public health emergencies.						

Climate conditions can influence the spread of infectious diseases, and changes to these conditions can lead to new patterns. Temperature differences can affect where insect populations live and the diseases they may carry (see projected increases in temperature in **Extreme Temperature**). Insects such as fleas, ticks, and mosquitoes can carry diseases like Lyme, West Nile, malaria, Zika, and more. The WHO identified multiple potential climate

[180] Madhav, Nita, Ben Oppenheim, Mark Gallivan, Prime Mulembakani, Edward Rubin, and Nathan Wolfe. "Pandemics: Risks, Impacts, and Mitigation." In *Disease Control Priorities: Improving Health and Reducing Poverty*, edited by Dean T. Jamison, Hellen Gelband, Susan Horton, Prabhat Jha, Ramanan Laxminarayan, Charles N. Mock, and Rachel Nugent, 3rd ed. Washington (DC): The International Bank for Reconstruction and Development / The World Bank, 2017. http://www.ncbi.nlm.nih.gov/books/NBK525302/.

[181] Maryland Department of Health. "Selected Notifiable Conditions Reported in Maryland (2011-2021)." health.maryland.gov, February 16, 2023. https://health.maryland.gov/phpa/OIDEOR/CIDSOR/Pages/default.aspx.

[182] Maryland Department of Health. "Cases of Selected Notifiable Conditions Reported in Maryland." Maryland.gov Enterprise Agency Template, 2020. https://health.maryland.gov/phpa/Pages/default.aspx.

change factors which could increase the number of infectious disease outbreaks and types of diseases that occur[183]:

- Increased use of dams, canals, and irrigation to manage water flow changes can increase the risk of schistosomiasis, malaria, and helminthiasis
- As annual average temperatures change, new agricultural areas can succumb to infestation, increasing the risk of malaria and Venezuelan hemorrhagic fever
- Urbanization or urban crowding can cause sanitation and contamination issues, increasing the risk of cholera, dengue, and cutaneous leishmaniasis
- Deforestation and populations spreading into wildland interurban areas can cause a rise in insect populations bringing malaria, oropouche, and visceral leishmaniasis
- Conversely, reforestation to combat tree loss can increase the risk of Lyme disease
- Ocean warming can increase the chance of toxic algae blooms like red tide
- Increased precipitation provides additional environment for mosquito breeding and rodent habitat, which increases the risk to rift valley fever and hantavirus pulmonary syndrome

When asked to consider the next 5-10 years, a group of Montgomery County Health and Human Services officials identified the effects of climate change as among their concerns. While some impending consequences of climate change – such as those identified above – are known and being tracked, there are likely many more consequences that are difficult to foresee. The unknown impacts of climate change will almost assuredly challenge the work of Montgomery Health and Human Services, although this is hardly unique to Montgomery County. Officials also acknowledged that their proximity to Washington D.C. *may* make the County slightly more vulnerable to diseases which originate outside of the U.S. but are brought into the country by diplomats, migrants, vacationers, and anyone else who recently spent time abroad.

A common point of discussion by news media, particularly following the emergence of COVID-19, has been the politicization of healthcare. The impact of misinformation and disinformation in combination with the public backlash experienced by healthcare workers has made the daily jobs of some healthcare workers more difficult. Fortunately, several Montgomery County Health and Human Services officials stated that their work has not been negatively impacted by

[183] World Health Organization. *Changement Climatique et Santé Humaine: Risques et Mesures à Prendre ; Résumé*. Genève, 2003. https://apps.who.int/iris/bitstream/handle/10665/42749/9241590815.pdf.

the politization of healthcare, and they are not overly concerned with the phenomena having more tangible effects in the near future.

e) Vulnerability Assessment

(1) People

All residents and visitors of Montgomery County could be susceptible to the effects and exposed to infectious disease. However, some residents of the County are placed at a greater risk for infection than others. Vulnerable populations include but are not limited to those with compromised immune systems, those with pre-existing medical conditions, individuals over the age of 65, individuals with limited access to adequate health care, individuals who are socioeconomically disadvantaged, and children. The CDC's Social Vulnerability Index (SVI) is a database which seeks to identify and map communities which may have an elevated need for support before, during, and after a hazardous event. The SVI incorporates 16 social factors to generate vulnerability rankings, and emergency response planners and public health officials are encouraged to review SVI rankings to ascertain which communities may need additional support.[184] Additionally, officials should recognize that SVI rankings are likely to shift over time as socio-economic conditions change.

(2) Systems & Structures

Epidemics and pandemics do not typically impact property directly. However, adjustments can be made to existing buildings and new projects, such as upgrading HVAC system ventilation and air filtration, improving cleaning and sanitizing procedures and frequency, and allowing more space for social distancing.[185] In contrast, epidemics and pandemics can significantly impact development, although the impacts are likely temporary and would last only as long as the infectious disease continues to spread. Depending on the severity of an epidemic or pandemic, critical services may be significantly impacted due to reduced staffing and safety measures put in place to limit further transmission of the disease. Industry and commerce are also likely to suffer losses; businesses in Montgomery County, the State of Maryland, and across the United States were widely impacted by the COVID-19 Pandemic.

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[184] CDC. "CDC SVI Documentation 2020." Cdc.gov, October 28, 2022. https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2020.html.

[185] Megahed, N. A., & Ghoneim, E. M. (2020). Antivirus-built environment: Lessons learned from Covid-19 pandemic. *Sustainable Cities and Society*, *61*, 102350. https://doi.org/10.1016/j.scs.2020.102350.

According to data from the U.S. Small Business Administration (SBA), Maryland businesses received 190,668 COVID-19 Paycheck Protection Program (PPP) loans as of April 25, 2023. Among the PPP loans received by Maryland businesses, 171,713 (90%) were of $150,000 or less, while the remaining 18,955 loans ranged in size from $150,001 to $10 million.[186] The COVID-19 Pandemic also had an impact on the overall unemployment rate in Maryland, which jumped from 2.8% in 2019 to 6.1% in 2020. The unemployment rate improved slightly in 2021 – dropping to 5.1% – before returning to 2.9% in 2022, which is near pre-pandemic levels.[187]

During the COVID-19 Pandemic, Montgomery County – like virtually all counties in the U.S. – implemented steps aimed at reducing the public's exposure and limited further transmission of the disease. Some of the actions taken by the County to protect populations placed at more risk include but are not limited to providing additional support to hospitals, nursing homes, and residential treatment centers, as well as providing financial assistance to individuals whose homes and livelihoods were jeopardized because of the pandemic. The County will likely benefit from reviewing their response to COVID-19 to assess what actions were successful and what was not. The findings from this review should be incorporated into future mitigation planning to strengthen the County's response to any future pandemic.

The probability of a pandemic occurring in Montgomery County in any given year is assessed as "unlikely" with an annual probability of less than 1%. This assessment is based upon the generally accepted definition of a pandemic by the World Health Organization, CDC, and various governmental entities. Generally, a pandemic is described by these entities as a worldwide spread of a new disease with near simultaneous transmission. The lethality of the disease is not deterministic of a pandemic.

