2014

Baltimore County
Hazard Mitigation Plan Update

Office of Homeland Security and
Emergency Management
700 East Joppa Road
Towson, MD 21286

S&S Planning and Design
76 Baltimore Street
Cumberland, MD 21502

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CHAPTER 1: INTRODUCTION

1.1 2014 PLAN UPDATE

The 2006 Baltimore County Multi-Hazard Mitigation Plan was completed by the Department of Public Works and JMT Consulting. The Plan was adopted and approved the Federal Emergency Management Agency (FEMA). In order to maintain compliance under the Disaster Mitigation Act of 2000, the Plan must be updated every five years. To that end, Baltimore County Homeland Security and Emergency Management applied for and received hazard mitigation grant funding through the Maryland Emergency Management Agency (MEMA). The Plan Update process began in 2013 with the hiring of S&S Planning and Design consulting firm, and the formation 2013 Hazard Mitigation Planning Committee (HMPC). The HMPC consists of a cross-section of disciplines and has served as a guide during the Plan Update development process. HMPC members and their agency/department are listed on Table 1-1.

1.2 THE IMPORTANCE OF HAZARD MITIGATION

The primary goal of any hazard mitigation planning effort is to determine which means are most effective in reducing and/or eliminating loss of life and property damage caused by natural disasters. Creating and maintaining a Hazard Mitigation Plan represents a proactive approach resulting in mitigation steps to be undertaken before a disaster occurs. Hazard mitigation planning provides Baltimore County with practical knowledge and strategies, empowering citizens, first responders, and government officials to prepare for and respond to natural disasters.

1.3 PLAN REQUIREMENTS

The Disaster Mitigation Act of 2000 encourages and rewards hazard mitigation planning efforts by state and local governments. These efforts are strongly encouraged for two primary reasons. First, the goal of these plans is to prevent and/or reduce the loss of life and injury as well as limiting future damage costs by developing methods to mitigate or eliminate damage from various hazards. Second, hazard mitigation is most effective when state and local jurisdictions are participating in the process and working together. As more local municipalities become involved in the hazard mitigation planning process, the state is able to fund more effective mitigation actions, which in turn benefit local jurisdictions.

Local governments are required to create and maintain a hazard mitigation plan in order to receive federal funding for hazard mitigation projects. This requirement reinforces the importance of proactive mitigation planning and emphasizes planning for disasters before they occur. Additionally, the plan improves the County's eligibility for funding from federal and state agencies for hazard mitigation and disaster relief. This includes the Stafford Disaster Relief and Emergency Act, the Disaster Mitigation Act of 2000, the Flood Mitigation Assistance Program created under the National Flood Insurance Reform Act, the Hazard Mitigation Grant Program (HMGP), the Pre-Disaster Mitigation Grant Program, and the Maryland Comprehensive Flood Management Grant Program.

According to the Federal Emergency Management Agency, the Hazard Mitigation Grant Program provides grants to states and local governments so that they can implement long-term hazard mitigation plans. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster.

The 2013 *Hazard Mitigation Assistance Unified Guidance*, produced by FEMA, 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 in order to be eligible for grant funding under the unified Hazard Mitigation Assistance (HMA) programs.

In keeping with the Disaster Mitigation Act, hazard mitigation plans are required to be updated every five years from the date of their initial FEMA approval. As such, Baltimore County has updated their *2006 Multi-Hazard Mitigation Plan* with the *2014 Baltimore County Hazard Mitigation Plan Update*. Regular plan updates allow for the determination of program and project effectiveness and ensures the plan utilizes the most up-to- date data available.

Plan Update

The local jurisdiction is required by 44 CFR §201.6(d)(3) to review and revise its plan, and resubmit it for approval within 5 years in order to continue to be eligible for mitigation project grant funding.

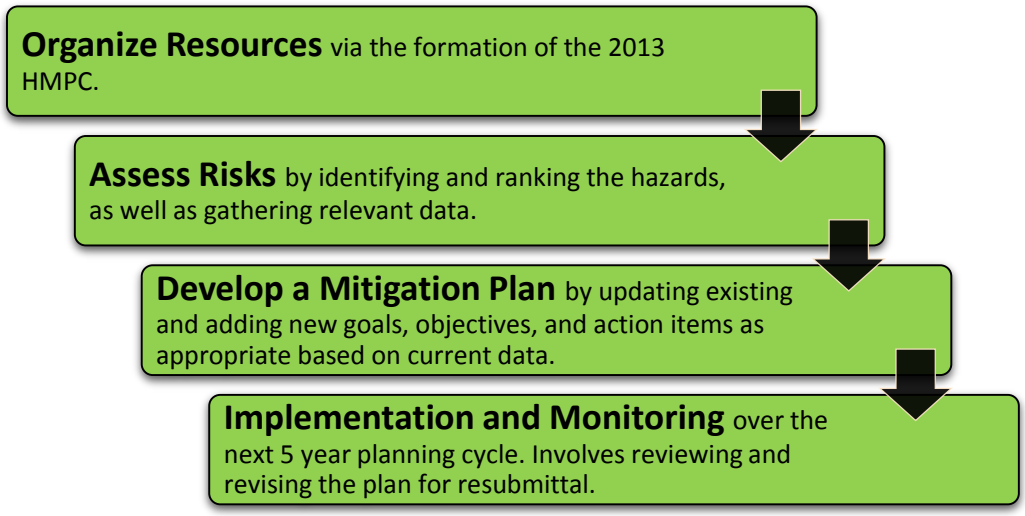
1.4 PLAN ORGANIZATION

The 2014 Hazard Mitigation Plan Update is primarily driven by all-inclusive hazard specific chapters. Each chapter begins with an introductory paragraph explaining how the chapter has been updated from the 2006 Plan. Then, a profile of the hazard is provided, focusing on answering the question, "How is this hazard a threat to Baltimore County?" Factors that create risk for each hazard are then explained, followed by a history of major hazard events within the county. Using the most recent and available data, each chapter contains a vulnerability assessment tailored for that hazard. When possible, these assessments include mapping products. Appropriate chapters, Flood, Coastal Storm and Flooding, Earthquake, and High Winds will include a HAZUS Level 2 Analysis (explained in *1.5.3 Vulnerability Assessment*). Finally, each chapter ends with a section regarding current mitigation activities and a section regarding future goals, their objectives, and actions items utilized to complete said goals and objectives. In some cases, larger datasets and results of vulnerability assessments are included in appendices, rather than in the parent chapter. However, it is the goal of the Plan Update to keep the majority of hazard-specific information within its related chapter.

1.5 PLANNING PROCESS

The requirements of a local hazard mitigation plan include: (1) inventorying critical facilities and other at-risk structures, (2) conducting risk assessments for the identified hazards, (3) providing mitigation strategies for high risk hazards, (4) preparing a method to maintain and update the Plan, and (5) ensuring public involvement throughout the process.

In order to meet these requirements, the Baltimore County Hazard Mitigation Plan Update process followed these four basic steps:



1.5.1 Organizing Resources

Baltimore County's first step in the Plan Update process was the creation of a Hazard Mitigation Planning Committee in June of 2013. The HMPC was composed of representatives from various county agencies, including the Fire Department, Budget Office, Department of Planning, Department of Public Works, Permits, Preservation Services, and the Office of Homeland Security and Emergency Management. Additionally, S&S Planning and Design was contracted to provide technical support to the lead agency, the Baltimore County Office of Homeland Security and Emergency Management in the Plan Update Process. HMPC members are listed in Table 1-1, below.

Table 1-1. Hazard Mitigation Planning Committee Members

Name	Organization/Department
Karin Brown	Preservation Services
John Bryan	Permits, Approvals and Inspections
Matt Carpenter	Budget Office
Irene Debye	Baltimore County Fire Department
Francis DiPaula	Baltimore County Fire Department
Dave Green	Department of Planning
Thomas Kimbel	Baltimore County Fire Department
Rusty Lam	Department of Planning
Paul Lurz	Baltimore County Fire Department
Stephen Miller	Baltimore County Fire Department
Tom Miller	Department of Public Works
Richard Muth	Public Schools
Jay Ringgold	Baltimore County Fire Department
Kathy Suter	Baltimore County Fire Department
Dave Thomas	Department of Public Works
Jennifer Utz	Baltimore County Fire Department
Steve Welzant	Office of Homeland Security and Emergency Management

Additional resources needed to complete the Plan Update process centered on the collection of the most recently available data specific to Baltimore County. The types of data collected included GIS data, demographic data, a variety of local planning documents, and data collected from local government agencies. Data sources and methodology of data usage is included with each hazard-specific chapter.

1.5.2 Risk Assessment

The initial step in preparing new hazard mitigation strategies for Baltimore County involved the identification of various hazards and their associated risk. In 2011, the Maryland Emergency Management Agency published the *Maryland State Hazard Mitigation Plan Update,* which is designed to identify natural hazards common to the State as well as propose mitigation strategies to lessen the negative effects of major natural disasters and events. Part of this process, represented in Table 1-2, involved determining the level of risk for each hazard. The State of Maryland ranked coastal flood, flood, and winter storm as 'high' risk for Baltimore County.

Table 1-2. Maryland State Hazard Assessment for Baltimore County, 2011

Hazard	Risk
Coastal	High
Drought	Medium-high
Flood	High
Landslide	Medium-low
Thunderstorm	Medium-high
Tornado	Medium
Wildfire	Medium-high
High Winds	Medium-high
Winter Storm	High
Karst/Sinkhole	Medium-low
Earthquake	Medium-low

Hazard: a source of danger

Vulnerability: open to attack or damage

Risk: possibility of loss or injury

During the beginning phases of Baltimore County's Hazard Mitigation Plan Update, members of the HMPC were asked to perform a Risk Assessment exercise at the Kick-off Meeting in June 2013. Committee members were able to add, remove, and/or modify any of the existing hazards. The basis for these decisions came from individual expertise brought by each member of the HMPC, as well as through analysis of data tables provided at the meeting. These data tables, which consisted of major weather related events collected by the National Climatic Data Center (NCDC), provided the necessary information to determine the probability of each hazard based upon the average number of events per year. The committee chose to keep all existing hazards, add three new hazards, and modify the ratings of several hazards identified in the 2006 Plan. The three new hazards added by the HMPC include: thunderstorm, high wind, and mass power outage. Results of the risk assessment exercise, as they relate to natural hazards, are represented in Table 1-3. Similar to the State of Maryland, the Baltimore

Table 1-3. Baltimore County Hazard Assessment, 2013

Hazard	Risk
Flooding (Tidal/Coastal)	High
Drought	Medium
Flooding (Flash/Riverine)	High
Soil Movement	Medium-low
Thunderstorm*	Medium-high
Tornado	Medium
Wildfire	Medium
High Wind*	Medium
Winter Weather	Medium-high
Earthquake	Medium-low
Extreme Heat	Medium

* Indicates a new hazard added by the HMPC

County HMPC rated coastal flooding and flash flooding as 'high' risk, yet differed in their rating of winter storm, which was determined to be 'medium-high'. The State differed on their rating of drought, wildfire, and high wind, ranking them as 'medium-high' instead of 'medium'. The remaining hazards, thunderstorm, tornado, soil movement (landslide/sinkholes), and earthquake were rated the same by the State and County; medium-high, medium, medium-low, and medium-low, respectively.

Table 1-4. Technological and Man-made Hazard Assessment, 2013

Hazard	Risk
Man-made	
Epidemic	Low
Technological	
Transportation Accident	High
Hazardous Materials	High
Dam Failure	Medium
Fire & Explosion	Medium-high
Mass Power Outage*	Medium-high
** Indicates a new hazard added by the HMPC*	

The 2006 Multi-Hazard Mitigation Plan went beyond identifying only natural hazards by including technological and "man-made" hazards, which are listed in Table 1-4. While identified, the majority of these hazards, excluding dam failure, were not profiled or assessed in the 2006 Plan. These hazards were addressed at the kick-off meeting, resulting in an updated ranking of "high" for transportation accident and hazardous materials. The 2014 Plan Update profiles and discusses all of these hazards in a single chapter called "Technological and Man-made Hazards."

The Mid-Point Meeting took place on November 6th and provided the HMPC members an opportunity to review the Hazard Identification and Ranking results. The Meeting also allowed the HMPC to identify goals and objectives for county-wide mitigation efforts. These goals and objectives represent the County and communities' vision for disaster resistance. The HMPC was asked to provide status updates for each 2006 mitigation action. The 2013 HAZUS Level 2 Analysis was distributed and discussed at this meeting. The HAZUS Analysis, discussed in more detail in the next section, *1.5.3 Vulnerability Assessment*, includes flood (riverine/coastal), earthquake, and hurricane wind. These hazards have an identifiable impact area that can be mapped and assessed for various vulnerabilities.

1.5.3 Vulnerability Assessment

A vulnerability assessment works to model and estimate potential damages to populations and property during a storm event. Each hazard-specific chapter in the 2014 Plan Update includes a vulnerability assessment which gathers available data relevant to each hazard in order to provide reasonable estimates of expected damages during a storm event.

Each assessment first identifies and briefly discusses those areas, populations, and/or infrastructure that are especially vulnerable to the hazard. Then, the 'Data Utilization' section lists the data, and their sources, utilized to perform the assessment. Assessments typically include affected infrastructure, such as buildings, roadways, and bridges, as well as impacts to critical facilities, land uses, transportation networks, future development, hazardous material storage facilities, and vulnerable populations.

Specific hazards for the 2014 Plan Update, flood, coastal storm and flooding, earthquake, and high winds, utilized a HAZUS Level 2 Analysis. Results of this type of analysis include essential facility

and general building stock damages, debris generation, shelter requirements, and associated economic losses. This level of analysis is more accurate than a Level 1 Analysis because the data used for the analysis is derived from user-supplied sources as well as data available in the Hazus database. According to the FEMA website:

> "Hazus is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes. Hazus uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters. It graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane, and floods."

1.5.4 Mitigation Strategies

Existing goals, objectives, and action items were updated during the November 6, 2013 Midpoint Meeting. Overall goals and objectives are located in *Chapter 3: Overall Hazard Mitigation Goals, Objectives, and Action Items,* while hazard-specific goals and objectives are located at the end of each hazard-specific chapter.

The Final Meeting was held on February 19, 2014. Utilizing an action item matrix, HMPC members were asked to review hazard-specific mitigation action items and prioritize them as being of high, medium, or low importance. Recommended projects, agencies responsible for their implementation, and project timelines were determined based on this prioritization. These high-priority action items and their associated mitigation projects are included in *Chapter 15: Hazard Mitigation Strategies*. Additionally, highlights from the Plan Update were presented at the meeting. Highlights focused on new chapters, new sections added to existing chapters, important findings and results, and relevant handouts.

1.6 PLAN MAINTENANCE

1.6.1 Implementation and Monitoring

The Baltimore County Office of Homeland Security and Emergency Management will implement the Plan and continue to perform periodic reviews and revisions to the Plan through on-going Hazard Mitigation Planning Committee meetings. The Committee will be entrusted with the responsibility to meet, at a minimum, annually to review the Plan and also hold public meetings to solicit citizen input.

1.6.2 Public Involvement and Plan Adoption

The Disaster Mitigation Act of 2000 requires that local Hazard Mitigation Plans and any updates be formally adopted by the County Council following review by MEMA and FEMA. The Plan and any Plan Updates are subject to a public hearing prior to adoption by the Council.

Public meetings were held on ___ for the 2014 Hazard Mitigation Plan Update.