(3) Natural, Cultural, & Historical Resources

A pandemic can have a wide-ranging impact on both natural and cultural resources in a community. educed Environmental Monitoring: During a pandemic, resources allocated for environmental monitoring and conservation efforts may be redirected to public health priorities. This can lead to reduced oversight and protection of natural habitats, wildlife, and ecosystems. As human activities are disrupted during a pandemic, there may be changes in land use and development patterns. Habitat fragmentation can occur when construction projects

[186] Willis, Moiz Syed, Derek. "Tracking PPP: Search Every Company Approved for Federal Loans." ProPublica, April 25, 2023. https://projects.propublica.org/coronavirus/bailouts/.
[187] Bureau of Labor Statistics. "Maryland Unemployment Rates - by County." msa.maryland.gov, August 24, 2023. https://msa.maryland.gov/msa/mdmanual/01glance/economy/html/unemployrates.html.

stall or shift, potentially affecting local biodiversity. Reduced human activity, such as tourism and outdoor recreation, can lead to changes in wildlife behavior. For example, wildlife may venture into urban areas in search of food or become more active in the absence of human disturbances. Economic hardships and reduced law enforcement capacity during a pandemic can result in an increase in illegal activities such as poaching, illegal logging, and wildlife trafficking, posing a threat to natural resources. Economic downturns during a pandemic can lead to budget cuts and reduced funding for conservation and environmental protection initiatives.

Cultural institutions such as museums, historic sites, and art galleries may be closed or operate at reduced capacity during a pandemic. This can lead to decreased access to cultural resources for the public. Cultural organizations often rely on visitor revenue and donations to sustain operations. Reduced visitation and economic uncertainty during a pandemic can strain the financial stability of these institutions, impacting their ability to preserve and protect cultural resources. Cultural resource preservation and restoration projects may be delayed or postponed due to budget constraints and public health restrictions, potentially leading to deterioration of historic buildings and artifacts. Archives, libraries, and repositories of cultural heritage materials may face disruptions in operations, making it difficult to access and preserve historical records and documents.

3. Natural Gas Explosions/Urban Fire

In recent decades, advancements in building codes and the use of fire-resistant construction materials have significantly reduced fatalities from structural fires. However, due to the vast number of structures, including historic ones, eradicating the risk of urban fires entirely remains challenging. Compounding the situation, structural fires can arise from events like thunderstorms and pipeline ruptures, which can hinder ongoing emergency response efforts. Particularly concerning are pipeline ruptures; their potential for explosion is high, and early warning signs are often elusive.

a) Location and Extent

For hazard mitigation purposes, major urban fires involving large buildings and/or multiple properties are of primary concern. Due to various factors, urban areas across virtually all of Maryland are considered at risk to one degree or another. Urban fires pose a more significant threat in areas where a relatively high number of buildings are more than 50 years old, as older structures that were built with lower standards for building construction and materials have created a threat of fire loss that is occurring on a regular basis. This can create challenges for communities with historic districts or structures, as the desire to retain historical value can result in low utilization of fire-resiliency measures which have since emerged. According to the

Maryland Department of Emergency Management (MDEM), Montgomery County has 58 historical state assets and 65 historical critical facilities.[188]

Statistically, urban fires are most likely to start because of human actions; in particular, cooking was identified as the cause of nearly 67% of residential fires in 2021.[189] For comparison, electrical malfunctions were identified as the cause of only 9% of residential fires in the same year.[190] 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. Additionally, pipelines are often used to transport flammable substances such as natural gas, and incidents can occur when pipes corrode, when they are damaged during excavation, incorrectly operated, or damaged by other forces. At present, more than 157 miles of pipelines are used to distribute natural gas throughout Montgomery County.[191]

b) Range of Magnitude

Urban fires occur in denser, more populated areas and most frequently occur in residential structures. Urban fire damage ranges from minor smoke or water damage to the destruction of residential, commercial or public properties. 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.[192] While most of these fires will be considered small and may not cause any significant damage, the possibility of a catastrophic loss due to fire is present. In the worst events, urban fires can result in multiple fatalities, and people can be displaced for months or years, depending on the magnitude of the event. Deaths from residential fires constitute a majority of the fire deaths in the U.S., accounting for 76% of all

[188] Maryland Department of Emergency Management. "2021 State Hazard Mitigation Plan." mdem.maryland.gov, 2021. https://mdem.maryland.gov/community/Documents/2021_MEMA%20HazMitPlanFINAL_CLEAN%20with%20Appendices.pdf.

[189] 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.

[190] 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.

[191] Pipeline and Hazardous Materials Safety Administration. "NPMS Public Viewer." phmsa.dot.gov, August 29, 2023. https://pvnpms.phmsa.dot.gov/PublicViewer/.

[192] 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

civilian fire deaths between 2018 and 2020.[193] From 2018 to 2020, an estimated average of 1,900 fatal fires in residential buildings were reported to fire departments across the country.[194] The effects of a major urban fire include minor to significant property damage, loss of life, and residential or business displacement.

c) Past Occurrences

Each year, the Maryland Office of the State Fire Marshal publishes a report of the fire deaths which occurred during the previous calendar year. Copies of the annual fire deaths reports published between 2004 and 2021 are available from the Maryland Department of State Police, and these 18 separate reports identify 90 fire deaths which occurred in Montgomery County during this time.[195] In the latest version of its annual report, the Maryland Office of the State Fire Marshal assessed that between 2017 and 2021, fires deaths in Montgomery County accounted for 6.2% of all fire deaths in Maryland. During this time span, Montgomery County recorded the 4th most fire deaths among all 24 counties in Maryland - only Prince George's County, Baltimore County, and Baltimore City recorded more fire deaths.

Table 43: Fire Deaths by Year in Montgomery County 2004-2021[196]

Year	Fire Deaths
2004	4
2005	7
2006	5
2007	13
2008	9
2009	3
2010	2
2011	4
2012	3
2013	4
2014	8
2015	2

[193] U.S. Fire Administration. "Fatal Fires in Residential Buildings (2018-2020)," Topical Fire Report series, 22, no. 2 (June 2022). Retrieved on 07/20/2023 from: https://www.usfa.fema.gov/downloads/pdf/statistics/v22i2.pdf.
[194] U.S. Fire Administration. "Fatal Fires in Residential Buildings (2018-2020)," Topical Fire Report series, 22, no. 2 (June 2022). Retrieved on 07/20/2023 from: https://www.usfa.fema.gov/downloads/pdf/statistics/v22i2.pdf.
[195] Maryland State Fire Marshall - Department of State Police. "Fire Deaths In Maryland." Maryland State Police, 2005-2022. https://mdsp.maryland.gov/firemarshal/Pages/DocumentDownloads.aspx.
[196] Maryland State Fire Marshall - Department of State Police. "Fire Deaths In Maryland." Maryland State Police, 2005-2022. https://mdsp.maryland.gov/firemarshal/Pages/DocumentDownloads.aspx.

Year	Fire Deaths
2016	6
2017	4
2018	3
2019	1
2020	7
2021	5
TOTAL	**90**

Across all fires deaths in Maryland from 2017-2021, 228 deaths were confirmed to have occurred in structures for which the age was known. Of these fire deaths, 159 (70%) occurred in structures older than 50 years of age. At the other end of the spectrum, over the same 5-year span, only 7 deaths (3%) occurred in structures built within the last 20 years in Maryland. In regard to age, fire death victims in Maryland between 2017-2021 are most likely to be 50-69 years old. Victims in this age group accounted for 36% of fire deaths, with another 26% of victims being 70-89 years old. Individuals in these two age groups accounted for 61% of fire deaths in Maryland between 2017-2021, yet only 36% of the State's population in 2021 was estimated to be between 50-89 years old.

The PHMSA maintains a record of natural gas pipeline incidents since 2003, and the data set can be filtered by state. For Maryland, the PHMSA has recorded 108 incidents between 2003 and 2022, and these incidents resulted in 11 fatalities and 55 injuries.[197] The total reported cost of these incidents was $40,861,989. Between 2003 and 2022, Maryland experienced an average of 5.4 pipeline incidents resulting in 0.6 fatalities and 2.8 injuries per year, and the average annual cost of pipeline incidents in Maryland during this time span was $2,043,100. While natural gas pipeline incidents in Maryland resulted in fewer than 1 death per year, severe incidents resulting in multiple fatalities are possible. This is evident by the fact that a single incident in 2016 resulted in 7 fatalities and 33 injuries, which represents more than half of all fatalities and injuries linked to natural gas pipeline incidents in Maryland over a 20-year period. Residents in Montgomery County may be particularly aware of this fact, as the tragic 2016 event occurred in Montgomery County community.

[197] Pipeline and Hazardous Materials Safety Administration. "NPMS Public Viewer." phmsa.dot.gov, August 29, 2023. https://pvnpms.phmsa.dot.gov/PublicViewer/.

Table 44: Pipeline Incidents in Maryland 2003 - 2022[198]

Year	Number of Pipeline Incidents	Fatalities	Injuries	Total Cost as Reported
2003	8	0	2	$1,427,345
2004	8	0	0	$4,868,731
2005	8	0	0	$1,750,000
2006	5	0	0	$2,054,500
2007	10	0	2	$1,486,994
2008	10	0	2	$4,513,202
2009	7	0	2	$3,486,638
2010	4	0	0	$574,225
2011	14	2	5	$4,374,370
2012	4	0	0	$1,092,008
2013	2	0	1	$5,000
2014	1	1	2	$70,000
2015	4	0	0	$2,147,917
2016	1	7	33	$1,702,454
2017	2	0	0	$800,002
2018	3	0	1	$1,722,216
2019	5	0	0	$7,170,343
2020	2	0	0	$873,157
2021	6	1	1	$697,063
2022	4	0	4	$45,824
TOTALS	**108**	**11**	**55**	**$40,861,989**

In August 2016, a gas explosion ripped through a 14-story apartment building in the unincorporated community of Silver Spring. The explosion killed 7 residents and injured 65 more, and the building partially collapsed because of the blast. The NTSB investigated the incident and concluded that the failure of an indoor mercury service regulator allowed natural gas to accumulate inside the structure before it ignited from an unknown ignition source. The NTSB's final report recommends several actions to the Public Service Commission of Maryland:[199]

1. Audit and verify the gas utility provider's (Washington Gas) service regulator replacement program, including its recordkeeping.

[198] Pipeline and Hazardous Materials Safety Administration. "NPMS Public Viewer." phmsa.dot.gov, August 29, 2023. https://pvnpms.phmsa.dot.gov/PublicViewer/.
[199] National Transportation Safety Board. "Building Explosion and Fire Silver Spring, Maryland August 10, 2016," August 10, 2016. https://www.ntsb.gov/investigations/AccidentReports/Reports/PAR1901.pdf.

2. Oversee the replacement process for the mercury service regulators that Washington Gas has in service.

The NTSB also found that the specific failure point which allowed natural gas to leak was inside the structure but not easily accessible, and this made it difficult for residents to detect the gas odor indicating a gas leak. As a result of this conclusion, the NTSB recommended that the PHMSA require all new service regulators be installed outside occupied structures, and existing interior service regulators should be relocated outside occupied structures whenever the line, meter, or regulator is replaced.

In 2022, two separate gas explosions occurred in Montgomery County. The first occurred on March 3rd at an apartment building in Silver Spring, and the explosion left 14 injured and displaced another 160 individuals. An investigation concluded that the explosion was set in motion when a plumber mistakenly cut into a gas pipe to attempt to remove a clog. The opening allowed natural gas to escape, and it quicky found an ignition source. In November of the same year, an explosion occurred in a condominium building in Gaithersburg, leaving one dead and 14 others injured. Shortly after the event, authorities concluded that the explosion was intentionally caused by the single individual who perished.

d) Future Occurrence

Unfortunately, urban fires and pipeline ruptures will likely continue to be a hazard in Montgomery County. Although building codes have improved and fire-resistant materials are more commonly used in construction than in previous decades, these measures do not make cities fire-proof. Even structures which are mainly built with materials often thought of as non-flammable (such as concrete and steel) are susceptible to fires as paper, furniture, plants, cleaning supplies and many more items which are commonly found inside occupied buildings can easily ignite. The risk of gas explosions and structural fires resulting from gas pipeline ruptures will also continue to be a hazard in the near future. Although pipeline incidents in Maryland have only led to a single fatality since 2017, the risk of such events has not been eliminated. Furthermore, a multi-fatality incident occurred in Montgomery County less than a decade ago, and natural gas usage across the nation reached an all-time high in 2022.[200]

The overall probability of both urban fires and natural gas explosions occurring within Montgomery County in any given year is assessed as “highly likely” with a greater than 90%

[200] U.S. Energy Information Administration. “U.S. Natural Gas Total Consumption (Million Cubic Feet).” eia.gov, July 31, 2023. https://www.eia.gov/dnav/ng/hist/n9140us2a.htm.

annual probability. This assessment is based on available data from PHMSA, USFA, and the Maryland State Fire Marshall's office. This assessment is not *necessarily* indicative of inadequate regulations, as many urban fires are the result of human activities like cooking which are difficult to regulate.

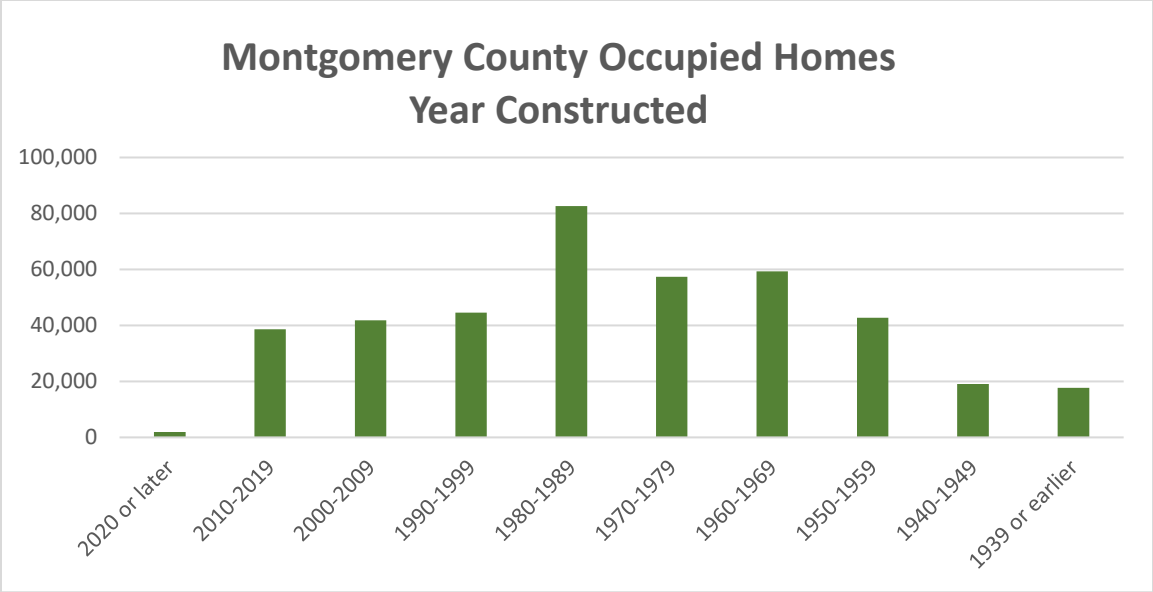
e) Vulnerability Assessment

In general, the areas in Montgomery County which are at an elevated risk of structural fires and gas pipeline explosions are those which have a significant number of older buildings and relatively dense development. In Montgomery County, many of the occupied homes are more than 30 years old. In 2021, research by the American Community Survey concluded that approximately 278,835 occupied homes in Montgomery County were built in 1989 or earlier. Therefore, nearly 70% of all occupied homes in Montgomery County were constructed before many fire-related codes and requirements went into effect. For instance, only homes constructed in 1989 or later are required to have interconnected smoke alarms; interconnected alarms all begin emitting sound as soon as a single unit detects smoke rather than on an individual basis.[201] Interconnected alarms, as well as additional items which are now mandatory in new structures, are designed to extend the amount of time occupants have to respond to a fire.