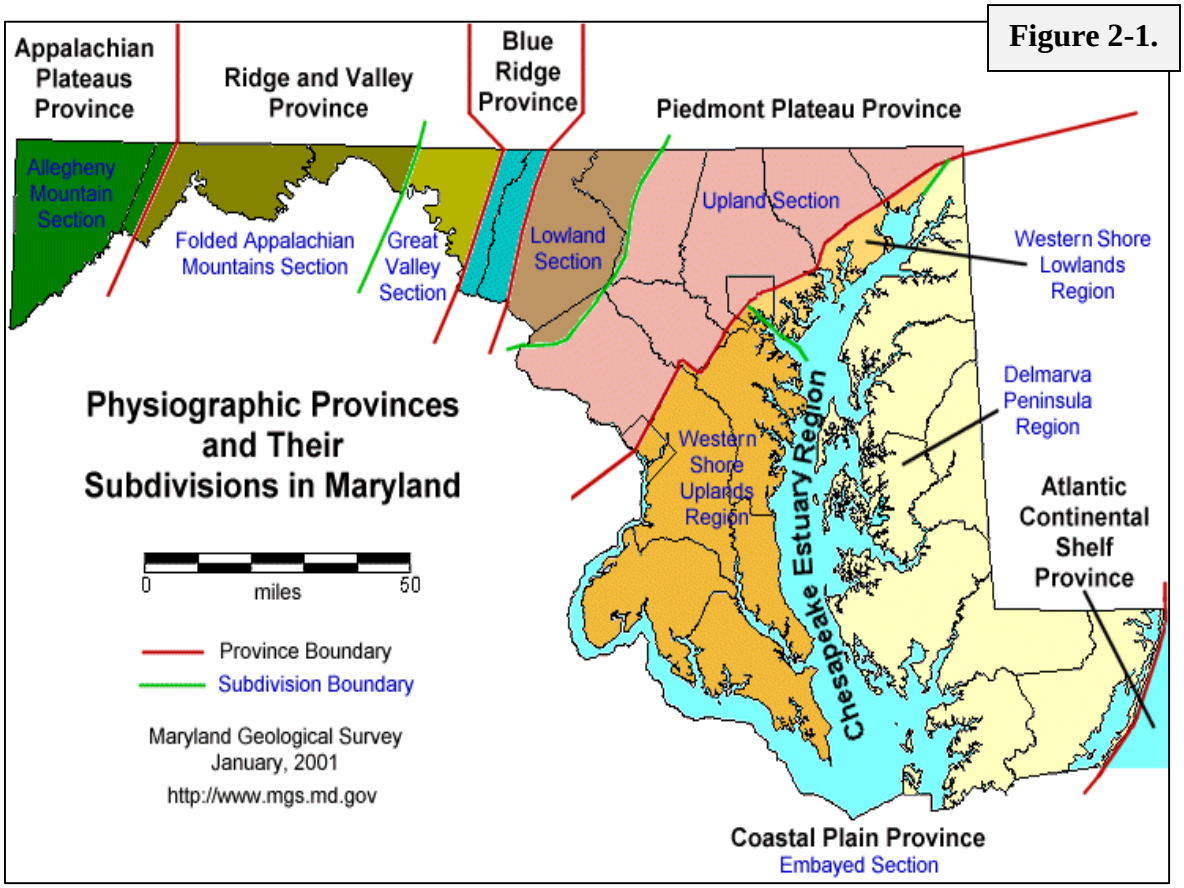
CHAPTER 2: COUNTY PROFILE

2.1 GEOGRAPHY AND THE ENVIRONMENT

Baltimore County is located in Central Maryland, bordering York County, Pennsylvania to the north, Harford County, MD to the east, the Chesapeake Bay to the southeast, Anne Arundel County to the south, Howard County to the southwest and Carroll County, MD to the west. Baltimore County also surrounds the City of Baltimore and its harbors but are entirely separate political units. Map 2-1, on the following page, provides a visual overview of the region.

The County's geography, depicted in Figure 2-1, below, is characterized by the Atlantic Coastal Plain and the Piedmont Plateau Province. The Atlantic Coastal Plain, stretching from New Jersey to Florida, around the Gulf of Mexico, south to Mexico and to the Yucatan Peninsula, is located in the southeastern portion of the County and is flat and low rising to around 400 feet. The Piedmont runs from New Jersey, southwest, to Alabama and is marked by low rolling landscapes and fertile valleys.[1] The County's elevation runs from sea level at the Chesapeake Bay to 966 feet at Middletown Road on the Mason-Dixon Line near Stiltz, PA.[2] On average, elevations in the County range from 200 to 700 feet.[3]

Figure 2-1.



Map 2-1. Regional Map

2.1.1 Water Resources

The County includes more than 2,100 miles of streams and rivers. About 46 percent of the land area drains to three reservoirs: Loch Raven, Prettyboy and Liberty. Loch Raven and Prettyboy Reservoirs are located within the County, while Liberty reservoir is located on the western boundary with Carroll County. These three reservoirs are owned and managed by the City of Baltimore as the drinking water source for over 1.8 million citizens in the metropolitan region, including the City, about 90 percent of Baltimore County, and small portions of three other counties.[4]

Baltimore County's streams and rivers ultimately drain to the Chesapeake Bay, the nation's largest estuary, where salt water from the ocean meets fresh water from the rivers.[5] The County has approximately 175 miles of shoreline along the Patapsco, Back, Middle, and Gunpowder Rivers and other smaller creeks which are sub-estuaries of the Bay.[6] Those streams along the coastal plain are tidal estuaries. The streams of the Piedmont Plateau portion of the county are rapidly flowing, fluctuating streams. The principal Piedmont streams are the Gunpowder River and its branches, Stemmers Run, Herring Run, Jones Falls, Gwynns Falls, and the Patapsco River. All are part of the Chesapeake Bay drainage system and reach the Bay through the broad estuaries of the Gunpowder, Middle, Back, and Patapsco Rivers.[7]

2.1.2 Climate

Baltimore County lies in a region about midway between the rigorous climates of the North and the mild climates of the South, and adjacent to the modifying influences of the Chesapeake Bay and Atlantic Ocean to the east and the Appalachian Mountains to the west. Since this region is near the average path of the low-pressure systems which move across the country, changes in wind direction are frequent and contribute to the changeable character of the weather. The net effect of the mountains to the west and the bay and ocean to the east is to produce a more equable climate compared with other continental locations inland at the same Latitude. Table 2-1 depicts annual precipitation and temperature averages for Baltimore County.

Table 2-1. Annual Averages

- Precipitation: 51.5”
- Snowfall: 23.8”
- Summer Temp: 75.2 F
- Winter Temp: 35.7 F
- Freeze-Free Period: 191 days

Note: Temperature and precipitation data based on 30 year averages. National Oceanic and Atmospheric Administration; Maryland State Office of Climatology.

Rainfall distribution throughout the year is rather uniform, however the greatest intensities are confined to the summer and early fall months. The average date for the last occurrence in spring of temperatures as low as 32 degrees is mid-April. The average date for the first occurrence in fall of temperatures as low as 32 degrees is late October. The freeze-free period is approximately 191 days. January is the coldest month, and July the warmest. Snowfall occurs on about eleven days per year on the average, however, an average of only about six days annually produces snowfalls of one inch or greater. Snow is frequently mixed with rain, sleet and ice, and snow seldom remains on the ground more than a few days. The annual prevailing wind direction is from the west. Winter and spring months have the highest average wind speed.[8]

2.1.3 Geology: Minerals and Soils

Baltimore County is part of two distinct physiographic provinces: the Coastal Plain Province and the Piedmont Plateau Province. The Coastal Plain Province is underlain by a wedge of unconsolidated sediments including gravel, sand, silt and clay, which overlaps the rocks of the Eastern Piedmont along an irregular line of contact known as the Fall Zone. The sediments of the Coastal Plain dip eastward at a low angle, generally less than one degree, and range in age from Triassic to Quaternary. Mineral resources of the Coastal Plain are chiefly sand and gravel, and are used as aggregate materials by the construction industry. Clay for brick and other ceramic uses is also important.

Small deposits of iron ore are of historical interest. Plentiful supplies of ground water are available from a number of aquifers throughout much of this region. The Piedmont Plateau Province is composed of hard, crystalline igneous and metamorphic rocks and extends from the inner edge of the Coastal Plain westward. Bedrock in the eastern part of the Piedmont consists of schist, gneiss, gabbro, and other highly metamorphosed sedimentary and igneous rocks of probable volcanic origin. In several places these rocks have been intruded by granitic plutons and pegmatites. Deep drilling has revealed that similar metamorphic and igneous rocks underlie the sedimentary rocks of the Coastal Plain. Several domal uplifts of Precambrian gneiss mantled with quartzite, marble, and schist are present in Baltimore County and in parts of adjacent counties. Differential erosion of these contrasting rock types has produced a distinctive topography in this part of the Piedmont.

The Piedmont Plateau Province contains a variety of mineral resources. Formerly, building stone, slate, and small deposits of nonmetallic minerals, base-metal sulfides, gold, chromite, and iron ore were mined. Currently, crushed stone is important for aggregate, cement, and lime. Small to moderate supplies of ground water are available throughout the region, but favorable geological conditions locally may provide larger amounts.[9]

2.2 DEMOGRAPHIC TRENDS AND CHARACTERISTICS

The basic demographics of Baltimore County has changed from predominantly rural to an urban-rural mix. According to the 2010 Census, about 90% of the County's population lives within the Urban Rural Demarcation Line (URDL) while the remaining 10% resides in the rural areas. According to the 2010 Census, Baltimore County's population is 805,029. The County's population has been growing significantly since 1950 (population of 270,273), increasing by 534,756 in 60 years.

Within Baltimore County, the 2010 Census designated places with the greatest populations are: Dundalk, Towson, Catonsville, Essex, Woodlawn, Parkville, Randallstown, Pikesville, and Carney. New population growth in Baltimore County is being directed toward two areas – Perry Hall-White Marsh and Owings Mills, which are the county's designated growth areas. Both of these town centers are adjacent to major transportation networks and regional shopping centers.[10]

The increased amount of people living in Baltimore County creates more community exposure and changes how agencies prepare for and respond to hazards. Furthermore, increased density can affect risk. For example, narrow, congested streets are more difficult for emergency service

vehicles to navigate, a higher ratio of residents to emergency responders affects response times, and homes located closer together increase the chances of fires spreading.[11]

As the County continues to experience population growth, other aspects of population, such as age structure (Table 2-2), racial composition, household and family type, employment status, and income level are changing. The median age of the population continued to grow from 28.9 in 1970 to 38.8 in 2008. This represents a growing number in the elderly 65 years old or over, which increased its percent share in the County's total population from 7.4 percent in 1970 to 14.4 percent in 2008. The percent share of the County's senior residents is projected to be 17 percent in 2020.[12] According to the 2010 Census, population distribution according to age shows 27.2% of the population is aged 55 or older. Persons below the age of 18 make up 22% of the total population.

Table 2-2. Age Structure in Baltimore County, 2010

Age Group	Total	Percent
Under 5 years	48,074	6.0
5 to 9 years	47,454	5.9
10 to 14 years	49,231	6.1
15 to 19 years	56,294	7.0
20 to 24 years	57,772	7.2
25 to 29 years	53,864	6.7
30 to 34 years	49,691	6.2
35 to 39 years	49,448	6.1
40 to 44 years	53,396	6.6
45 to 49 years	59,590	7.4
50 to 54 years	61,626	7.7
55 to 59 years	54,414	6.8
60 to 64 years	46,699	5.8
65 to 69 years	32,328	4.0
70 to 74 years	24,142	3.0
75 to 79 years	20,927	2.6
80 to 84 years	19,398	2.4
85 years and over	20,681	2.6
Total population	805,029	100.0

Source: 2010 U.S. Census

Along with its population increase, Baltimore County has undergone a change in racial composition, which is depicted in Table 2-3. According to the 2010 Census, approximately 65% of the County's population is White compared to 96.5% in 1970. Approximately 26% of the minority population is African-American with the remaining 9% primarily comprised of Hispanic and Asian populations. Specifically, the largest Hispanic populations are located in Cockeysville, Reisterstown-Owings Mills, Catonsville-west of Rolling Road, east Lansdowne, and Perry Hall-north of White Marsh Boulevard. The largest Asian populations are located in Cockeysville-Timonium, Carney, Perry Hall-north of White Marsh Boulevard, Catonsville-west of Rolling Road, and Catonsville-Arbutus near University of Maryland Baltimore County. This ethnic diversity suggests a need to address multi-cultural needs and services.

Table 2-3. Racial Composition in Baltimore County, 2010

Race/Ethnicity	Total	Percent
White	520,185	64.6
Black or African American	209,738	26.1
American Indian and Alaska Native	2,625	0.3
Asian	40,077	5.0
Asian Indian	10,549	1.3
Chinese	6,761	0.8
Filipino	7,280	0.9
Japanese	624	0.1
Korean	5,339	0.7
Vietnamese	2,132	0.3
Other Asian	7,392	0.9
Native Hawaiian and Other Pacific Islander	319	0.0
Native Hawaiian	69	0.0
Guamanian or Chamorro	114	0.0

Race/Ethnicity	Total	Percent
Samoan	33	0.0
Other Pacific Islander	103	0.0
Hispanic or Latino (of any race)	33,735	4.2
Mexican	7,461	0.9
Puerto Rican	5,523	0.7
Cuban	1,017	0.1
Other Hispanic or Latino	19,734	2.5
Some Other Race	12,801	1.6
Two or More Races	19,284	2.4
Total population	805,029	100.0

Source: 2010 U.S. Census

Population and demographic characteristics are a critical component to preparing and responding to hazard events. Items to be considered include:

- Multi-cultural needs and services – Communication and cultural norm (belief) are critical to preparing and responding to a hazard event, including the ability to communicate with non-English speaking individuals and communities;
- Vulnerable populations – Vulnerable populations include seniors, disabled citizens, children and low-income households;
- Involvement of citizen groups – Citizen groups include: neighborhood watch programs and other local community groups, non-profit and religious groups who assist with recovery efforts;
- Mass Care Shelters – Should be accessible to vulnerable and special needs populations and be able to accommodate large populations in the event of a hazard event;
- Insurance Companies – Insurance companies should prioritize the education of their staff relevant to policies covering hazard events. This education will allow insurance agents to better explain and answer questions about specific policy issues with citizens and business owners.

2.3 LAND AND DEVELOPMENT

Central to the way that the County has developed is the concept of delineating two distinct land management areas – the urban area and the rural area. This concept manages growth in a manner that preserves important natural and agricultural resources and maximizes the efficiency of County revenues spent on transportation improvements, utilities, and other capital projects. In 1967, Baltimore County took the first significant step toward creating a sustainable policy framework for growth and development when it established an urban growth boundary, the Urban Rural Demarcation Line (URDL). The URDL divides the County into urban and rural land management areas. The division allows infrastructure investments and most land development to be focused in the urban areas, while natural and agricultural resources in the rural areas are preserved. Subsequently, Resource Conservation (RC) zones were adopted to restrict the number, configuration, size and location of new building lots in order to preserve agriculture and protect natural resources, while permitting limited growth. The protection of agriculture has been a key component of the rural growth management of the County for over 40 years.[13]

2.3.1 Master Plan Land-Use Visions

Baltimore County Comprehensive Plan, 1975 & Baltimore County Master Plan, 1980

These Plans reorganized land use and development planning into a comprehensive growth management program, creating the current land use framework. These plans modified the County's land use policy to reduce inefficient low density suburban development and establish urban and rural zoning. Two growth areas – Owings Mills and Perry Hall-White Marsh – were created. Future development was to be directed in these areas, preserving agriculture and watershed land in other areas of the county.[14]

Master Plan 1990

This Plan balanced County efforts between growth areas and community conservation areas in the urban areas with the philosophy of enhancing the quality of development. In the rural areas, policies reaffirmed the county's commitment to agricultural and natural resource protection, while providing some areas for low density rural residential growth.[15]

Master Plan 2000

The 2000 Plan focused on maintaining flexibility to respond to opportunities and problems as they arose. The Plan created land management areas for urban and rural portions of the county. The intent was to achieve a balanced development in designated growth and community conservation areas and preserve agricultural activities and natural resources outside the URDL.[16]

Master Plan 2010

This Plan recognized the interdependence of traditional land use issues with nontraditional master plan topics such as education, public safety, social services, economic development, and community stewardship. Master Plan 2010 recognized that Baltimore County's sustained prosperity will require continued significant reinvestment in its urban areas. Buildings, facilities, and infrastructure in most of the communities adjacent to the Baltimore County-Baltimore City Line are 50 years old. The infrastructure is reaching the end of its life expectancy and is in need of repair and replacement.[17]

Master Plan 2020

This latest Plan seeks to continue the success of growth management, improve the built environment, and strengthen resource conservation and protection within Baltimore County. The plan will build on the successful concepts and strategies of previous plans, and will strengthen these long-term goals using a framework of sustainability. The present and future needs of citizens within Baltimore County with respect to the economy, community, and the environment will be protected and enhanced by actions proposed in this plan, with the intention of achieving a sustainable community.[18]

2.3.2 Growth Areas

Baltimore County has more than a twenty-year history of implementing multiple smart growth principles. As the size and amount of undeveloped land parcels within the URDL diminishes, the redevelopment of ailing or underused property at greater density and with a mix of land uses provides significant environmental and economic benefits.[19] Owings Mills is the designated growth area within the County. This location is targeted as a self-sustaining planned community with employment-intensive business and residential development. It is a preferred location for industrial and office development with established, concentrated retail areas. At its fullest development potential, Owings Mills would be home to 44,000 residents and provide jobs for approximately 32,000 employees.