Figure 73: Year of construction for Occupied homes in Montgomery County[202]

[201] Montgomery County Fire & Rescue. "Montgomery County Residential Smoke Alarm Requirements." montgomerycountymd.gov. Accessed August 30, 2023. https://www.montgomerycountymd.gov/mcfrs-info/resources/files/laws/smokealarmmatrix_2013.pdf.

[202] American Community Survey

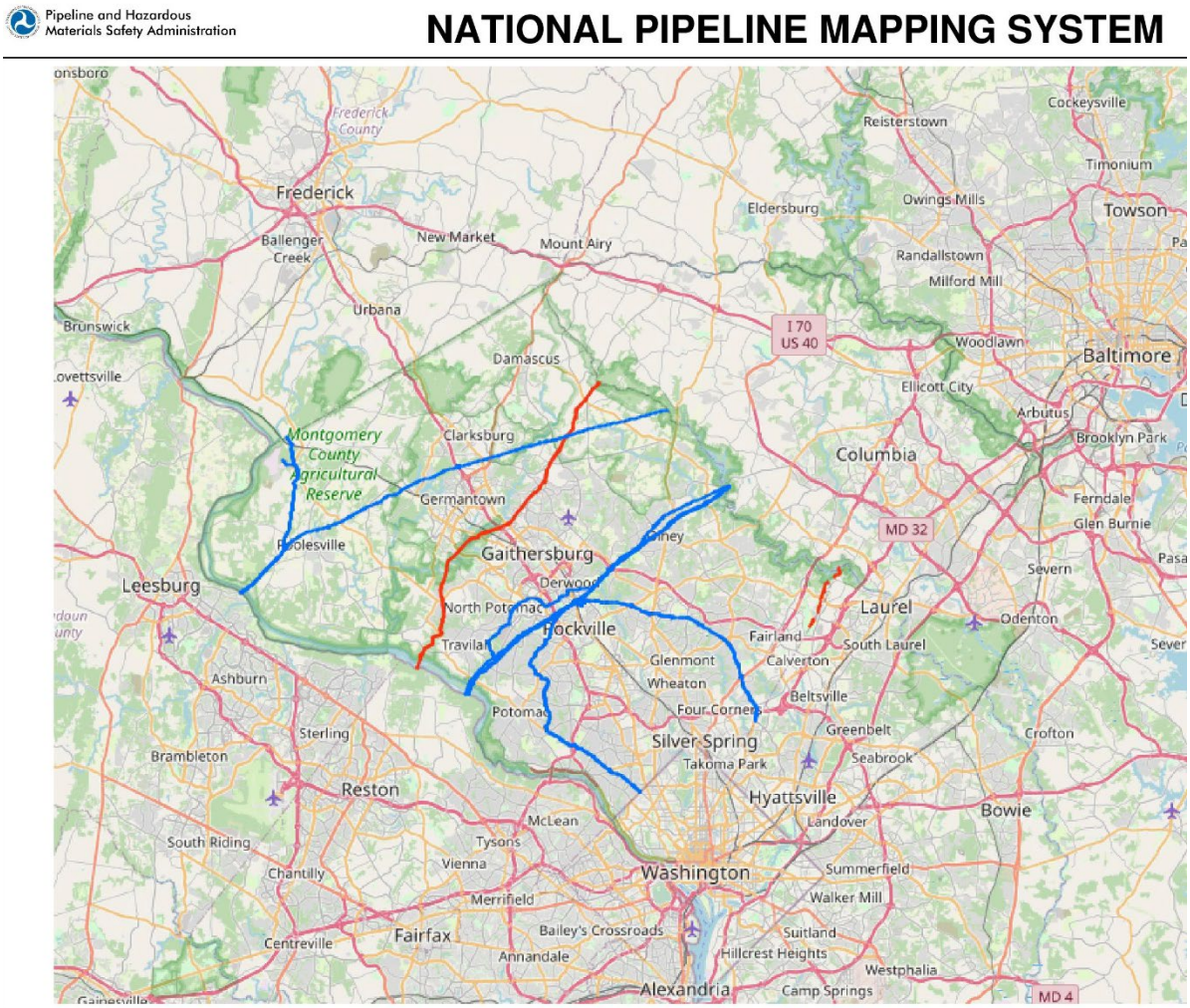


Data retrieved from the PHMSA indicates that gas transmission and hazardous liquid pipelines generally cut across Montgomery County from the Potomac to the border with Howard County (SW to NE). There are no pipelines documented by PHMSA which run the length of the County from Washington D.C. to the border with Fredrick County. However, there are two pipelines which stretch from Washington D.C. and Prince George's County to an area roughly near I-270 between Rockville and Gaithersburg. Additionally, there is a single hazardous liquid pipeline in Montgomery County which runs across the length of the County roughly perpendicular to I-270 between Gaithersburg and Germantown.

Figure 74. Pipeline and Hazardous Materials Safety Administration Map

Red: hazardous liquid pipelines

Blue: gas transmission pipelines



Many more distribution lines branch off the major pipelines identified by the PHMSA, and this exposes virtually all individuals who reside in or near facilities which use natural gas to the potential consequences of pipeline incidents. This risk was highlighted in 2018 when work on a gas transmission line in Massachusetts led to multiple explosions and fires which damaged hundreds of structures. In their final report of this incident, the National Transportation Safety Board (NTSB) concluded that an error during maintenance allowed natural gas to enter distribution lines at pressures far higher than normal. The natural gas then surged into homes and businesses and quickly found ignition sources. The NTSB final report on this incident

included a recommendation for 34 states – including Maryland – to remove an exception which allows utility providers to work on gas transmission lines without first having a professional engineer approve the planned work. This incident, as well as the gas explosion in Silver Spring in 2016, demonstrate that natural gas transmission systems remain susceptible to faults, and the possibility of future incidents cannot be fully ruled out at this time.

D. Hazard Vulnerability Summary

1. Methodology

Prioritizing hazards plays a crucial role in helping communities establish objectives and mitigation strategies based on their vulnerabilities. Montgomery County employed the Risk Factor (RF) methodology, as described below, to assess and rank hazards according to their threat levels. This ranking underwent scrutiny and evaluation by the Steering Committee and all stakeholders during the Draft Plan Review phase.