In addition to existing growth areas, Master Plan 2020 proposes the Middle River Redevelopment Area. The proposed Middle River Redevelopment Area is currently employment-oriented with some residential development. It is among the largest employment centers in the Baltimore region and presents great potential for future growth. This area is diverse in land use and has been divided into nine sub-areas.[20]

Directing land development in the County's employment centers includes preserving industrially zoned land for future growth in employment. The County's employment centers include the Southwest Industrial Corridor, UMBC, Woodlawn–Security, Hunt Valley-Timonium, Loveton, Towson/Loch Raven, Middle River, Philadelphia-Pulaski, North Point, and White Marsh. The urban center of Towson has the County's largest concentration of diverse uses including office and retail businesses, government facilities, nonprofit institutions, and restaurants. The future of Towson is focused on maintaining and improving upon the economic vitality of businesses, providing open space, and continuing the viability of residential neighborhoods. The area encompassing GBMC, Towson University, St. Joseph's Hospital, and Sheppard Pratt Health System are being evaluated for growth opportunities.

2.3.3 Waterfront Development

The County's waterfront has a variety of residential, industrial, and protected land uses. It has been the County's policy to limit growth and control density along the waterfront in an effort to protect water quality and biological integrity. It is also the County's policy to ensure that any surplus sewerage capacity that may exist is not used to support unplanned growth along the waterfront. Areas along the Bird River are targeted as agricultural preservation areas and surplus property owned by Lockheed-Martin at Dark Head Creek is being studied for the development of a commercial waterfront destination. The underused and abandoned industrial land along the waterfront is also targeted for redevelopment to support port-related uses.

2.3.4 Critical Areas Act

The Chesapeake Bay Critical Areas law helps to protect water quality and sensitive waterfront areas by regulating development within 1000 feet of tidal water. The County, as part of the State of Maryland's commitment to save the Chesapeake Bay from further environmental degradation, enforces this legislation. Although sites available for new development are limited, the Chesapeake

Bay Critical Areas regulation includes a mechanism called "growth allocation" that allows for density increases on a limited amount of Chesapeake Bay Critical Areas land. To implement growth allocation, Baltimore County has established a committee consisting of representatives from various county departments to evaluate petitions for site design excellence and environmental sensitivity.[21]

2.3.5 Rural Development

Baltimore County's rural areas continue to face development pressure. While approximately 37,000 acres of land have been preserved for agricultural use, the goal of preserving 80,000 acres by 2020 is still being threatened by traditional suburban development. Tools for directing development in rural areas of the county include agricultural preservation districts, land preservation easements, land trusts, purchase of development rights, transfer of development rights and the rural legacy program. Designated agricultural preservation areas include Caves, Upperco/Worthington/Sparks, Parkton, Monkton/White Hall, Bird River, Greenspring, Patapsco/Granite, Freeland/Maryland Line, and Long Green. It is the County's policy to preserve lands for agricultural and avoid conflicts with incompatible uses.

Areas intended as resource preservation areas for the protection of historic, cultural, recreational, and environmental resources include Patapsco/Granite, Gunpowder, Chesapeake Bay, Soldiers Delight, Prettyboy Reservoir, Liberty Reservoir and Loch Raven reservoir. The focus for these areas is limiting residential development and acquiring available land for public benefit.

The bulk of residential development in rural areas have occurred in the Freeland, Patapsco/Granite, Kingsville, Chestnut Ridge, Hereford and Jacksonville land management areas. The County continues to face challenges in limiting new residential growth and maintaining these areas' rural character. The only two designated rural commercial centers, Hereford and Jacksonville, are to remain geographically small, rural in character, and be regulated through a master plan process.

2.4 HOUSING AND COMMUNITY DEVELOPMENT

The 2010 Census indicates that the total number of housing units within the County is 335,622. Of these, 316,715 (94.4%) are occupied, and 18,907 (5.6%) are vacant. The Maryland Department of Planning (MDP) provides household projections up until 2040. The MDP predicts a positive trend in households, indicating the number of households increasing to 338,500 by 2020, and increasing to 351,900 by 2040. Household size is expected to slowly decline in the coming decades. As of 2010, the average household size was 2.48. The MDP expects this size to decrease to 2.44 by 2020, and to 2.39 by 2040.

A major component to the increasing household population in Baltimore County is due to large amounts of in-migration from residents leaving Baltimore City between 2006 and 2010; thirty-eight percent of all in-migration within the state comes from Baltimore City.[22] This shift to the suburbs is likely being driven by quality-of-life issues related to schools, taxes, and crime.

New housing will need to be constructed in order to keep pace with the expected future demand. Within the last three years (2010-2012), 2,412 housing units were authorized for construction. Of

these, 1,758 were single family units and 654 were multi-family units. This means that on average, 804 housing units are being constructed per year.

2.4.1 Community Programs

The overall objective of Baltimore County's Housing Opportunities Program is to improve housing stock and preserve neighborhoods by working with community based organizations, creating home ownership opportunities, assisting homeowners to bring their residences up to Baltimore County codes and standards, and to stimulate the development and redevelopment of high quality multi-family housing for County renters.[23]

The CDBG Grants Administration provides for the appropriation of entitlement funds awarded to Baltimore County from Federal and State housing and community development programs, such as the Community Development Block Grant (CDBG) Program, the HOME Investment Partnerships (HOME) Program, and the Stewart B. McKinney Emergency Shelter Grant (ESG) Program funded under the U.S. Department of Housing and Urban Development (HUD), and the Maryland State Department of Housing and Community Development (DHCD). These grant programs are primarily designed to benefit low and moderate-income households and individuals through various activities carried out by public agencies and non-profit organizations, such as housing rehabilitation, home ownership assistance, drug and alcohol counseling, fair housing, education and counseling services to the homeless and at-risk, capital improvements for community-based facilities and public infrastructure, and programs which benefit the disabled. Baltimore County has been designated by the U. S. Department of Housing and Urban Development as an entitlement jurisdiction for the Community Development Block Grant (CDBG) Program and the Stewart B. McKinney Emergency Shelter Grant (ESG) Program, and a participating jurisdiction for the Home Investment Partnerships (HOME) Program.[24]

2.5 EMPLOYMENT AND INDUSTRY

Table 2-4. Employment Statistics

- Number of Businesses: 21,000+
- Labor Force: 448,625
- Employment: 422,390
- Unemployment: 26,235
- Unemployment Rate: 5.8%

Source: DLLR Employment and Payroll Data, December 2013

Baltimore County has a diverse corporate presence within the region with over 21,000 businesses reported in 2012, including headquarters for companies such as Aether Systems, Black & Decker, and McCormick & Company. The business community is balanced among industry sectors, including major operations for GM Powertrain, T. Rowe Price, Lockheed Martin, BD Biosciences, Proctor & Gamble, Alpharma USPD and International Steel Group. Table 2-5 details the total employment by industry within Baltimore County.

Economic highlights of the region include:

- The Eastern business corridor includes some of the region's largest manufacturers, is accessible by interstate, rail, air, and public and private port facilities and is a revitalization area of underutilized business and industry.
- The White Marsh business community is a fast-growing area in the County, seeing more than 3.8 million square feet of businesses development in the past decade. It includes retail

and entertainment centers, clusters of financial, insurance and health care operations, light manufacturing, and technology distribution.

- The Hunt Valley corridor provides a diverse business community with a substantial number of technology companies including: bioscience, software, defense/aerospace, and high tech machinery/instrument firms.
- Owings Mills provides a core of commercial office and industrial development in one of the fastest growing communities in the County. Businesses include retail, health care, financial, and bioscience firms.
- Woodlawn is a center for federal government headquarters, government contractors and business services and offers a mix of office, flex, and manufacturing sites.

Table 2-5. Percentage of Total Employment by Industry	
Federal Government	4.4%
State Government	3.3%
Local Government	8.1%
Natural Resources & Mining	0.1%
Construction	6.0%
Manufacturing	4.8%
Trade, Transportation & Utilities	18.5%
Information	1.4%
Financial Activities	8.0%
Professional & Business Services	14.7%
Education & Health Services	18.6%
Leisure & Hospitality	8.7%
Other Services	3.2%

Source: DLLR Employment data, 2012

Mitigation activities are needed at the business level to ensure the safety and welfare of workers and limit damage to industrial infrastructure. Employees are highly mobile, commuting from a surrounding area to industrial and business centers. This creates a greater dependency on roads, communications, accessibility and emergency plans to reunite people with their families. Before a natural hazard event, large and small businesses can develop strategies to prepare for natural hazards, respond efficiently, and prevent loss of life and property.

2.6 TRANSPORTATION AND COMMUTING PATTERNS

One of the major challenges facing Baltimore County's transportation system is accommodating the increased demands placed on its radial roadway network, which no longer matches predominant commuting patterns. Land use decisions in the past have not adequately addressed growing transportation needs, and therefore permitted a considerable increase in vehicle miles traveled, consumption of green-fields, and water and air quality degradation.[25] Other roadway transportation challenges include: heavy weekday commuter traffic near Baltimore, heavy vacation traffic on the weekends, substantial truck traffic, and suburban land use patterns and sprawl nearby that tends to promote auto travel. Preventing congestion can be accomplished through a combination of highway capacity improvements, management of existing services and facilities, and implementation of Transit-Oriented Development (TOD).

Ninety percent of all travel in the county is made in private automobiles. More than 2,700 miles of state and county roads provide the infrastructure to serve the mobility needs of residents, but roadway capacity has not kept pace with demand. Roadway improvements recommended in Master Plan 2020 support growth management and land use policies by reinforcing the County's commitment to focus growth inside the URDL. Additionally, policy will seek to continue support for regional rail transit services, actively support Transit-Oriented Development, continue to plan and implement improvements to the County's physical infrastructure, assure adequate roads for rural areas, provide appropriate pedestrian facilities, and expand those facilities to meet the needs of current and future residents.[26]

2.6.1 Roadways

Baltimore City's transportation infrastructure, developed in the classic radial "star" pattern, laid the framework for the development of Baltimore County. Radial arterial highways – such as Baltimore National Pike, Liberty Road, Reistertown Road, York Road, Belair Road, and Pulaski Highway – provide radial access to the County. The Baltimore Beltway (I-695), the County's circumferential connector, is designed to carry large volumes of traffic. The arterial highways provide the spokes of the beltway wheel and allow for through trips to Baltimore City. Collector roads provide the link between the arterial network and local streets. I-83 and I-95 provide access to the north and south while I-70 provides access to the west.

Table 2-6. Major Transportation Corridors

• I-70	• I-795
• I-83	• U.S. 1
• I-95	• U.S. 40
• I-195	• U.S. 140
• I-695	• Rt. 43

2.6.2 Mass Transit

The transportation system also consists of transit services provided by the state, county, and the private sector. Transit services consist of:

- Fixed route bus service linking Baltimore County with Baltimore City;
- Express bus routes;
- Para-transit service for people with disabilities (CountyRide);
- Light rail, running from Hunt Valley through downtown Baltimore with extensions to Penn Station and BWI Airport;
- Maryland Rail Commuter (MARC), linking Baltimore City with Washington, D.C. and includes stops in Baltimore County;
- Baltimore Metro (subway-heavy rail), a 9.5-mile subway line connecting Owings Mills to Baltimore City.

2.6.3 Freight Rail

CSX Transportation (CSXT) and Norfolk Southern provide rail freight transportation service for business and industry throughout the Baltimore region and connects with systems throughout North America. Major freight facilities include the Dundalk Marine Terminal. The Maryland Midland Rail road (MMID) is a small regional railroad serving Carroll, Frederick and western Baltimore County and serves customers who need coal and other raw materials. MMID has an

interchange point with CSXT in Glyndon. The Canton Railroad serves businesses in Baltimore City's Canton area, and operates in the eastern part of Baltimore City to Eastpoint in Baltimore County. The Patapsco and Back Rivers Railroad transports raw materials to and from Sparrows Point (formerly Bethlehem Steel).

2.6.4 Truck

The County's public roads are used extensively for freight movement by the trucking industry and for access to major freight movement and industrial facilities in the region. Roadways providing internal access between port facilities include Broening Highway and Dundalk Avenue. Direct regional highway access to BWI Airport is provided from I-95 and I-695 via I-195 and MD 295. Approximately 60 motor freight common carriers serve the County.

2.6.5 Water

The County's 175 miles of shoreline provides water access for business and recreation use. Although the majority of the port facilities are located in Baltimore city, the International Steel Group complex (formerly Bethlehem Steel), Dundalk Marine Terminal, and storage warehouses are located within the County. The County's transportation infrastructure is instrumental in moving goods shipped through the port.

2.6.6 Air

Baltimore County is served by Baltimore Washington International Thurgood Marshall Airport (BWI) in neighboring Anne Arundel County, Ronald Reagan National (DCA), and Washington Dulles Airport (IAD). Martin State Airport, in Middle River, is a major facility with approximately 120,000 flight operations per year. Many area businesses use the airport for corporate travel needs. The Baltimore County marine police, Baltimore City Police, Air National Guard, Medevac, television news stations and over 200 privately owned aircraft are based at the airport. Baltimore County also has privately-owned Baltimore Air Park and Essex Skypark serving small airplanes. There are also several private airstrips serving mainly agricultural needs in the County.

[1] http://www.netstate.com/states/geography/md_geography.htm
[2] http://www.mgs.md.gov/esic/fs/fs1.html
[3] http://www.bcpl.info/community/infobank-physical-features
[4] http://water.epa.gov/type/watersheds/
[5] http://www.chesapeakebay.net/discover/bay101/facts
[6] http://water.epa.gov/type/watersheds/
[7] http://www.bcplonline.org/info/comm/
[8] http://www.baltimorecountymd.gov/Agencies/economicdev/baltimorecountybusiness/qualityoflife/baltimorecountyintroindex.html#Climate
[9] http://www.bcplonline.org/info/comm/
[10] Master Plan 2020
[11] Clackamas County, page 2-6
[12] Master Plan 2020
[13] Master Plan 2020

[14] Comprehensive Plan 1975 and Master Plan 1980
[15] Master Plan 1990
[16] Baltimore County Department of Planning
[17] Master Plan 2010
[18] Master Plan 2020
[19] Master Plan 2020
[20] Master Plan 2020
[21] Master Plan 2020
[22] The American Community Survey
[23] http://www.baltimorecountymd.gov/Agencies/neighborhoodimprovement/housing.html
[24] http://www.baltimorecountymd.gov/Agencies/neighborhoodimprovement/faq/comcdbgfaq.html
[25] Master Plan 2020
[26] Master Plan 2020

CHAPTER 3: OVERALL HAZARD MITIGATION GOALS, OBJECTIVES, AND ACTION ITEMS

3.1 HAZARD MITIGATION STRATEGIES

The purpose of hazard mitigation strategies is to reduce or eliminate long-term risk to people and property from hazards and their effects using mitigation measures that promote environmental and fiscally responsible objectives and strategies.

Mitigation strategies include goals, objectives, and action items. Goals provide a general guideline as to what Baltimore County hopes to achieve within the next planning cycle, 2014-2019. Objectives are not as broad as goals or defined as action items, but serve to provide a measureable connection between goals and action items. Action items consist of real-world steps that can be taken to fulfill the mitigation goals set by the County. The flow chart below represents this relationship.

To promote consistency with State mitigation efforts, the 2006 Plan utilized general goals and objectives provided by MEMA, which are to be used as guidelines for state and local governments. The goals and objectives detailed on the following pages provide a framework for implementing mitigation strategies in Baltimore County. Objectives and action items are based on successful mitigation projects implemented throughout the United States where those projects are aligned with the needs of Baltimore County.

The goals and objectives provided in this chapter are not always specific to a certain hazard, but general to hazard mitigation planning. Hazard specific goals and objectives are located at the end of each hazard's chapter. The 2013 HMPC provided status updates to the goals and objectives in this chapter. Those goals, objectives, and action items that were kept and/or modified by the 2013 HMPC have been included. Goals and objectives in their original form provided in the 2006 Plan are located in Appendix A.

GOAL 1: Eliminate or reduce human, environmental, social and economic loss from natural and technological hazards	
OBJECTIVE	**ACTION ITEM(S)**
1. Direct new development away from hazard areas	1. Regulate the location, type and intensity of new development in hazard areas which can include flood-zone regulations, steep slopes, and coastal erosion areas.
	2. Evaluate the Resource Conservation zones to determine if an overlay zoning district is needed that applies additional development standards for sensitive lands, such as wetlands, coastal areas and hillsides.
2. Reduce the number of repetitive loss properties	1. Assess repetitive damages.
	2. Purchase or relocate repetitive loss properties with public funds.
3. Reduce the number of properties within the 100-year riverine floodplain	1. Determine feasibility of acquiring undeveloped lands in hazard-prone areas.
	2. Place use restrictions on deeds of vacant land to prevent future residential or commercial development where appropriate.
4. Identify and protect historic structures that are at risk from hazards	1. Identify historic properties and structures within the 100-year floodplain.
	2. Develop action plan to protect or relocate identified historic structures.
5. Develop and improve upon hazard data using GIS as the technical foundation for floodplain management planning	1. Evaluate and broaden inventory of infrastructure, demographic and property statistics.
	2. Coordinate with FEMA to ensure that data created through future Flood Insurance Studies are compatible with existing systems and models.
	3. Equip emergency response vehicles with computers containing GIS data of properties in the community, including homes and businesses located in the floodplain and those with special assistance needs.
	4. Use GIS as an education and marketing tool to illustrate acquisition plans and benefits and to assist with relocation planning.
6. Facilitate accurate insurance ratings	1. Apply for the Community Rating System program. CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS. (1) reduce flood losses; (2) facilitate accurate insurance rating; and (3) promote the awareness of flood insurance.