The RF methodology generates numerical values that facilitate the comparison of identified hazards. These values reflect the relative risk posed by each hazard, with higher RF values indicating a greater level of hazard risk. RF values are determined by attributing varying degrees of risk to five categories for each hazard: probability, impact, spatial extent, warning time, and duration. Each degree of risk within these categories is assigned a value ranging from 1 to 4, accompanied by a corresponding weighting factor. The RF approach is summarized in the table below. To calculate the RF value for a particular hazard, one must multiply the assigned risk value for each category by its respective weighting factor. The summation of these values across all five categories yields the final RF value, as illustrated in the following example equation:

Table 45: Risk Factor Methodology Equation

RF Value = [(Probability x .30) + (Impact x .30) + (Spatial Extent x .20) + (Warning Time x .10) + (Duration x .10)]

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 Possible Likely Highly Likely	Less than 1% annual probability Between 1% and 49.9% annual probability Between 50% and 90% annual probability Greater than 90% annual probability	1 2 3 4	30%

Risk Assessment Category	Degree of Risk			Weight Value
	Level	Criteria	Index	
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	
	Catastrophic	High number of deaths / injuries possible. More than 50% of property in affected area damaged or destroyed. 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	Less than 1% of area affected	1	20%
	Small	Between 1% and 10.9% of area affected	2	
	Moderate	Between 11% and 25% of area affected	3	
	Large	Greater than 25% of area affected	4	
Warning Time: Is there usually some lead-time associated with the hazard event? Have warning measures been implemented?	More than 24 hours	Self-Defined	1	10%
	12 to 24 hours	Self-Defined	2	
	6 to 12 hours	Self-Defined	3	
	Less than 6 hours	Self-Defined	4	
		Note: Levels of warning time and criteria that define them may be adjusted based on the hazard addressed.		
Duration: How long does the hazard event usually last?	Less than 6 hours	Self-Defined	1	10%
	Less than 24 hours	Self-Defined	2	
	Less than 1 week	Self-Defined	3	
		Self-Defined	4	
		Note: Levels of warning time and criteria that define them may be adjusted based on the hazard addressed.		

Risk Assessment Category	Degree of Risk				Weight Value
	Level	Criteria		Index	
	More than 1 week				

2. Ranking Results

Using the methodology described above, the following table lists the Risk Factor calculated for each of the 17 potential hazards identified in the 2024 update. Hazards identified as high risk have risk factors greater than or equal to 2.5. Risk Factors ranging from 2.0 to 2.4 are considered moderate risk hazards. Hazards with Risk Factors less than 2.0 are considered low risk. According to the default weighting scheme applied, the highest possible RF value is 4.0.

Table 46: Risk Results

Hazard	0.3	0.3	0.2	0.1	0.1	Overall Risk
	Probability	Impact	Spatial Extent	Warning Time	Duration	
Flooding	4	3	3	4	3	**3.4**
Extreme Temperatures	4	1	4	2	4	**2.9**
Pandemic	1	4	4	1	4	**2.8**
Winter Storm	3	2	4	1	3	**2.7**
Severe Thunderstorms/ High wind	4	2	2	4	1	**2.7**
Lightning	4	2	1	4	1	**2.5**
Hailstorm	4	2	1	4	1	**2.5**
Tropical Cyclone	2	2	4	1	3	**2.4**
Dam Failure	1[203]	4	2	4	1	**2.4**
Hazardous Materials	4	1	1	4	2	**2.3**
Gas Explosions/ Urban Fires	4	1	1	4	2	**2.3**
Drought	2	1	4	1	4	**2.2**

[203] There have been no recorded instances of dam failures impacting Montgomery County.

Sea Level Rise	4	1	1	1	4	**2.2**
Tornado	2[204]	2	1	4	1	**1.9**
Wildfire	2	1	2	4	2	**1.9**
Land Subsidence	2	1	1	4	2	**1.7**
Earthquake	1	1	2	4	1	**1.5**

Sea level rise: The factors contributing to sea level rise and the subsequent impacts are complex and not uniformly agreed upon. Several studies have established a link between anthropogenic activity and sea level rise, but the specific dynamics of this link remain a matter of scientific debate. Additionally, it is difficult to predict the outlook for emissions and other factors linked to sea level rise. Government regulations, social trends, and other factors can alter the extent to which anthropogenic activity affects sea level rise.

[204] This assessment is based on NCEI data for all recorded tornadoes to have occurred within Montgomery County since 1950. However, a significant majority of these events occurred within the last 30 years. When looking at tornado events since 1990, the assess probability is "likely" with between 50% and 90% annual probability.

VI. Hazard Mitigation Goals, Objectives, and Strategy

A. Introduction

The Mitigation Strategy functions as a comprehensive guide for future hazard mitigation policies, projects, and administration within Montgomery County and its participating municipalities. It directly reflects the consensus of the Montgomery County Mitigation Planning Committee and incorporates findings from the Hazard Identification and Risk Assessment. The three components of the Mitigation Strategy include:

1. **Mitigation Goals**: These represent the overarching aspirations. Broad policy statements, they depict the long-term outcomes Montgomery County hopes to achieve.
2. **Mitigation Objectives**: Detailing the "paths to success" strategies or steps aimed at realizing the goals.
3. **Mitigation Actions**: Specific and actional "steppingstones" that moves the community along the path toward resiliency goals. These actions make up a "menu" of projects for future implementation or grant funding applications.

B. 2024 Montgomery County Mitigation Goals and Objectives

The planning process and writing of the 2024 updated Hazard Mitigation Plan reflects a shift in the approach and purpose of this planning effort. Increasing the emphasis on access and understanding of the County's hazards and placing significant focus on actionable progress toward meeting the communities' goals. As such, while the content of the mitigation strategy has not been significantly altered from the 2019 plan, the formatting has. Overall, the County and participating jurisdictions highlight a single overarching goal, and 7 supporting Objectives

Goal: Minimize the loss of life and property by minimizing the effects and impacts of each hazard on buildings, infrastructure, critical facilities, lifelines, and private property.

Objectives:

1) Encourage building and land use regulations that increase safety and resiliency and reduce risks posed by natural disasters.
2) Protect public health, safety, and welfare by increasing public awareness of existing natural hazards and by fostering individual and public responsibility in mitigating risks caused by those hazards.
3) Ensure that infrastructure is adequate and properly maintained to provide continued functionality of all critical services necessary to protect residents and property.
4) Improve communications and increase natural hazard awareness through education and citizen participation.
5) Enhance the capabilities of local jurisdictions to identify and mitigate natural hazards.

6) Participate and comply with the National Flood Insurance Program (NFIP) through floodplain identification, mapping, and management.
7) Promote actions that protect historic and cultural resources, while enhancing hazard mitigation and community resiliency.

C. Changes from 2018

The intent of Montgomery Conty and all participating entities remains the same as it was in 2018. No major modifications were made to the Goals or Objectives outside of clarity and simplification. However, substantial increases can be seen in the number and specificity of Mitigation Actions, which leverages other planning mechanisms like the 2020 Climate Action plan, and internal integration efforts with other County departments like DEP and DOT.

D. Community Values, Historic and Special Considerations

Given the interconnected relationships between multiple entities and also certain practical, legal, or fiscal limitations, the overall conclusion of the action development process was that most actions require cross-jurisdictional participation to some extent. Many actions also benefit multiple entities. Newly identified actions were sourced from the 2020 Climate Action Plan and collaboration efforts with DEP and DOT. Jurisdictional actions were developed through the one-on-one individual meetings with wholistic, whole community approaches to future planning and development in mind.

E. Mitigation Actions

Due to the number new Mitigation Actions, the full listing is included as Appendix E. 76 New Actions were identified, 48 from the 2020 Climate Action Plan.

VII. Capability Assessment, Implementation, and Plan Maintenance Procedures

A. Capability Assessment

Capability and capacity are two defining features of community's resilience. Capability referring to the "tools" available to the community and capacity as the ability to use those tools. This portion of the Plan assesses the current capacity of the communities within Montgomery County to mitigate the effects of the natural hazards and implement successful mitigation programs. This assessment includes an examination of:

- **Administrative Capability** – mechanisms of public service available to local government.
- **Technical Capability** – knowledge and staffing within the local government.
- **Fiscal Capability** – budgets, grants, and ability to utilize.
- **Policy and Program Capability** – past, present, and future projects, programs, and plans.
- **Legal Authority** –how the four broad government powers (i.e., regulation, acquisition, taxation, and spending) are used to influence hazard mitigation activities.

Through careful analysis, existing gaps, shortfalls, or weaknesses within existing governmental activities that could exacerbate a community's vulnerability were identified and noted as areas for improvement within the Mitigation Strategy. The assessment also highlights the positive measures underway at the local level that will continue to be supported and enhanced through future mitigation efforts.

The capability assessment serves as the foundation for designing an effective hazard mitigation strategy. It not only helps inform plan goals to be both achievable but aspirational to reduce the County's exposure to natural hazards. To inform this capability assessment, each jurisdiction completed an intensive one-on-one comprehensive review of community and government functions, that included their current administrative, technical, fiscal, programmatic, and legal capabilities. Additionally, each jurisdiction completed a survey to qualitatively review their current hazard mitigation capabilities. Information was captured in meeting notes and through a Local Jurisdictional Worksheet, included in Appendix D.

For the most part, jurisdictions are well covered by emergency services, law enforcement, and fire departments provided by the county. Few municipalities oversee their own delivery of these services, noted below, and some supplement the police services provided by the County by paying off-duty officers for additional patrols. Please note that all jurisdictions except Barnesville, Town of Chevy Chase, and Martin's Additions completed a worksheet. Numerous attempts were made to contact the communities however, multiple schedule conflicts and medical issues precluded meetings during the planning phase. A list of participating jurisdictions and the point of contact is listed in the planning process.

The Maryland Local Government Code Ann. § 21-514 (2021) identifies thirteen mandatory steps for a municipality to achieve full regulatory, legal, and fiscal authority. Although all municipalities included in this planning process meet the legal and fiscal requirements, some have been statutorily restricted from achieving full authority over zoning. All are restricted from adopting standards that are less restrictive than the state and County. Most residents must seek approval from both the County and municipality when pursuing a Building Permit. Floodplain reviews are in nearly all cases performed by the County.

The county provides all Emergency Management and Fire Department support. However, some communities, Like Washington Grove, supplement emergency management functions with volunteer safety committees to advocate for community member needs with city council.

Table 47: Administrative Capability

Jurisdiction	Building and Code Enforcement	Stand-alone Law Enforcement	Emergency and Safety Committee
Barnesville	X		
Brookeville	X		
Chevy Chase Section 3		X	
Chevy Chase Section 5		X	
Chevy Chase	X		
Chevy Chase View*			
Chevy Chase Village	X		
Rockville	X	X	X
Gaithersburg	X	X	X
Garrett Park	X		X
Glen Echo		X	
Kensington	X	X	
Laytonsville*			
Martin's Addition	X (contracted)		
North Chevy Chase*			
Poolesville	Contracted Code Enforcement	X	Shared responsibility
Somerset		X	X
Takoma Park	X	X	X

Washington Grove	X		X
Montgomery County	X	X	X

For successful implementation of a mitigation program, it is necessary to have a broad range of people involved who can inform and contribute to holistic mitigation actions through diverse backgrounds and experience. People with the necessary expertise to influence outcomes can include local planners, engineers, building inspectors, emergency managers, floodplain managers, Geographic Information Systems (GIS) analysts and grant writers, among others.

GIS systems include the hardware, software and technicians that collect, manage, analyze and display spatially-referenced data. GIS is invaluable in identifying areas vulnerable to hazards. Improved online archived technical information has greatly improved update processes and quality of emergency operations plans, continuity of operations plans, hazard mitigation plans and emergency management, resiliency and mitigation messaging. This increases community resiliency, especially outreach efforts using social media.

With the exception of Gaithersburg, most jurisdictions in Montgomery County either contract out many hazard mitigation functional positions or rely on the County.

Table 48: Technical Capability

Jurisdiction	Land Use / Development	Building and Code Enforcement	Engineering	Floodplain Manager	GIS	Grants	Comments
Barnesville							Contracted
Brookeville							Contract with either County or State
Chevy Chase Section 3							Rely on County
Chevy Chase Section 5							
Chevy Chase			Contract				Rely on County

Chevy Chase Village			Contract		Have ESRI but need training on how to use it		
Gaithersburg	X	X	X	X[205]	X	X	
Garrett Park	X		Contract				
Glen Echo							Rely on County
Kensington	X	X	Contract				
Laytonsville*							
Martin's Addition		X	Contract		Contract		
North Chevy Chase*							
Poolesville	X		X	X			
Rockville	X	X	X	X	X	X	
Somerset		Contract	Contract			X	
Takoma Park			X		X	X	
Washington Grove	X		X				
Montgomery County	X	X	X	X	X	X	X

As a snapshot of fiscal capability, participating jurisdictional budgets varied widely in 2023. Revenues which support local budgets come from property taxes, State and local sales taxes, local service fees, and through restricted intergovernmental contributions (federal and state pass through dollars). Outside of the County, few jurisdictions have taken advantage Mitigation projects funded through FEMA's post-disaster Hazard Mitigation Grant Program (HMGP) or annual Building Resilient Infrastructure and Communities (BRIC) program. The lack of utilization is not due to lack of federal availability or funding, but due to lack of personnel at the local level

[205] While Gaithersburg has historically maintained this position, their last Floodplain Manager vacated the position in 2021. The roles has been assumed as one of many responsibilities for the Public Works Director, supplemented by contractors. The need to fill this role has been identified as a Mitigation Action.

with the capacity to take on even more responsibility and workloads. FY 2023 budgets provided by local jurisdiction are below.

Table 49: Fiscal Capability

Jurisdiction	Total FY 2023 Budget	Public Safety FY 2023 Budget
Barnesville	$102,000	$20,000
Brookeville	N/A	N/A
Chevy Chase Section 3		
Chevy Chase Section 5	$425,000	Roughly $30,000
Chevy Chase	$2,600,000	$340,000 to pay for off duty policing patrol.
Chevy Chase View		
Chevy Chase Village		
Gaithersburg	$9,210,085	
Garrett Park	0	0
Glen Echo	$302,000	0
Kensington	$2,900,000	$233,836
Laytonsville		
Martin's Addition	$1,000,000	
North Chevy Chase		
Poolesville	$3,478,478	All services provided by the County
Rockville	$130,300,000	$11,529,590
Somerset		
Takoma Park		
Washington Grove	$635,432	$29,500

In general, most local officials generally feel that their government capacity is at least moderate in most areas. However, there are practical reasons for the County to maintain responsibility for some services, policy, and programs capabilities. To describe the nuances in the table below, planning efforts that were conducted as stand-alone plans, independent of County plans that may cover the jurisdictional area are marked with an "**X**". If the jurisdiction was an active participant in a broader planning effort, their participation is marked with a "**C**". In progress planning efforts are marked as "**IP**". If a plan exists but needs updating and has been identified as a gap. This is marked with an "**O**". All jurisdictions have adopted the 2013 Montgomery County's Hazard Mitigation Plan through local resolution.