GOAL 2: Support mitigation measures that show potential for environmental enhancement and cost-effectiveness	
OBJECTIVE	**ACTION ITEM(S)**
1. Develop a Green Infrastructure Plan that would redevelop areas as open spaces that create amenities and services to benefit the overall community	1. Identify hub areas for appropriate activities and links with connectors or greenway segments.
	2. Determine appropriate activities that include heritage tourism, passive recreation and active recreation.
	3. Utilize the most vulnerable part of the floodplain as a greenway, park or wildlife habitat.
2. Ensure adequacy of stormwater management facilities and infrastructure	1. Use structural mitigation measures and techniques as appropriate to minimize future flood damages.

OBJECTIVE	ACTION ITEM(S)
3. Ensure public water and wastewater facilities and infrastructure failure is minimized to reduce adverse impacts to communities and the environment	1. Evaluate back-up power at facilities to determine if further actions are required (many critical sites now have back-up power).
	2. Determine if submersible pumps are needed at pumping stations to ensure operation during hazard events.

GOAL 3: Promote hazard mitigation as the cornerstone of emergency management in Maryland	
OBJECTIVE	**ACTION ITEM(S)**
1. Educate the public about natural hazard risks, preparedness, and mitigation	1. Develop an outreach program to increase awareness in the community.
	2. Enroll people to help get the message out.
	3. Provide educational materials to the construction industry, homeowners, tenants, and businesses.
	4. Establish a web site that provides notices of when businesses reopen after a hazard event.
	5. Increase risk awareness and encourage adequate business insurance.
	6. Work with the real estate industry to develop hazard disclosure requirements.
	7. Hold briefings or training at disaster recovery centers after a hazard event.
2. Target owners of properties within hazard areas for outreach regarding mitigation and preparedness	1. Develop and outreach program to increase property owner participation in the National Flood Insurance Program.
	2. Create a public awareness campaign on the many benefits of floodplain preservation and restoration.
3. Develop public/private partnerships toward the protection of private properties	1. Educate business owners about losses due to natural hazards such as safety for employees and customers, reduced down-time in production, reduced damages to inventory and supplies, protected information systems, reduced damages to facilities and nonstructural components (have held numerous business continuity seminars and performed many community presentations that include points concerning emergency and continuity planning).
	2. Develop a recovery planning task force composed of community leaders, representatives of local government, and citizens to structure long-term recovery planning.
	3. Coordinate with electricity providers to develop a feasible and phased approach to putting electrical lines underground in high hazard areas. Over time, this will reduce the number of power disruptions during severe storms, high winds, winter weather events, and hurricanes/tropical storms.
4. Improve communication and coordination between County agencies	1. Form a Hazards and Emergency Management Council to promote communication and coordination between various departments with a focus on hazards and emergency related concerns. The Council should be inclusive of emergency management, emergency response, planning, information services (GIS), public works, social services and environmental resource management agencies.

CHAPTER 4: FLOOD

The update process for *Chapter 4: Flood*, as part of the Baltimore County 2014 Hazard Mitigation Plan Update, included researching and integrating the most up-to-date and available data during this planning cycle. Updates to this chapter include: new sections and narratives, new tables, figures, and maps, updates to existing sections and tables, and new formatting. As detailed in the highlighted figure, six new sections have been added, and four have been updated. Additionally, a HAZUS Level II analysis was conducted for this hazard and is included in section 4.6.

Chapter Highlights

New Sections:
4.4 National Flood Insurance Program
4.4.1 Flood Mapping
4.4.2 Community Rating System
4.6 HAZUS Level 2 Analysis
4.7 Flood Hazard Assessment - Infrastructure
4.8 2014 Mitigation Goals & Action Items

Updated Sections:
4.1, 4.2, 4.3, 4.5

4.1 HOW ARE FLOODS A THREAT TO BALTIMORE COUNTY?

As discussed in *Chapter 2: County Profile*, there are three primary factors that contribute to flooding in Baltimore County: geography, climate, and soils. Baltimore County's geographic location in the mid-Atlantic region, with its coastal presence on the Chesapeake Bay, and its inland terrain, make the County susceptible to coastal, riverine, and flash flooding.

Events such as Hurricane Isabel produced both coastal and riverine flooding. As Isabel moved inland, the storm produced more extensive flooding from storm surge and coastal still-water flooding than from riverine flooding from heavy rains. Excessive damage was witnessed in many communities along the Chesapeake Bay and coastlines on inland waterways. Many structures were destroyed as a result of the storm surge[1]. The devastation inflicted by Isabel created a renewed interest in mitigation measures to protect life and property within the County. Subsequently, the 2006 Baltimore County Hazard Mitigation Plan focused heavily on damage assessment data resulting from the event, and flood measures were undertaken.

Table 4-1. Presidential Declarations

Event	Date
Severe storms and flooding	August 17, 1971
Tropical Storm Agnes	June 23, 1972
Heavy rains and flooding	October 4, 1975
Severe storms, tornadoes and flooding	September 14, 1979
Blizzard of '96	January 11, 1996
Severe winter storm	April 10, 2000
Severe snowfall	March 14, 2003
Hurricane Isabel	September 19, 2003
Blizzard	December 19, 2009
Blizzard	January 31, 2010
Blizzard	February 5, 2010
Hurricane Irene	August 25, 2011
Tropical Storm Lee	September 2, 2011
Derecho	June 29, 2012
Hurricane Sandy	October 26, 2012

Isabel is not the only event in Baltimore County's history that has raised concern regarding the County's vulnerability to flooding. Presidential declarations have been made in past years allowing for Federal assistance to supplement State and local efforts and capabilities to save lives and to protect property and public health and safety, or to lessen or avert the threat of a catastrophe. These declarations, listed in Table 4-1 and outlined in section 4.3, are a result of severe storms, hurricane/tropical storms, and large snow events.

4.2 CONTRIBUTING FACTORS TO FLOOD RISK

4.2.1 Weather

Most flash floods are caused by intense, localized, convective thunderstorms. These storms, which are most frequent in summer, occur in late afternoon and sometimes last well into the evening. A persistent, active frontal system lingering in the area can also gradually saturate the ground with slight to moderate rainfall for several days. Then, a single, intense storm moving along the frontal system can induce floods because of the saturated ground conditions. Hurricanes and other convective tropical storms inundate large areas with intense rainfall, commonly six inches or more in less than 24 hours. Flooding can be either local and sudden, or regional and prolonged. While sometimes overlooked, rapid snow melt also contributes to flooding. According to NOAA, flooding as a result of snowmelt occurs every year in the northern U.S., but most events are relatively minor and localized. However, eight of the most significant floods of the 20th century (in terms of area affected, property damage, and deaths) were related to snowmelt.[2]

4.2.2 Development

According to the National Weather Service (NWS) flooding causes, on average, 8.17 billion in damages to communities per year.[3] In Baltimore County, the rapid growth and development since the 1950's has created highly urbanized watersheds with runoff characteristics that lead to fast-rising, dangerous riverine floodplain areas. Recognizing this risk factor, the County's development policies have prohibited construction of dwellings in the riverine floodplain area since as early as the 1955 Department of Public Works Design Manual. To address the urbanization of watersheds, the County's floodplain criteria requires the delineation of the area of hazard to be based on the design assumption of fully developed, not existing, watershed areas. In this way, the area of hazard does not increase with build-out of the developing area. Nevertheless, there remains an unavoidable area of hazard.

In the last 20 years, but especially since tropical storm Isabel, substantial residential development of a much larger scale occurred, presenting the following issues: increased impervious surface area, diminished viewsheds, reduction in public access to the water, and excessive permitting issues due to regulations that fail to consider current residential trends.

Source: Baltimore County Master Plan 2020

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. These factors affect the function and capacity of the watershed and drastically increase the risk of flooding.[4] One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard.

Land development patterns over the past several decades have emphasized sprawling suburban communities and homes constructed with little or no attention paid to protection against high winds, flooding, wildfire, or other natural hazards. Building is often permitted in high hazard areas because it satisfies an economic need or locational preference. Yet, much of this development is not sustainable in the long run. We allow some people to build in environmentally sensitive areas susceptible to natural hazards, and then we pay to help them recover when disaster strikes. This is

not sound environmental or fiscal policy. These decisions cost more because the vulnerability of these sites has never been fully examined.

4.2.3 Hydraulic Structures

Bridges over streams act as significant constrictive hydraulic structures. Even during small floods, upstream ponding occurs until floodwaters can flow through small bridge openings or over the top of high roadways. Examples include: Old Court Road Bridge over Gwynns Falls, the B&O Railroad Bridge over Herbert Run, and the downstream bridge at Interchange 33 over Stemmers Run.[5]

4.3 HISTORY OF FLOODING

Baltimore County's history of flood events primarily are the result of three weather-related conditions: tropical storms and hurricanes, snowmelt from winter weather events, and severe thunderstorms. The following are brief descriptions of some of the most significant weather events that have affected Baltimore County. Additionally, Table 4-2 provides a chronological listing of these significant storm events. During this planning cycle, three significant storm events occurred and have been included, identified on Table 4-2.

Table 4-2. Significant Tropical Storms/Hurricanes Affecting Baltimore County

- Chesapeake-Potomac, 1933
- Hazel, 1954
- Agnes, 1972
- Gloria 1985
- Bertha 1996
- Fran, 1996
- Dennis, 1999
- Floyd, 1999
- Isabel, 2003
- Irene, 2011
- Lee, 2011
- Sandy, 2012

4.3.1 Tropical Storms/Hurricanes

Sandy – October 2012

Compared to many locations in the Northeast, Baltimore County avoided disaster in terms of damage from Sandy. With the exception of flooding on the Eastern Shore that destroyed parts of the Ocean City boardwalk, and heavy snowfall in Western Maryland that shutdown I-68, most of central Maryland was left relatively unscathed. In total, about 300,000 BGE customers lost power starting on October 28; a rather light number compared to the June Derecho and Hurricane Irene, which each had about 750,000 reported power outages.[6]

Tropical Storm Lee – September 2011

On the heels of Hurricane Irene, Tropical Storm Lee set up in a north/south orientation across Maryland from Charles County into Baltimore County on September 7. Rainfall rates of 2 to 3 inches per hour occurred for several hours within this region, causing numerous high water

rescues, road closures, and flooded homes. Of note was a rain gauge in Bowie, MD, that observed 4.57 inches of rain in 3 hours, which is an amount that only has a 0.5 percent chance of occurring in a given year. Across much of the Baltimore region, the storm dumped more rain than Hurricane Irene did, but lighter winds meant that far fewer people lost electrical service. About 66,000 BGE customers lost service for a time; and almost 6,000 were still in the dark into the following morning.[7]

Irene – August 2011

Hurricane Irene tracked up the Mid-Atlantic Coast during the evening hours of August 27th through the early morning hours of the 28th. Irene passed by just to the east of Ocean City, Maryland during the early morning hours of the 28th. The minimum central pressure was 958 millibars and maximum sustained winds were 80 mph, making Irene a category one hurricane. Irene produced tropical storm conditions across portions Maryland near and east of the Interstate 95 Corridor. The worst conditions were near the Chesapeake Bay. As with most of the state, Baltimore County did not receive the amount of damage and flooding that had been predicted. However, high winds did lead to downed trees and power lines, which caused some 130,000 reported power outages throughout the county.[8]

Isabel – September 2003

Areas adjacent to the Chesapeake Bay and its tributaries were particularly hard hit, with storm surge exceeding the previous record levels set by the Chesapeake-Potomac Hurricane of 1933. In Baltimore County alone, $3 million in damage is estimated to have occurred from erosion of the shoreline. Residential areas of Millers Island, Edgemere, North Point, Bowley's Quarters and Turners Station were hard hit with more than 400 people being rescued from their homes and over 300 buildings destroyed. Marinas were also destroyed or severely damaged. Baltimore County was estimating 3189 tons of debris to be hauled from the storm. While most people had their power back in a week, some locations took up to two weeks. Many injuries and three fatalities occurred from carbon monoxide poisoning from people improperly running generators in their houses. Other injuries were related to chain saws and the clean-up of debris. Heavy rains, several days after Isabel, added to localized and flash flooding throughout the County. The State was declared a Federal Disaster Area on September 19, 2003. 4,113 Baltimore County residents have registered with the federal government for disaster relief. For the entire State of Maryland, the amount of claims reported to the National Flood Insurance program totaled approximately $122 million.

Floyd – September 1999

The highest rainfall reports ranged from 5 – 6 inches throughout the County. Across Baltimore County, 57,000 customers lost power. Winds gusted to 69 MPH at Martin State Airport, and hundreds of trees fell in Gunpowder State Park. Countywide, fallen trees damaged homes, sheds, fences, and cars, and closed 125 roads. Officials reported 6 rapid water rescues and 350 flooded basements. A 10 year old boy was swept into a storm drain and carried 300 feet in a buried pipe before fire fighters opened a manhole cover and rescued him uninjured. The impact of Floyd was compounded by the effects of Hurricane Dennis which had produced rainfall on the Atlantic coast one week prior to Floyd's arrival. This resulted in already saturated conditions in the region.

Agnes – June 1972

Agnes is a reminder that we cannot assume that the size and category of hurricane tells the whole picture. Agnes evolved from a weak Category 1 hurricane at landfall on the Gulf of Mexico, to a tropical depression as it moved eastward. Total storm damage in the United States from Agnes was estimated at just under $3.5 billion with a death toll of 122 lives. Total storm damage in Maryland and the District of Columbia was estimated at $110 million. In Maryland heavy rains in less than 24 hours resulted in severe flooding. Just west of Baltimore County, the highest total rainfall was 14.68 inches at Westminster and 13.85 inches at Woodstock. The heavy rains caused disastrous flash flooding of creeks and streams. Flooding along the Patapsco River broke all existing records, inundating the chronically flooded Ellicott City and Oella regions of Baltimore and Howard Counties with flood waters cresting almost 15 feet above Main Street in Ellicott City. The American Red Cross in Maryland reported 103 houses destroyed and 1,930 damaged, 17 farm buildings destroyed and 44 damaged, and 82 small businesses destroyed. Damage to residential, farm, and business structures was estimated at $48.5 million.[9] Damage to State roads and bridges in Maryland was estimated to be $6.5 million and to county roads and bridges, $25 million.[10] Flooding along the larger streams and rivers severely damaged or destroyed crops through erosion or silt deposition. Excessive runoff into the Chesapeake Bay decreased salinity levels and severely affected the shellfish industry.[11]

Hurricane of 1933

Prior to Agnes, this storm was the storm of record in terms of flooding. The storm caused 13 deaths statewide and $12.3 million in damages.

4.3.2 Winter Storms

"Snowmageddon" – February 2010

Baltimore County was paralyzed by back-to-back blizzard events that led to significant accumulations of snow across the region. According to NOAA, total snow accumulation by the end of February at BWI Airport was 50 inches.

Severe Winter Storm – February 2003

Baltimore set a new snowfall record with the President's Day storm (15-18, 2003). A total of 28.2 inches of snow fell making this storm the top snow storm on record.

Blizzard – January 1996

Baltimore recorded over 22 inches of snow. The entire state was paralyzed and the Federal Government remained shut down after a month-long furlough. As road crews worked to clear the snow, another storm moved through on Tuesday, January 9 dumping an additional 3 to 5 inches from Washington northeast through Baltimore. Plows that would have been working on secondary roads and residential areas were sent back to the primary roads. The government remained closed for 4 days that week and many schools and businesses announced their closure for the entire week.

A third storm struck on Friday, January 12 dumping another 4 to 6 inches over the metro areas. By the week's end approximately 3 to 4 feet of snow had fallen in the region.

4.3.3 Significant Severe Thunderstorms

Derecho – June 2012

A long-lived line of severe thunderstorms struck Baltimore County on the evening of June 29, 2012 with prolific lightening and wind gusts that exceeded 75 miles per hour. Numerous trees and limbs were knocked down onto homes, power lines, and parked vehicles. It took over a week to fully restore power to all Baltimore County residents.