Table 50: Policy and Program Capability

Jurisdiction	Hazard Mitigation Plan	Emergency Operations Plan	Evacuation Plan	Continuity of Operations Plan	Floodplain Management Ordinance	Comprehensive Land Use Plan	Stormwater Management Plan	Natural Resource Protection Plan	Capital Improvement plan	Firewise Community	Storm Ready
Barnesville	C					X		X			
Brookeville	C					X					
Chevy Chase Section 3	C										
Chevy Chase Section 5	C										
Chevy Chase	C			X							
Chevy Chase View	C										
Chevy Chase Village	C			X	X		X		X		
Gaithersburg	C	X		X	X	X	X	X	X	X	
Garrett Park	C			IP				X	X		
Glen Echo	C								IP		
Kensington	C								X		
Laytonville	C					X					
Martin's Addition	C										
North Chevy Chase	C										
Poolesville	C	O		X		IP		X	X		
Rockville	C	X		X	X	X	X		X		
Somerset	C								X		
Takoma Park	C					IP					
Washington Grove	C					X	X		X		
Montgomery County	X	X	X	X	X	X	X	X	X		X

The importance of the planning powers of local governments is illustrated by the requirement that zoning regulations be made in accordance with a comprehensive plan. While the ordinance itself may provide evidence that zoning is being conducted "in accordance with a plan," the existence of a separate planning document ensures that the government is

developing regulations and ordinances that are consistent with the overall goals of the community.

Zoning is the traditional and most common tool available to local governments to control the use of land. Broad enabling authority is granted for municipalities and counties in Maryland to engage in zoning. Land ''uses" controlled by zoning include the type of use (e.g., residential, commercial, and industrial) as well as minimum specifications that control height and bulk such as lot size, building height and setbacks, and density of population. Local governments are authorized to divide their territorial jurisdiction into districts, and to regulate and restrict the erection, construction, reconstruction, alteration, repair or use of buildings, structures, or land within those districts. Districts may include general use districts, overlay districts, and special use or conditional use districts. Zoning ordinances consist of maps and written text.

Subdivision regulations control the division of land into parcels for the purpose of building development or sale. Flood-related subdivision regulations are included in the floodplain management ordinance, requiring developers to install adequate drainage facilities and design water and sewer systems to minimize flood damage and contamination. They also may prohibit the subdivision of land subject to flooding unless flood hazards are mitigated through filling or other measures, and they prohibit filling of floodway areas.

Table 5 5 summarizes each jurisdiction's legal capabilities related to hazard mitigation planning. Zoning regulations have the highest number of jurisdictions with legal authority, followed by building code, subdivision regulations, and floodplain ordinances. It is evident from the table that jurisdictions rely on the County for many legal authorities.

Table 51: Legal Authority Capability

Jurisdiction	Floodplain Management Ordinance	Zoning Regulations	Subdivision Regulations	Building Code
Barnesville		X	X	
Brookeville	X	X	X	X
Chevy Chase Section 3		MoCO and MNCPPC Authority	X	
Chevy Chase Section 5		MoCO and MNCPPC Authority	X	
Chevy Chase		X	X	X

Chevy Chase View		MoCO and MNCPPC Authority	X	
Chevy Chase Village		MoCO and MNCPPC Authority	X	X
Gaithersburg	X	X	X	X
Garrett Park	X	MoCO and MNCPPC Authority	X	
Glen Echo	X	X	X	
Kensington		MoCO and MNCPPC Authority	X	
Laytonsville			X	
Martin's Addition		MoCO and MNCPPC Authority	X	X
North Chevy Chase		MoCO and MNCPPC Authority	X	
Poolesville	X	X	X	
Rockville	X	X	X	X
Somerset	X	MoCO and MNCPPC Authority	X	
Takoma Park	X	MNCPPC Authority	X	
Washington Grove		X	X	X
Montgomery County	X	X	X	X

Table 52: Self-Ranked Capacity Score

Jurisdiction	Administrative and Technical Capability	Fiscal Capability	Planning and Regulatory Capability	Community Legal Capability
Barnesville	Limited	Limited	Limited	Limited
Brookeville	Limited	Limited	Limited	Limited
Chevy Chase Section 3	Limited	Moderate	Limited	Moderate

Chevy Chase Section 5	Moderate	Moderate	Moderate	Moderate
Chevy Chase	Limited	Moderate	Limited	Moderate
Chevy Chase View*				
Chevy Chase Village	Limited	Moderate	Limited	Moderate
Gaithersburg	High	High	High	High
Garrett Park	High	High	High	High
Glen Echo	Moderate	High	Moderate	Moderate
Laytonsville*				
Martin's Addition	Moderate	High	Moderate	Moderate
North Chevy Chase*				
Poolesville	High	High	High	High
Rockville	High	High	High	High
Somerset	Limited	High	Limited	High
Takoma Park	Moderate	Limited	Moderate	High
Kensington	Moderate	High	Moderate	High
Washington Grove	Moderate	Moderate	High	High
Montgomery County	High	High	High	High

Finally, after reviewing all aspects of capability a consequence analysis was completed by each jurisdiction to help determine their community's ability to recover after a natural hazard event. Representatives ranked how likely each system would be impaired by an event on a scale of zero to five, with zero being no impacts to the system and five being significantly impacted. The results are shown in the table below. Across the different systems, impacts to the public received the highest average score across all communities, indicating it would be the most impacted system from a natural hazard event. Please note that the survey included small communities that operated only administrative offices and were unable to respond to the questions as they rely on the County for all resources and services. If the community could not provide a score because the have no oversite of that system, They ranked 0.

Table 53: Consequence Analysis

Impacted System	Barnesville	Brookeville	Chevy Chase	Chevy Chase View	Chevy Chase Village	Chevy Chase Sec. 3	Chevy Chase Sec. 5	Gaithersburg	Garrett Park	Glen Echo	Kensington	Laytonsville	Martins Addition	North Chevy Chase	Poolesville	Rockville	Somerset	Takoma Park	Washington Grove	Impact Average
Public	4	2	2	3	3	2	2	3	4	5	2	2	2	2	5	5	2	2	3	3.2
Responders			2	5	5	2	2	3	3	4	2	2	2	2	2	3	2	2	3	2
Continuity of Operations	0	0	1	5	5	1	1	2	2	4	1	1	1	1	2	2	1	1	3	2.3
Property, facilities, and infrastructure	2	2	1	3	3	1	1	2	4	3	1	1	1	1	2	1	1	1	3	2.3
Environment	0	4	3	5	5	3	3	1	3	3	3	3	3	3	1	1	3	3	3	2.4
Economic condition of the jurisdiction	0	0	2	1	1	2	2	2	1	3	2	2	2	2	3	3	2	2	3	1.7
Public confidence in the jurisdiction's governance	0	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	0	1.6
Total	6	10	12	23	23	12	12	18	18	24	12	12	12	12	16	16	12	12	1	16

B. Implementation and Maintenance

As the roadmap to develop and implement community resilience, reduce future impacts from hazards, and protect the health, safety, and welfare of the residents in the community, implementation of the plan is critical.

1. Adoption

As with the 2013 and 2018 Plans, the 2024 planning process was overseen by the staff of the Montgomery County OEMHS. The Montgomery County Council has authorized the submission of this Plan to both the Maryland Emergency Management Agency and the Federal Emergency Management Agency for their respective reviews and subsequent approvals. And upon approval, formally adopted this Plan. Adoption by all participating jurisdiction took several months process, as the Mitigation Planning Committee required significant coordination with their governing bodies to complete the following:

- Place the plan review and adoption on the appropriate meeting agendas in each jurisdiction;
- Advertise the review process and provide copies in the County Council and local jurisdiction council members' adoption meeting packets;
- Facilitate the actual adoption;
- Collect the adoption resolutions; and
- Incorporate the adopted resolutions into the final hazard mitigation plan.

Montgomery County appreciates the willingness that both Maryland Emergency Management Agency and FEMA Region III demonstrated by reviewing this and providing comments for revision prior to the adoption process.