Storm – August 1971

The thunderstorm of August 1-2, 1971, was one of the most damaging in the Baltimore metropolitan area during the past 50 years. A "bucket" survey indicated an unofficial rainfall total of 11 inches in less than 10 hours, with a total of 12.61 inches near White Marsh. The National Weather Service gage in Baltimore recorded 5.5 inches in 3 hours. Floods at stations along the Gunpowder and Back River basins had recurrence intervals equivalent to or in excess of 100 years. Fourteen people died as a result of the flooding. Bridge and roadway washouts were widespread. Total damage attributable to the flood was estimated at $6.5 million.[12]

Storms – July 1968

The effects of these storms killed approximately 50 people with an estimated $2 million in damages.

Storm – March 1936

This storm was significant, because it was preceded by a cold spell that formed thick ice in local rivers and streams. In addition, entire basins were covered with snow averaging 15 inches in depth. Rain and snowmelt caused by mild temperatures in early March saturated the ground and caused moderate rises in stream flow.

Great Flood of 1868

In 1868 rain fell so hard that the Patapsco River rose 5 feet in 10 minutes, killing more than 1,000 people and wiping out every mill that lined the river. According to the marker, in 1868 the waters rose to 21.5 feet.[13]

4.4 NATIONAL FLOOD INSURANCE PROGRAM

The National Flood Insurance Program (NFIP) was enacted by the Federal government in 1968 to facilitate citizens' access to affordable flood insurance and shift the burden of private property flood losses from taxpayers to floodplain property owners. The program is also designed to guide development away from flood hazard areas and requires new design and construction to be carried out in a way that minimizes or prevents flood damage.[14]

Baltimore County NFIP Policy and Claim Information (as of 10/31/2013)

Number of policies in force: 4,654
Total coverage value: $1,091,896,600
Annual premium: $5,167,225
Number of claims: 2,970
Total claim value: $64,186,927
Average claim value: $21,612

Source: bsa.nfipstat.fema.gov

4.4.1 Flood Mapping

A Flood Insurance Rate Map (FIRM), created for floodplain management insurance purposes, is an official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community. Digital versions of these maps are called DFIRMS, which are compatible with Geographic Information Systems (GIS). The improvements in spatial accuracy provided by the new base map, and the availability of electronic floodplain information should greatly enhance the ability to use the maps for planning, permitting, and insurance applications.[15]

The State of Maryland in conjunction with the Federal Emergency Management Agency (FEMA) has been systematically updating Flood Insurance Rate Maps (FIRMs) for communities over the past several years. As of December 2013, the Effective Map date for Baltimore County for riverine floodplain mapping is August 2011. For coastal floodplain mapping, the Preliminary date is November 2012, and the Targeted Effective Map date is May 2014.[16]

4.4.2 Community Rating System

The NFIP's Community Rating System (CRS) is a voluntary incentive program that recognizes communities for implementing floodplain management practices that exceed the Federal minimum requirements of the NFIP to provide protection from flooding.

In exchange for a community's proactive efforts to reduce flood risk, policyholders can receive reduced flood insurance premiums for buildings in the community. These reduced premiums reflect the reduced flood risk resulting from community efforts toward achieving the three CRS goals:

1. Reduce flood damage to insurable property;
2. Strengthen and support the insurance aspects of the NFIP;
3. Encourage a comprehensive approach to floodplain management.

Participation in the Community Rating System (CRS) is voluntary. By participating, communities earn credit points that determine classifications. There are 10 CRS Classes: Class 1 requires the most credit points and provides the largest flood insurance premium reduction (45 percent), while

Class 10 means the community does not participate in the CRS or has not earned the minimum required credit points, and residents receive no premium reduction. The CRS Classes are based on completion of 19 creditable activities organized into 4 categories:

1. Public Information
2. Mapping and Regulations
3. Flood Damage Reduction
4. Warning and Response

Baltimore County's 5-year CRS Forecast

The County's five year CRS plan is an aggressive effort to continue to update codes, inspections, and record keeping in order to stay up to date on the County's floodplain management program.

Flood Plain Regulations found in the Baltimore County Code ARTICLE 32, TITLE 8 Floodplain Management, as well as the Baltimore County Building Code Bill 40-12 usually meet or exceed FEMA requirements as well as the Insurance Services Office who perform the CRS survey.

The County received their Community Assistance Visit (CAV) in September of 2013. Recommendations once received will be reviewed to be incorporated into the 2015 Baltimore County Building Code based on the proposed 2015 edition of the International Building Code with local amendments.

4.5 REPETITIVE LOSS PROPERTIES

Repetitive loss properties are the biggest drain on this country's Flood Insurance Fund. According to the NFIP, a property is considered a repetitive loss property when there are two or more losses reported and $1,000 or more was paid on each loss. The two losses must be within ten years of each other and be at least ten days apart; only losses proceeding January 1, 1978 are considered. Additionally, a property may be considered a 'severe repetitive loss property' if it meets the following criteria:

- Has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or
- For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.
- For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.

As of July 31, 2013, Baltimore County has 121 residential repetitive loss properties; 27 of which are non-residential (Table 4-4, following page). Of these, two are severe repetitive loss properties. The top five communities with the greatest amount of repetitive loss properties are listed in Table 4-3, below.

Table 4-3. Communities With the Greatest Amount of RLP in the County

Community	# of Properties	% of total RLP (out of 121)
Middle River	33	27%
Sparrows Point	22	18%
Cockeysville	19	16%
Dundalk	13	11%
Pikesville	6	5%
Total:	**93**	**77%**

Table 4-4. Repetitive Loss Properties			
Street Name	Community	Street Name	Community
4th St	Sparrows Point	Mcshane Way	Dundalk
8th St	Sparrows Point	(2) Middle River Ave	Middle River
(2) 9th st	Sparrows Point	Milford Mill Rd	Pikesville
(2) Alt Rd	Cockeysville	Nannette Ln	Middle River
Anita Rd	Pikesville	New Section Rd	Middle River
Annapolis Rd	Halethorpe	Northview Rd	Dundalk
(3) Bay Dr	Middle River	Oakdene Rd	Middle River
(2) Bayside Rd	Essex	Off Of Cockeysville Rd	Cockeysville
Beach Dr	Middle River	Old Court Rd	Pikesville
Beach Rd	Middle River	Philadelphia Rd	Rosedale
(6) Beaver Run Ln	Cockeysville	Pinecrest Ave	Rosedale
(2) Beech Dr	Middle River	Poplar Rd	Essex
Bird River Grove Rd	White Marsh	(2) Pulaski Hwy	Rosedale
Blue Mount Rd	Monkton	(2) Railroad Ave	Lutherville
Boxwood Ln	Cockeysville	Red Rose Farm Rd	Middle River
Briar Pt Rd	Middle River	Reisterstown Rd	Owings Mills
Bullneck Rd	Dundalk	Ridgeway Rd	Catonsville
(2) Burke Rd	Middle River	(11) River Drive Rd	Sparrows Point
(2) Chapelwood Ln	Lutherville	River Drive Rd*	Sparrows Point
Chatsworth Ave	Glyndon	(2) Sandy Plains Rd	Dundalk
Chesapeake Ave	Sparrows Point	Schaadts Rd	Middle River
Chestnut Rd	Middle River	Scotts Level Rd	Pikesville
Circle Rd	Towson	Searles Rd	Dundalk
(2) Clarks Point Rd	Middle River	Shore Rd	Middle River
(2) Cold Spring Rd	Middle River	Sudvale Rd	Pikesville
Cornwall Rd	Dundalk	Sw Corner Falls & Old Court	Pikesville
Cove Rd	Dundalk	Thruway	Dundalk
Cuckold Point Rd	Sparrows Point	Township Dr	Owings Mills
Dennis Ave	Towson	Transverse Ave	Middle River
Dogwood Rd	Woodlawn	Veneer Ln C	Cockeysville
Dundalk Ave	Dundalk	Watersedge Rd	Dundalk
Edmondson Ave	Catonsville	Williamson Ln	Cockeysville
Ella Ave	Sparrows Point	Willow Spring Rd	Dundalk
Fairgreen Rd	Dundalk	(2) Wilson Point Rd	Middle River
Falls Rd	Mount Washington	Windsor Rd	Parkville
Falls Rd	Roland Park	(6) York Rd	Cockeysville
Falls Rd*	Monkton		
(2) Frog Mortar Rd	Middle River		
(2) Galloway Rd	Middle River		
Gambrill Rd	White Marsh		
Glenwood Rd	Middle River		
Grace Rd	Sparrows Point		
Greenbank Rd	Middle River		
(2) Hinton Ave	Sparrows Point		
Home Rd	Sparks Glencoe		
Ivy Hill Rd	Cockeysville		
Kingston Rd	Middle River		

Note: (#) Indicates number of RLP on street.
* Indicates a Severe Repetitive Loss Property

4.6 HAZUS Level 2 FLOOD Analysis – 2013

4.6.1 Plan Update

As part of the 2014 Plan Update, a HAZUS Level 2 Analysis was conducted for *Chapter 4 Flood*. Results of this type of analysis include essential facility and general building stock damages, debris generation, shelter requirements, and associated economic losses. This level of analysis is more accurate than a Level 1 Analysis because the data used for the analysis is derived from user-supplied sources, including best-available data specific to Baltimore County, as well as data available in the Hazus database. Examples of user-supplied data utilized for this analysis include:

Table 4-5. HAZUS Default Data v. County Data

Critical Facility Type	HAZUS Default Data (utilized in HAZUS Level 1 Analyses)	County Data Utilized for HAZUS Level 2 Analysis
Fire stations/EMS	16	65
Police Stations	10	20
Schools	132	375
Medical Facilities	0	25
EOC	1	1

- Building stories
- Year built
- Structure value
- Square Footage

U.S. Census Bureau Data Utilization

The HAZUS analysis conducted during the 2014 Plan Update utilized the most recent version of the software (version 2.1), which was released in October of 2013. At the time of this HAZUS Level 2 Analysis for Flood, FEMA had not yet integrated 2010 Census data into the Hazus version 2.1 software. This data will be made available with the next release. As such, household numbers and other demographic data has been increased by 5.6% to better represent the total number of households (316,716) in Baltimore County per the 2010 U.S. Census. This percentage increase was derived by determining the percent change in demographic data from 2000 to 2010. For example, the total number of households in Baltimore County has changed from 299,000 in 2000 to 316,715 in 2010, which represents an increase of 17,715 households. This change was calculated as a percentage (5.6%) and related household values were increased by this amount where necessary (see Table 10-6). In the case of population estimates, a 6.3% change was calculated and added to necessary population values.

4.6.2 Introduction

The HAZUS Flood Model analyzes both riverine and coastal flood hazards. Flood hazard is defined by a relationship between depth of flooding and the annual chance of inundation to that

depth. Depth, duration and velocity of water in the floodplain are the primary factors contributing to flood losses. The flood model does not estimate the losses due to high velocity flash floods at this time.

Note: The full report of the HAZUS Level 2 Analysis for Flood is included in Appendix B.

4.6.3 County Overview

Baltimore County is roughly 599 square miles and contains 7,879 census blocks. The region contains 316,715 households and has a total population of 805,029 people (2010 Census Bureau data). There are an estimated 269,655 buildings in the region with a total building replacement value (excluding contents) of 59,023 million dollars (2006 dollars). Approximately 93% of the buildings (and 76% of the building value) are associated with residential housing.

HAZUS Riverine Flood Parameters

Study Region: Baltimore County
Scenario: 100-year flood
Return Period Analyzed: 100

Table 4-4, below, provides building exposure values by occupancy type for the 100-year flood event scenario. The information contained in this table represents only building stock that was determined by HAZUS to have been affected ("exposed") by the 100-year flood event.

Table 4-6. Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	8,411,234	72.0%
Commercial	2,307,332	19.7%
Industrial	612,170	5.2%
Agricultural	49,407	0.4%
Religion	175,977	1.5%
Government	49,140	0.4%
Education	79,043	0.7%
Total	**11,684,303**	**100.00%**

Note: Dollar exposure values are produced from the square footage values derived from U.S. Census data, Maryland Property View, and Dun & Bradstreet, by applying the RS Means replacement values for typical building square foot factors and construction for each occupancy type.

Critical Facility Inventory

Critical facilities were broken down into two groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations,

police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants, and hazardous material sites.

For essential facilities, there are 25 hospitals in the region with a total bed capacity of 1,800 beds. There are 375 schools, 65 fire stations, 20 police stations and 1 emergency operation center.

4.6.4 Damage Estimates

General Building Stock Damage

Hazus estimates that about 1,595 buildings will be at least moderately damaged. This is over 72% of the total number of buildings in the scenario. There are an estimated 309 buildings that will be completely destroyed. Table 4-5, below, summarizes the expected damage by general occupancy for the buildings in the scenario.

Table 4-7. Expected General Building Stock Damage by Occupancy

Occupancy	Count
Residential	1,585
Commercial	9
Industrial	1
Agricultural	0
Religion	0
Government	0
Education	0
Total	**1,595**

Essential Facility Damage

Before the flood event analyzed in this scenario, Baltimore County had 1,800 hospital beds available for use. On the day of the scenario flood event, the model estimates that all of these hospital beds will remain available for use. Table 4-6, below, summarizes the expected damage to essential facilities in Baltimore County due to the proposed flood event. With the exception of three schools (listed below), HAZUS results indicate that essential facilities are within flood hazard areas.

Table 4-8. Expected Damage to Essential Facilities

Classification	Total	At Least Moderate Damage	At Least Substantial Damage	Loss of Use
Fire Station	65	0	0	0
Hospital	25	0	0	0
Police Station	20	0	0	0
School	375	3	0	3

Affected Schools:

- Ashland Preschool Center, Cockeysville, MD
- Options Celebrating Education One on One Tutorial, Woodlawn, MD
- CCBC & MD Department of Health and Mental Hygiene, Nottingham, MD

4.6.5 Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) 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 97,511 tons of debris will be generated. Of the total amount, Finishes comprises 29% of the total, and Structure comprises 38% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 3,900 truckloads (@25 tons/truck) to remove the debris generated by the flood.

4.6.6 Economic Loss

The total economic loss estimated for the flood is 749.12 million dollars, which represents 6.4 % of the total replacement value of the scenario buildings.

Building-Related Losses

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 745.55 million dollars. Less than 1% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 45% of the total loss. Table 4-7, below, provides a summary of the losses associated with the building damage.

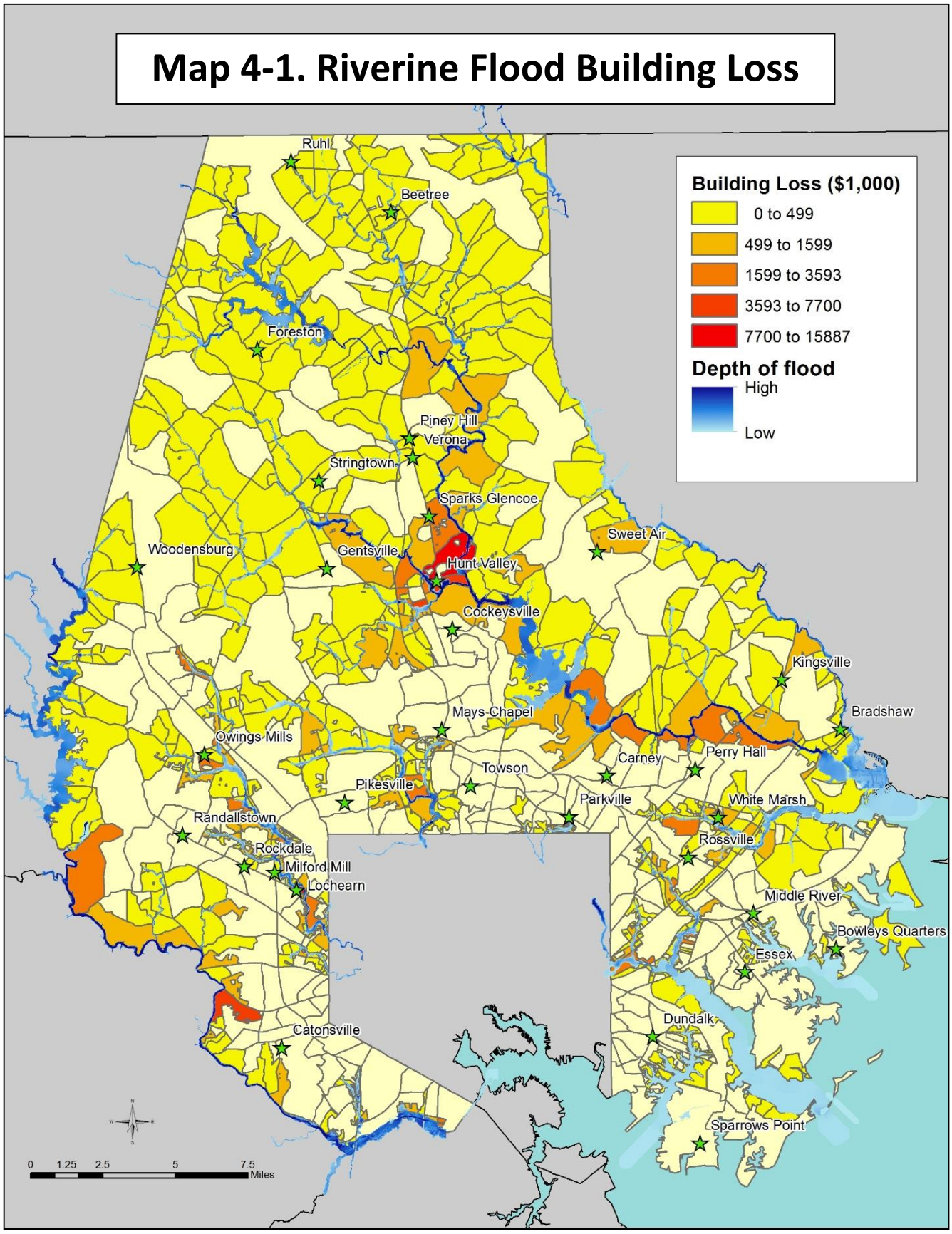
Table 4-9. Building-Related Economic Loss Estimates (Millions of Dollars)					
Type	Residential	Commercial	Industrial	Others	Total
Building	207.7	90.2	25.4	6.5	329.8
Content	126.3	182.8	62.8	26.8	398.7
Inventory	0.0	4.9	11.7	0.4	17.0
Total	**334.0**	**277.9**	**99.9**	**33.7**	**745.5**

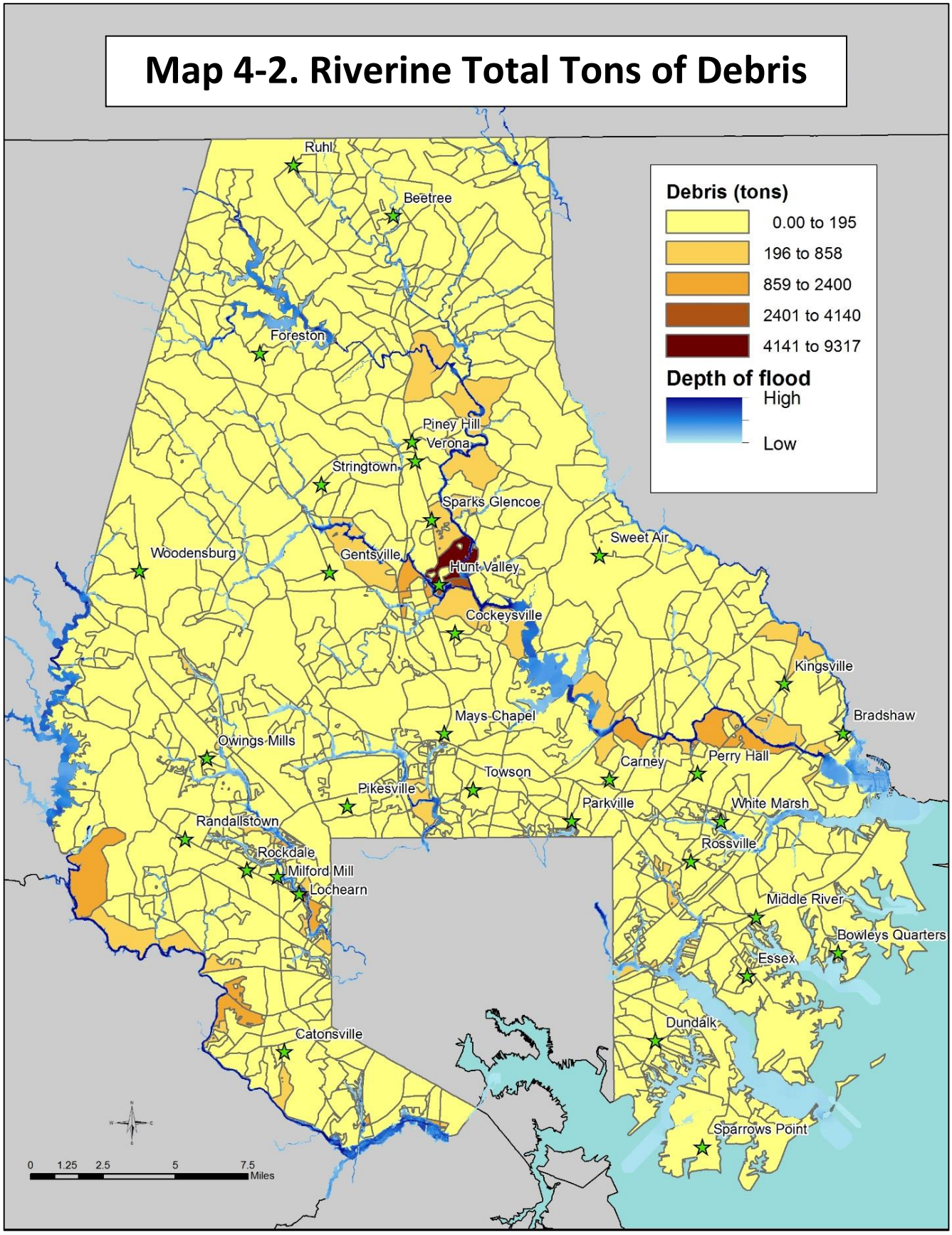
4.6.7 Social Impact

Shelter Requirements

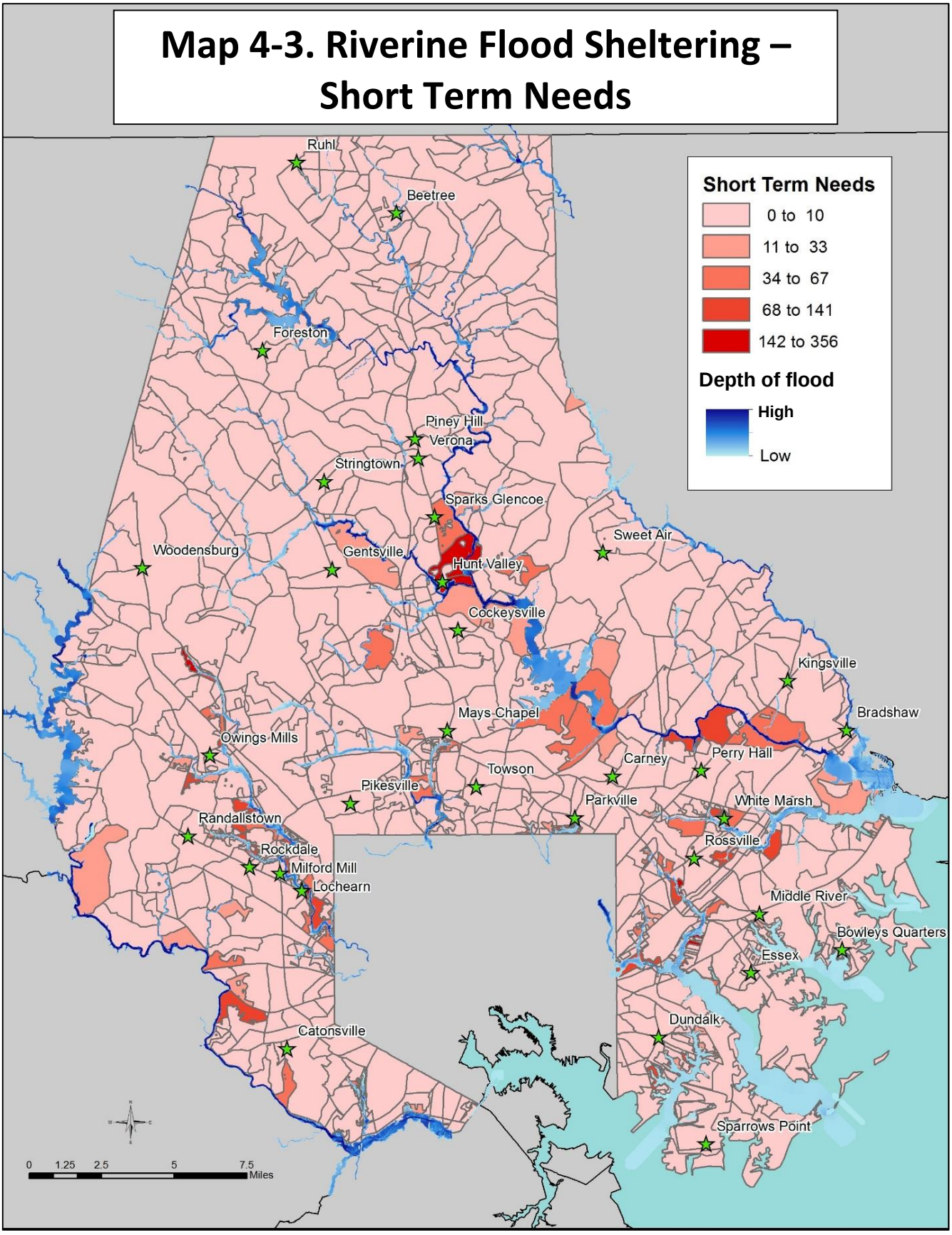
Hazus estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. Hazus also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 4,009 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 8,835 people (out of a total population of 805,029) will seek temporary shelter in public shelters.

These short-term shelter needs are depicted by census block on Map 4-3. Areas with the greatest short term shelter needs tend to follow major waterways. Based on the results, the Cockeysville, Hunt Valley, and Phoenix areas will have the highest demand for short term sheltering.


Map 4-1. Riverine Flood Building Loss
Building Loss ($1,000)
0 to 499
499 to 1599
1599 to 3593
3593 to 7700
7700 to 15887
Depth of flood
High
Low
Ruhl
Beetree
Foreston
Piney Hill
Verona
Stringtown
Sparks Glencoe
Sweet Air
Woodensburg
Gentsville
Hunt Valley
Cockeysville
Kingsville
Bradshaw
Mays Chapel
Owings Mills
Carney
Perry Hall
Towson
Pikesville
Parkville
White Marsh
Randallstown
Rossville
Rockdale
Milford Mill
Lochearn
Middle River
Bowleys Quarters
Essex
Dundalk
Catonsville
Sparrows Point
0 1.25 2.5 5 7.5
Miles


Map 4-2. Riverine Total Tons of Debris
Debris (tons)
0.00 to 195
196 to 858
859 to 2400
2401 to 4140
4141 to 9317
Depth of flood
High
Low
Ruhl
Beetree
Foreston
Piney Hill
Verona
Stringtown
Sparks Glencoe
Sweet Air
Woodensburg
Gentsville
Hunt Valley
Cockeysville
Kingsville
Bradshaw
Mays Chapel
Owings Mills
Carney
Perry Hall
Towson
Pikesville
Parkville
White Marsh
Randallstown
Rossville
Rockdale
Milford Mill
Lochearn
Middle River
Bowleys Quarters
Essex
Dundalk
Catonsville
Sparrows Point
0 1.25 2.5 5 7.5
Miles

Map 4-3. Riverine Flood Sheltering – Short Term Needs



4.7 FLOOD HAZARD ASSESSMENT – INFRASTRUCTURE

4.7.1 Introduction

In the Baltimore County 2006 Multi-Hazard Mitigation Plan, infrastructure within the FEMA mapped 100-year floodplain were identified. Identified infrastructure included: roadways, bridges, sewer lines, and communication towers.

The HAZUS Level 2 Analysis for Flood primarily considered impacts to residential, commercial, and industrial structures, and essential and critical facilities. Impacts to infrastructure were not included in the HAZUS Level 2 Analysis.

Therefore, in order to complete the 2014 Plan Update, infrastructure within the 100-year floodplain based upon the new FEMA 2011 Effective Firm maps were identified. For this assessment, infrastructure includes: roadways, bridges, culverts, and communication towers.

4.7.2 Data Utilization

The following shapefiles (sources included) were utilized to determine hazard areas and affected infrastructure:

- 100-year floodplain – FEMA DFIRM Final (Effective Date: 8/2/2011)
- Bridges – Baltimore County Office of Information Technology (2011)
- Culverts – FEMA DFIRM Database (8/2/2011)
- Street Centerlines – Baltimore County Office of Information Technology (June 2013)
- Communication Towers – Federal Communications Commission (2010)

4.7.3 Method

Data listed in section 4.7.2 was analyzed using ArcMap 10.1, a geographic information system (GIS). This program allows various data layers, such as shapefiles, to be overlaid and spatially compared. To determine vulnerable infrastructure within the County, each infrastructure shapefile (bridges, roadways, etc.) was intersected with the 100-year floodplain. Infrastructure was deemed to be vulnerable to flood if it was within (intersects) the 100-year floodplain.

4.7.4 Assessment Results

Based on the assessment, the following structures were determined to be within the FEMA defined 100-year floodplain:

Bridges within FEMA 100-year floodplain

In total, there are about 537 bridges within Baltimore County. Of these, 88 are within the 100-year floodplain. Figure 4-1 further highlights this relationship. Additionally, Table 4-10 lists total bridges within the 100-year floodplain by their location. Map 4-5 illustrates bridges in the county within the 100-year floodplain.

Figure 4-1.

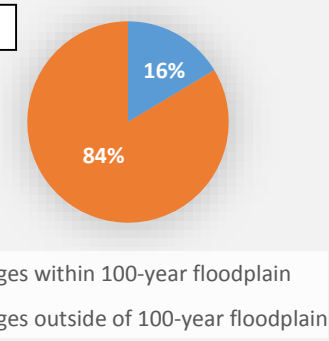
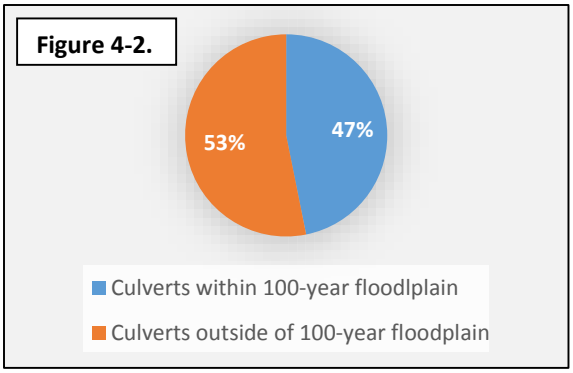


Table 4-10. Total Impacted Bridges by Location

Road/River Name	Total Bridges	Road/River Name	Total Bridges
IS 695 Il	6	Buffalo Creek	1
Stemmers Run	6	Csx Trans. & Gwynns Fall	1
IS 895	4	Deep Run	1
Jones Falls	4	Dogwood Road	1
US 1	4	Fourth Mine Branch	1
Beaverdam Run	3	Georges Run	1
Gwynns Falls	3	Haystack Branch	1
IS 695 Ol	3	Herbert Run	1
Trib To Herring Run	3	Indian Run	1
Western Run	3	IS 83 Sbr & Jones Falls	1
Whitemarsh Run	3	Little Falls	1
Csx Trans,Pat Riv,Co Rd	2	Long Green Creek	1
Goodwin Run	2	Long Quarter Branch	1
Greene Branch	2	Mcgill Run	1
Gunpowder Falls	2	Middle River	1
Honeygo Run	2	North Branch	1
Ncr Trail & Little Falls	2	Owl Branch	1
Old Pimlico Road	2	Painters Mill Rd, Gwynns	1
Patapsco River	2	Piney Creek	1
Redhouse Creek	2	Piney Run	1
Bean Branch	1	Roland Run	1
Blackrock Run	1	Slade Run	1
Br Of Long Green Creek	1	Slaughterhouse Branch	1
Branch Of Whitemarsh Run	1	US1 Nbr, Amtrak, Herbert	1

Culverts within FEMA 100-year floodplain

In total, there are roughly 13,566 culverts within Baltimore County. Of these, 6,453 are within the 100-year floodplain. The Figure 4-2, below, further highlights this relationship. Map 4-6 illustrates culverts in the county within the 100-year floodplain.



Roadways within FEMA 100-year floodplain

In total, there are roughly 9,789 roadways within Baltimore County. Of these, 782 are within the 100-year floodplain. This translates to over 446 miles (10% of total road miles) of roadway within the 100-year floodplain. Tables 4-11 and 4-12 list the most impacted roads by total miles, and communities by number of affected roadways, respectively. Map 4-4 illustrates roadways in the county within the 100-year floodplain.