2. Evaluation, Monitoring, and Updating

Monitoring, evaluating, and updating this plan is necessary to maintaining visibility on effective implementation and progress, and paves the way for continued momentum while identifying future gaps. While the methodology and schedule are similar to what was outlined in the 2018 Montgomery County Hazard Mitigation Plan, additional refinements were made based on the County's experience with actually maintenance activities since the 2013 plan, and throughout the challenges of the COVID-19 pandemic.

Since the previous hazard mitigation plan was adopted in 2018, each jurisdiction has made progress toward increasing resilience in local communities, but often not documented progress in planning material. The Montgomery County Mitigation Planning Committee has been unable to meet during this last maintenance period due to the everyday requirements of their positions and the global pandemic that altered the landscape of daily life for every American.

The Montgomery County Mitigation Planning Committee, established during the 2018 Plan update, is designated to lead the plan maintenance processes of monitoring, evaluation and updating with support and representation from all participating municipalities. The Mitigation Planning Committee will coordinate maintenance efforts, but the input needed for effective periodic evaluations will come from community representatives, local emergency management coordinators and planners, the general public, and other important stakeholders. In addition, the committee will serve in an advisory capacity to the Montgomery County Council and the Montgomery County OEMHS.

Each municipality will designate a community representative to monitor implementation of mitigation activities and hazard events within their respective communities. This individual will be asked to work with the Montgomery County Mitigation Planning Committee to provide

updates on applicable mitigation actions and feedback on changing hazard vulnerabilities within their community.

In addition, the municipal monitor will be responsible for reviewing the planning and land use regulatory element of the municipality's capability assessment to identify potential opportunities for incorporating appropriate elements of this Plan into local planning mechanisms and will also identify locally generated plans, information, reports, etc.

The Mitigation Planning Committee will oversee the progress made on the implementation of action items identified and modify actions, as needed, to reflect changing conditions. The Montgomery County Mitigation Planning Committee will meet annually to evaluate the plan and discuss specific coordination efforts that may be needed with participating jurisdictions and other stakeholders. The annual evaluation may include the participation of individual municipal monitors, or at least will include reports prepared by them.

The annual evaluation of the 2023 Hazard Mitigation Plan will not only include an investigation of whether mitigation actions were completed, but also an assessment of how effective those actions were in mitigating losses. A review of the qualitative and quantitative benefits (or avoided losses) of mitigation activities will support this assessment. Results of the evaluation will then be compared to the goals and objectives established in the plan and decisions will be made regarding whether actions should be discontinued or modified in any way in light of new developments in the community. Progress will be documented by the Mitigation Planning Committee for use in the next Hazard Mitigation Plan update and submitted to the Montgomery County OEMHS. Finally, the Mitigation Planning Committee will monitor and incorporate elements of this Plan into other planning mechanisms. The annual reviews will be led by the Director of the Montgomery County OEMHS.

This Plan will be updated by the FEMA approved five-year anniversary date, as required by the Disaster Mitigation Act of 2000, or following a disaster event. Future plan updates will account for any new hazard vulnerabilities, special circumstances, or new information that becomes available. During the five-year review process, the following questions will be considered as criteria for assessing the effectiveness of the Montgomery County Hazard Mitigation Plan.

- Has the nature or magnitude of hazards affecting the County changed?
- Are there new hazards that have the potential to impact the County?
- Do the identified goals and actions address current and expected conditions?
- Have mitigation actions been implemented or completed?
- Has the implementation of identified mitigation actions resulted in expected outcomes?
- Are current resources adequate to implement the plan?

- Should additional local resources be committed to address identified hazards?

Issues that arise during monitoring and evaluation which require changes to the local hazard, risk and vulnerability summary, mitigation strategy, and other components of the plan will be incorporated during future updates.

Update process for plan prior to 5-year update. Any interested party wishing for an update of this Plan sooner than the 5-year update will submit such a request to the Montgomery County OEMHS for consideration through the Director of the Montgomery County OEMHS and Chairman of the Montgomery County Mitigation Planning Committee. The request shall be accompanied by a detailed rationale. The Montgomery County OEMHS will evaluate all such requests and determine whether the update request should be acted upon. If the decision is in the affirmative, an assignment will be made for an individual to author the update. The draft updated section along with a detailed rationale will be submitted to the Montgomery County Mitigation Planning Committee. The committee will circulate the draft updated section to every jurisdiction participating in the plan for comment and after an appropriate period of time, the committee shall make a decision to update the plan at least partially based on the feedback received from the other jurisdiction. County and municipal adoptions will then occur.

3. Plan Update and Maintenance

As was done during the development of all previous Hazard Mitigation Plans, the 2023 Montgomery County Mitigation Planning Committee will involve the public during the evaluation and update of this Plan through integration with identified workshops and meetings. The public will have access to the current Plan through their local municipal office and the Montgomery County OEMHS website. Information on upcoming events related to this Plan or solicitation for comments will be announced via newsletters, newspapers, mailings, and the County website. The public is encouraged to submit comments on the Plan at any time. The Montgomery County Mitigation Planning Committee will review and determine relevant comments to include during the next update of the hazard mitigation plan.

A. Acronyms

ADA	Americans with Disabilities Act
ARC	American Red Cross (in the National Capital Region)
CAO	Chief Administrative Officer

CE	County Executive
COG	Continuity of Government
COOP	Continuity of Operations
DHHS	Department of Health and Human Services
DHS	U.S. Department of Homeland Security
DM	Disaster Manager
DOC	Department Operations Centers
EAS	Emergency Alert System
ECC	Emergency Communications Center
EOP	Emergency Operations Plan
FEMA	Federal Emergency Management Agency
FNSS	Functional Needs Support Services
FRS	Fire and Rescue Services
GETS	Government Emergency Telecommunications
HMP	Hazard Mitigation Plan
JIC	Joint Information Center
JIS	Joint Information System
LEPC	Local Emergency Planning Council
MACC	Multiagency Coordination Center
MACS	Multiagency Coordination System
MCPD	Montgomery County Police Department
MDEM	Maryland Department of Emergency Management
MIEMAC	Maryland Intrastate Emergency Management Assistance Compact
MOU	Memoranda of Understanding
MWCOG	Metropolitan Washington Council of Governments
MWCOG	Metropolitan Washington Council of Governments
NCR	National Capital Region
NFPA	National Fire Protection Association
NOAA	National Oceanic and Atmospheric Administration
NRF	National Response Framework
NWS	National Weather Service
OEMHS	Office of Emergency Management and Homeland Security
OPI	Office of Public Information
PA	Public Assistance
PDA	Preliminary Damage Assessment
PDRP	Pre-Disaster Recovery Plan
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIO	Public Information Officer

POC	Point of Contact
PSA	Public Service Announcement
REPC	Regional Emergency Coordination Plan
SEOC	State Emergency Operations Center
SMT	Senior Management Team
SOG	Standard Operating Guidelines
THIP	Threats and Hazards Identification Process
TRI	Toxic Release Inventory
USGS	United States Geological Survey
WEA	Wireless Emergency Alerts
WMATA	Washington Metropolitan Area Transit Authority
WPS	Wireless Priority Service
WSSC	Washington Suburban Sanitary Commission

APPENDIX A: COUNTY AND MUNICIPAL RESOLUTIONS

APPENDIX B: PLANNING MEETINGS

APPENDIX C: 2023 LOCAL MITIGATION PLAN REVIEW TOOL

APPENDIX D: LOCAL JURISDICTION SURVEYS – STRATEGY AND CAPABILITY ASSESSMENTS

APPENDIX E: MITIGATION ACTIONS