Table 4-11. Most Impacted Roadways by Total Miles Within 100-year Floodplain

Road Name	Total Miles	Road Name	Total Miles
I 695	18.64	Key Brg	2.23
I 83	16.23	Dogwood Rd	2.23
Falls Rd	7.82	Long Ln	2.22
Pulaski Hwy	7.11	Wilson Point Rd	2.15
I 95 N	6.46	Tufton Ave	2.14
I 95 S	5.53	Owings Mills Blvd	2.06
I 895	4.01	I 795	2.03
White Marsh Blvd	3.20	Harford Rd	2.00
Butler Rd	2.82	York Rd	1.99
Carroll Island Rd	2.77	Cold Bottom Rd	1.99
Bowleys Quarters Rd	2.74	Southwestern Blvd	1.98
Harris Mill Rd	2.73	Graystone Rd	1.86
Benson Mill Rd	2.71	Mount Zion Rd	1.71
Corbett Rd	2.63	Dairy Rd	1.68
Ridge Rd	2.62	Hunter Mill Rd	1.63
Gunpowder Rd	2.55	Belmont Ave	1.60
Philadelphia Rd	2.54	W Warren Rd	1.55
Mantua Mill Rd	2.36	Frederick Rd	1.54
Ensor Rd	2.29	Blue Mount Rd	1.53
Jordan Sawmill Rd	2.29	Glen Arm Rd E	1.50

Table 4-12. Communities by Number of Affected Roadways			
Community	Affected Roadways	Community	Affected Roadways
Dundalk	102	Mount Washington	12
Sparrows Point	89	Carroll	10
Essex	88	Glen Arm	10
Middle River	79	Perry Hall	10
Bowleys Quarters	57	Upperco	10
Gwynn Oak	41	Hampstead	8
Halethorpe	40	Randallstown	8
Reisterstown	34	Raspeburg	8
Parkton	28	Woodstock	7
Pikesville	27	Baldwin	5
Rosedale	25	Hydes	5
Sparks Glencoe	25	Kingsville	5
Cockeysville	24	Loch Raven	5
Catonsville	23	Oella	5
Lutherville	23	Hunt Valley	4
Nottingham	23	Manchester	4
Parkville	22	Northwood	3
Monkton	21	Brooklyn	2
Windsor Mill	21	Highlandtown	2
Owings Mills	20	Arlington	1
Towson	18	Joppa	1
Freeland	17	Roland Park	1
White Hall	16	Upper Falls	1
White Marsh	15		
Phoenix	14		

Communication Towers within FEMA 100-year floodplain

1 Communication
- Nextel Communications of the Mid-Atlantic, Inc. (Cockeysville)

1 Broadcast
- WCBM Maryland, Inc. (Owings Mills)

2 AM Radio
- WBGR (Rosedale)
- WVIE (Pikesville)

4.7.5 Assessment Analysis

Transportation Impacts

While many roadways within the 100-year floodplain are at risk, there are several regions in the County with high densities of roadways within the floodplain. These areas include: Bowleys Quarters, Dundalk, Middle River, Sparrows Point, and Essex. Roadways within the 100-year floodplain in these regions make up 36% of all the impacted roadways in the County.

Development Impacts

According to Baltimore County's Master Plan 2020, Owings Mills is the County's designated Growth Area, Middle River is a Redevelopment Area, and Pulaski Highway is also a Redevelopment Area.

Owings Mills Growth Area

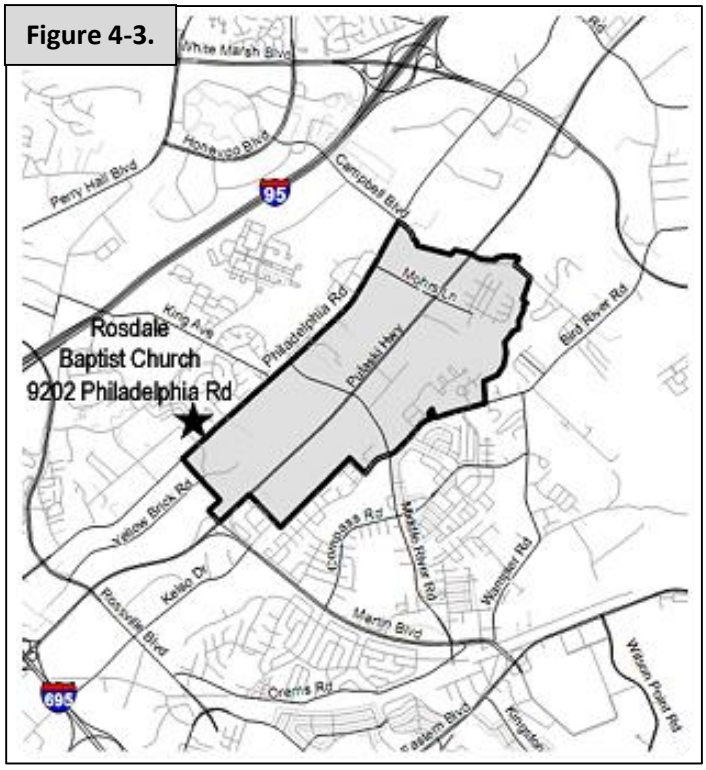
Based on both the HAZUS Level 2 Analysis and the Infrastructure Analysis, the Owings Mills area can expect to face minimal impacts from a 100-year flood event.

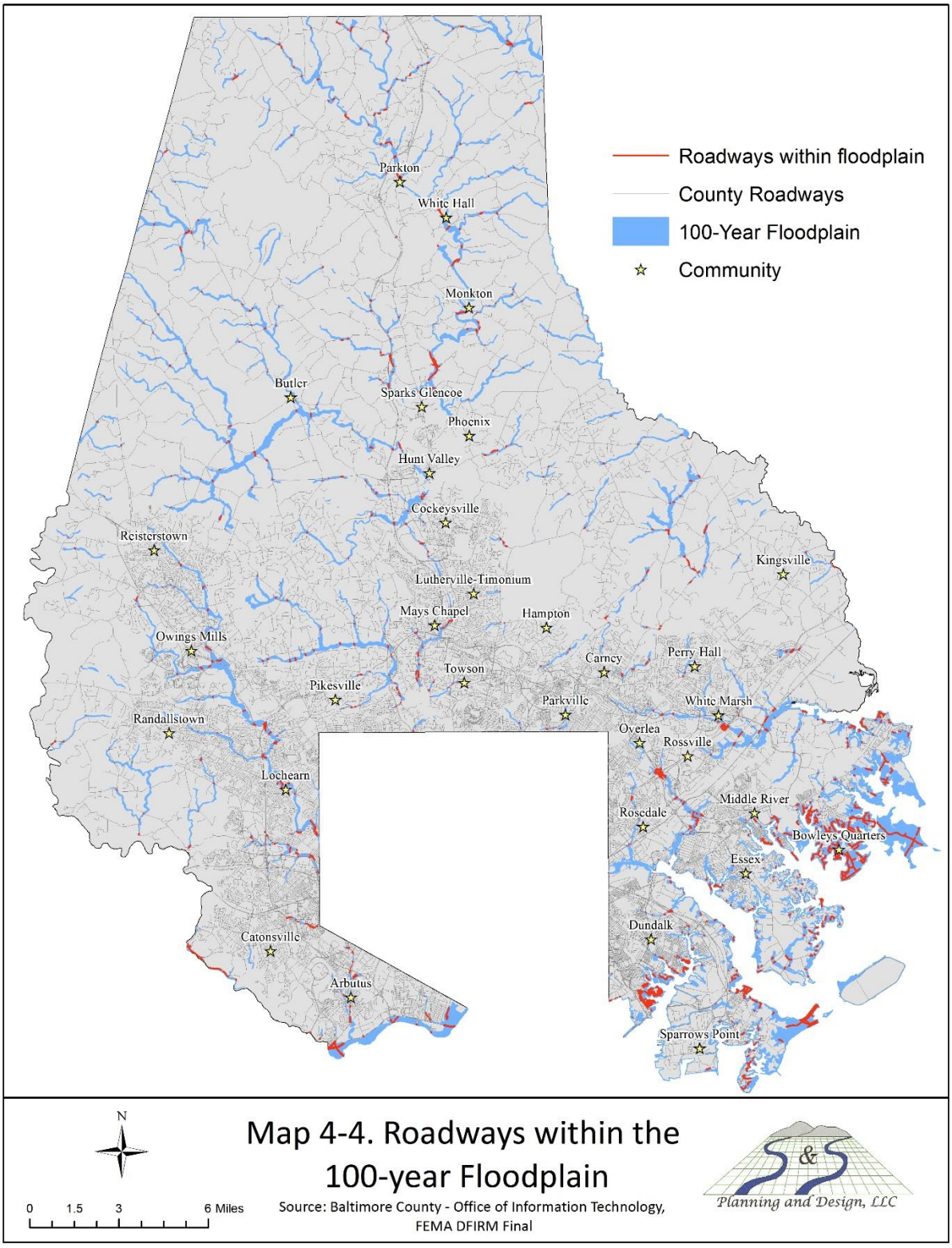
Middle River & Pulaski Highway Redevelopment Areas

The largest problem the Middle River area may face is related to the amount of roadways within the 100-year floodplain. It ranks in the top five of the communities with the most roadways within the floodplain, coming in at 79 roadways. Pulaski Highway, within Middle River, also faces floodplain problems. Just over 7 miles of the highway is within the 100-year floodplain.

Baltimore County's *Master Plan 2020* identifies a 920-acre district along a five-mile segment of Pulaski Highway U.S.40 in the Middle River community as a potential target area for community-scaled redevelopment. Figure 4-3, below, highlights this location.

Figure 4-3.

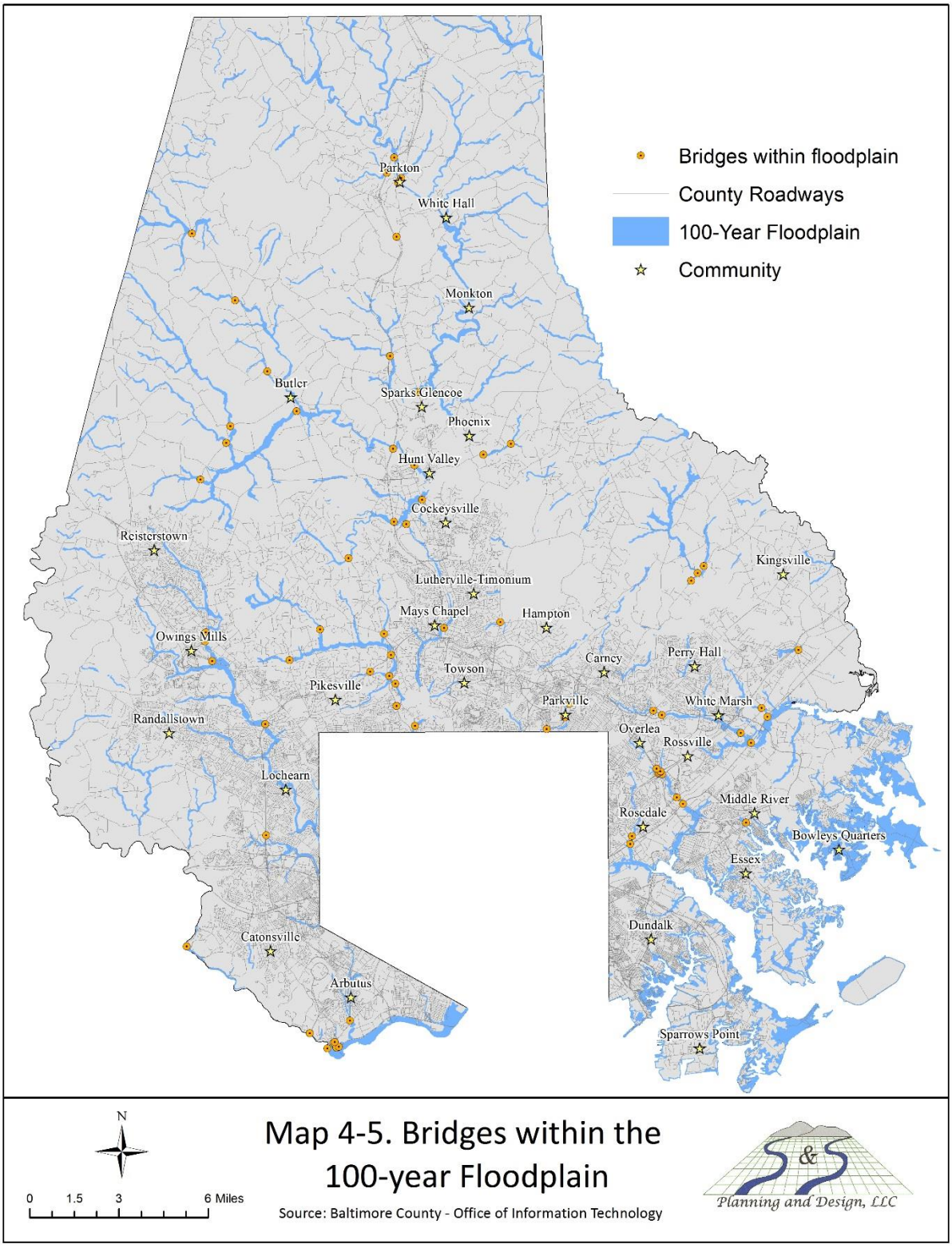


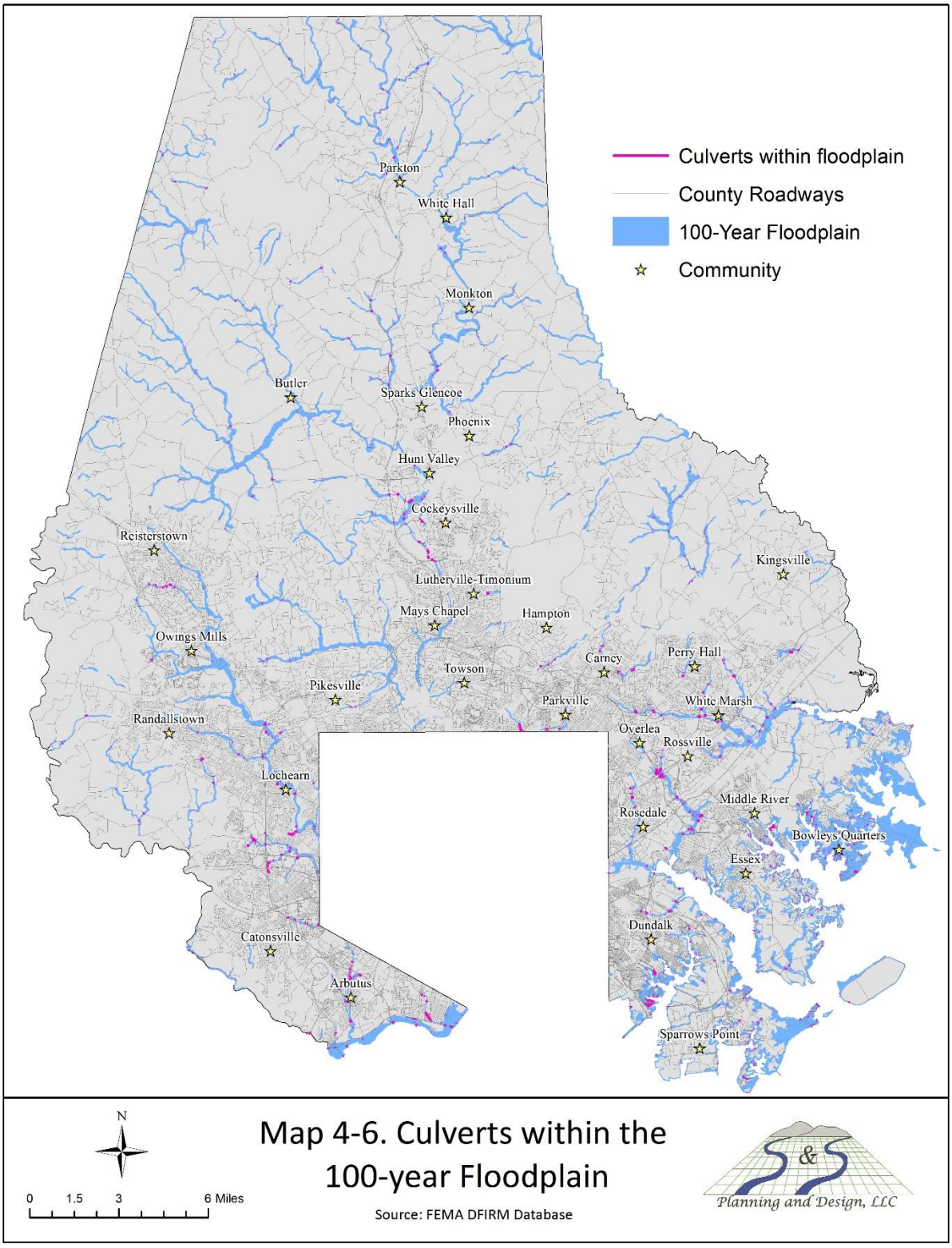


Map 4-4. Roadways within the 100-year Floodplain

Source: Baltimore County - Office of Information Technology, FEMA DFIRM Final

Planning and Design, LLC


Bridges within floodplain
County Roadways
100-Year Floodplain
Community
Parkton
White Hall
Monkton
Butler
Sparks Glencoe
Phoenix
Hunt Valley
Cockeysville
Reisterstown
Kingsville
Lutherville-Timonium
Mays Chapel
Hampton
Owings Mills
Carney
Perry Hall
Towson
Pikesville
Parkville
White Marsh
Randallstown
Overlea
Rossville
Lochearn
Middle River
Rosedale
Bowleys Quarters
Essex
Dundalk
Catonsville
Arbutus
Sparrows Point
N
0 1.5 3 6 Miles
Map 4-5. Bridges within the 100-year Floodplain
Source: Baltimore County - Office of Information Technology
Planning and Design, LLC



Map 4-6. Culverts within the 100-year Floodplain

4.8 2014 MITIGATION GOALS AND ACTION ITEMS

During the 2014 Plan Update, new mitigation goals and action were added. Additionally, previous mitigation goals and action items from the 2006 Plan were reviewed, and those that were determined to be still in progress or relevant were included.

GOAL 1: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about natural hazards risks, preparedness, and mitigation.	1. Continue to provide information on the County's web site about flood risk and vulnerability.	County	High
	2. Develop an educational plan for updates on emergency preparedness, including communications, evacuation, traffic, area closures, visitor controls, damage assessment, clean up etc.	County	Medium
2. Provide technical assistance for homeowners regarding flooding.	1. Develop a technical assistance information program for homeowners to teach them how to strengthen their homes against flooding. The program could include providing local government building departments with copies of existing strengthening and repair information for distribution to homeowners. Other potential distribution sources include insurance companies, realtors, homeowner associations, and libraries.	County	Medium

GOAL 2: Eliminate or reduce human, environmental, social and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Identify potential contributing factors to flood risk within the floodplain.	1. Conduct stream corridor assessments to determine the status of bridges, culverts, pipes, failing channelization, debris blockages, and other issues that may increase the severity of flood events.	County	High
2. Enforce current building standards.	1. Continue to perform building inspections to ensure compliance with current building standards as they relate to flooding.	County	Medium
3. Identify flood prone properties for mitigation efforts.	1. Focus flood mitigation efforts in the communities identified as having the greatest amount of Repetitive Loss Properties: Middle River, Sparrows Point, Cockeysville, Dundalk, and Pikesville (Table 4-3).	Middle River, Sparrows Point, Cockeysville, Dundalk, Pikesville	High
	2. Elevate or acquire repetitive loss and severe repetitive loss properties affected by flooding when funding from State and Federal sources is available.	County	Medium

	3. Acquired properties that are adjacent should be considered for open space and stream restoration projects. Prime examples include RLP properties on River Drive Road and Beaver Run Road (see Table 4-4).	County, River Drive Road, Beaver Run Road	Medium
	4. Identify pre-FIRM structures located within the 100-year floodplain and determine the mitigation measures that are needed to reduce flooding.	County	Medium

GOAL 3: Provide outreach to agencies and organizations within Baltimore County regarding hazard mitigation.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Utilize planning documents, reports, and analyses as targeted material for outreach and preparedness efforts.	1. Provide HAZUS flood data to shelters within the projected high hazard flood zone within the County.	See Map 4-3	Medium
	2. Provide HAZUS flood data regarding shelter requirements to Emergency Preparedness for planning and mitigation purposes.	See Map 4-3	High
	3. Provide HAZUS flood data regarding debris generation to the Bureau of Highways for planning and mitigation purposes.	See Map 4-2	Medium
	4. Include HAZUS flood data regarding debris generation as an amendment to the County's Ten Year Solid Waste Management Plan.	See Map 4-2	Medium

4.9 EXISTING FLOOD MITIGATION ACTIVITIES

Baltimore County's current capabilities provide a framework for future mitigation action items.

- National Flood Insurance Program (NFIP)
  - Enforce floodplain management regulations in identified flood hazard areas
  - Bill 173-93 Floodplain Management Ordinance adopted in 1993 which complies with Section 60.3 (D) of the regulations for the National Flood Insurance Program as revised on October 1, 1986
  - No new development is allowed in the 100-year riverine floodplain
  - Citizens are eligible to purchase flood insurance that is not normally available through private insurance companies
  - FEMA Flood Hazard Mapping Program
  - As of December 2013, the Effective Map date for riverine floodplain mapping was August 2011. For coastal floodplain mapping, the Preliminary date was November 2012, and the Targeted Effective Map date is May 2014.
- Building Codes
  - No new buildings or additions shall be constructed in any riverine floodplain.
  - Anyone rebuilding within the state's official floodplains must elevate their first floor above the 100-year flood level.
  - Rebuilt homes will have no basements. Owners sign non-conversion agreement promising not to convert ground level floor space to a living area. This agreement becomes part of the deed.
  - Ground floor may be used for storage or garage, but must include flood venting.
  - Any outbuildings larger than 100 square feet must meet the same flood codes as the house.
  - Newly constructed homes in 100 year tidal floodplain to be elevated a minimum of 2 feet above flood elevation.
- Participation in the national "Turn Around, Don't Drown" program.
- Utilization of social media (Facebook and Twitter) to disperse warnings and information prior to and during a severe weather and/or flood event.

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[1] Hurricane Isabel Rapid Response Coastal High Water Mark (CHWM) Collection, p. 7
[2] http://www.floodsafety.noaa.gov/snowmelt.shtml
[3] http://www.nws.noaa.gov/hic/
[4] Rebuilding for a More Sustainable Future: An Operational Framework, 4-4
[5] Flood Insurance Study, Baltimore County, MD. October 16, 1987
[6] The Baltimore Sun, 2012
[7] The Baltimore Sun, 2011
[8] The Baltimore Sun, 2011
[9] National Oceanic and Atmospheric Administration, 1972, v. 76, no. 6, p. 63
[10] National Oceanic and Atmospheric Administration, 1972, v. 76, no. 6, p.63
[11] http://md.water.usgs.gov/publications/wsp-2375/md-dc
[12] U.S. Environmental Data Service, 1971
[13] http://www.theviewnewspapers.com/article.asp?article=1206&paper=84&cat=225
[14] http://www.mdfloodmaps.net/pdfs/Flood_Insurance_Factsheet.pdf

[15] www.mdfloodmaps.net
[16] http://www.mdfloodmaps.net/pdfs/Floodplain_Factsheet.pdf

CHAPTER 5: DROUGHT

The update process for *Chapter 5: Drought*, as part of the Baltimore County 2014 Hazard Mitigation Plan Update, included researching and integrating the most up-to-date and available data during this planning cycle. Updates to this chapter include: updates to existing sections and tables, new figures, maps, and new formatting. As detailed in the highlighted figure, five sections have been updated in this chapter.

Chapter Highlights

Updated Sections/New Additions:
5.1 – Added text regarding Palmer Drought Severity Index.
5.2 – "Rural Water Supply"
5.3 – Added two (2) new drought events.
5.4 – Updated vulnerability assessment with latest available data. Added Map 5-1.
5.5 – New action items for 2014.

5.1 HOW ARE DROUGHTS A THREAT TO BALTIMORE COUNTY?

Drought has the potential to affect the environmental, economic, and social systems within Baltimore County. Residents, farms, and businesses need a constant, reliable supply of water, and a reduction in that supply will have physical and economic impacts. As the population in Baltimore County continues to grow, the demand for water will increase as more and more is consumed for residential, commercial, agricultural and industrial uses. Conversely, the water supply will remain relatively static, which makes reducing the impact of drought a critical component to the responsible management of the water supply.

The State of Maryland uses the U.S. Army Corp of Engineers' definition of drought which states "droughts are periods of time when natural or managed water systems do not provide enough water to meet human and environmental uses because of natural shortfalls in precipitation or stream flow."[1]

Predicting drought has proven difficult if not impossible, as so many variables come together to affect the extended weather patterns relative to a region. Adding to the complexity, drought rarely has a well-defined beginning or end and generally affects a large area.

Maryland Department of the Environment (MDE) uses four main indicators based on the amount and effect of precipitation in the hydrologic system to monitor potential drought conditions.[2] The indicators are evaluated by comparing the current conditions to natural conditions within the period of record. The indicators are: (1) precipitation levels, (2) stream flows, (3) ground water levels, and (4) reservoir storage.

Other indicators used by MDE to determine drought include the Palmer Drought Severity Index and the condition of the water system as monitored by water suppliers. The Palmer Drought Severity Index uses temperature and rainfall to determine dryness of a region. The index is very slow to change, and is not useful for short term monitoring of the water supply. However, the index is useful in long term planning as it reflects the status of the water supply in reservoirs, aquifers and streams. The condition of the water supply is specific to a particular system and is the

responsibility of those monitoring the supply. One supply system may suffer negative impacts sooner than another, indicating the potential for more wide-spread problems.

5.2 CONTRIBUTING FACTORS TO DROUGHT RISK

5.2.1 Climate and Weather

"Climate is what you expect, weather is what you get."[3] Drought is a natural part of every climate, describing the relative departure from normal precipitation for a particular region. Weather, however, plays the more integral role in determining the likelihood of a drought. Persistent high pressure systems over the Southeastern U.S. can keep moisture producing low pressure systems to the north of the Baltimore Metropolitan region. These high pressure systems can occur at any point within the seasonal year—a lack of winter snowfall can be as detrimental as a lack of summer rainfall when considering the groundwater supply for the region.

5.2.2 Water Resource Allocation

The water supply for Baltimore County is fairly static even though the population continues to grow at a fast pace. This growing population creates an increased competition for the available water supply from several groups of consumers—residential, industrial, commercial, agricultural and recreational. Within the Metropolitan District Line, which designates the extent of the public utility network, suburban communities rely on urban infrastructure which can lead to inefficient distribution of public water due to age or failures. Outside of the Metropolitan District Line, sprawling residential development relies on individual wells to supply homeowners and businesses with water.

Rural Water Supply

Roughly 10% of the County's population currently resides in the rural areas outside the URDL and relies on some 30,000 domestic wells as their primary source of drinking water. These include 9 community well supplies and approximately 270 transient and non-transient non-community water supplies.

Source: Baltimore County Water Resources Element

5.3 HISTORY OF DROUGHT

The following is a brief description of significant drought events that have affected Baltimore County.

- **1930-1931** – The 13-month period from January, 1930 to January, 1931 was the driest on record, with precipitation totaling 15-26 inches below normal for weather stations throughout Maryland.[4] The weather station in Woodstock, MD at the Baltimore-Howard County line, recorded the precipitation as -25.10 inches below normal.

- **1963-1966** – The longest drought to grip Maryland lasted from 1963 to 1966. For the 4 year period between January, 1963 and December, 1966, precipitation was between 26 and 38 inches below normal.[5] The Division 6 station, which includes Baltimore County, registered a departure from normal of -38.23 inches, which was the worst in the state.

- **1998-1999** – The 13-month period from July, 1998 to July, 1999 was extremely dry throughout Maryland, with precipitation totaling 10-21 inches below normal.[6] The weather station in Woodstock, MD at the Baltimore-Howard County line, recorded the precipitation as –11.46 inches below normal. While this drought was not as long as the one in the 1960s nor as severe as the one in the 1930s, it caused a number of problems for residents and businesses in Maryland. This was the first time in its history that Maryland declared a statewide drought emergency and implemented mandatory water restrictions.[7]

- **2001-2002** – By the end of 2001, rainfall totals across Maryland were 30 percent below normal, putting the state in an emergency category. By mid-February 2002, nearly all of Maryland was in a state of severe drought, which is a very unusual classification for the middle of winter.[8] The period of September, 2001 to August, 2002 was the second driest 12 month period in Maryland history, when record keeping began 108 years prior.[9] Reservoir levels fell to 49 percent capacity in August 2002, levels not seen since the severe drought of the 1960s.[10]

- **October, 2007** – Severe Drought conditions persisted through October. In early October, rainfall deficits totaled nearly 10 inches. However, a series of low pressure systems late in the month brought between 3 and 6 inches of rainfall to slightly reduce those deficits. Many counties and cities posted both voluntary and mandatory water restrictions throughout the month.[11]

- **June-August, 2012** – During this period, much of Maryland, particularly the Eastern Shore and Southern Maryland, entered what the U.S. Drought Monitor considers to be "severe" drought. By the end of July, 29% of the State would be considered to be under a "severe" drought status; the week prior only 20% of the State was considered to meet this criteria. Many central Maryland counties, such as Anne Arundel, were in a "moderate" drought, while southern Baltimore County experienced "abnormally dry" conditions.[12]

5.4 VULNERABILITY ASSESSMENT

5.4.1 Introduction

All of Baltimore County is vulnerable during a drought, but farmers (via crop damage) and those residents living and working outside the Metropolitan District Line, where the public water supply ends, are at greatest risk. While those residents utilizing the public water supply will not be exempt from the risks, public officials will be monitoring the water supply and imposing restrictions as necessary to manage the supply until precipitation returns to normal in the area.

The Metropolitan District Line represents the geographic area within which public water and sewer services are provided. Properties that are adjacent to the line but outside it may petition to be included. During a drought, properties experiencing well failure have the best chance of accessing public water when they are relatively close to this boundary.

5.4.2 Data Utilization

The following data sources and shapefiles were utilized to determine land uses and critical facilities especially vulnerable to drought:

- Metropolitan District Line (URDL) - Baltimore County Office of Information Technology (2012)
- Structures/Parcels – Baltimore County Office of Information Technology (2007)
- Critical Facilities – Baltimore County Office of Information Technology (June 2013)
    - Fire Stations, Police Stations, Schools, Colleges, Hospitals/Health Centers
- U.S. Census Bureau (2010)

5.4.3 Method

Data listed in section 5.4.2 was analyzed using ArcMap 10.1, a geographic information system (GIS). This program allows various data layers, such as shapefiles, to be overlaid and spatially compared. Land uses and critical facilities within the County were determined to be especially vulnerable to drought if they were outside of (did not intersect) the Metropolitan District Line, which is the extent of the public water and sewer supply.

Estimated economic losses to land uses within the County due to drought are based on the Maryland Department of Assessments and Taxation Real Property Database for all affected parcels. Tax Exempt properties include but are not limited to Public, County, State, or Federal owned Hospitals, Schools, Museums, Airports, Police Stations, and/or Fire Departments. Also included are church properties and other non-profit or charitable organizations. Economic losses are based on assessed value of property, and do not include contents value or indirect costs related to drought.

5.4.4 Assessment Results

Based on the 2014 assessment, the following land uses and critical facilities were determined to be vulnerable to drought:

Table 5-1. Land Uses Affected by Drought

Land Use	Buildings Affected	Parcels	Value of Parcels
Residential	30931	32886	$11,883,064,825
Commercial/Residential	-	74	$18,361,767
Institutional	969	-	-
Agricultural	-	4316	$1,180,636,701
Commercial	1999	506	$514,271,503
Exempt Commercial	-	333	$759,432,130
Exempt	-	1553	$392,037,166
Industrial	-	546	$209,054,200
Apartment	-	8	$145,143,000

Land Use	Buildings Affected	Parcels	Value of Parcels
Storage Tank	150	-	-
Water Tower	24	-	-
Silo	505	-	-
Total	34578	40222	$15,102,001,292
Note: Land uses located outside of public water service area.			

Critical Facilities

11 Fire Stations

- Baltimore County Fire Department Station 38 - Long Green
- Baltimore County Fire Department Station 42 - Boring
- Baltimore County Fire Department Station 43 - Arcadia
- Baltimore County Fire Department Station 44 - Hereford
- Baltimore County Fire Department Station 45 - Maryland Line
- Baltimore County Fire Department Station 47 - Jacksonville
- Baltimore County Fire Department Station 48 - Kingsville
- Baltimore County Fire Department Station 49 - Butler
- Baltimore County Fire Department Station 50 - Chestnut Ridge
- Baltimore County Fire Department Station 60 - Parkton
- Baltimore County Fire Department Station 53 - Hereford Ambulance

41 Schools

Table 5-2. Schools Outside of the Metropolitan District Line	
School	Location
Public	
Carroll Manor Elementary School	Baldwin
Fifth District Elementary School	Upperco
Hereford High School	Parkton
Hereford Middle School	Monkton
Jacksonville Elementary School	Phoenix
Kingsville Elementary School	Kingsville
Prettyboy Elementary School	Freeland
Seventh District Elementary School	Parkton
Sparks Elementary School	Sparks Glencoe
Private	
B.Y. Junior High School	Owings Mills
Brooklandwood Admissions Office	Lutherville
Free State Montessori School	Fork
Jemicy School	Owings Mills
Liberty Christian School	Owings Mills
Little Sheep Day School	Reisterstown
Maryland Line United Methodist Church Nursery	Freeland
Maryvale Middle School	Lutherville
Max & Esther Gutmann Elementary School	Randallstown

School	Location
Monkton Country Day Care & Preschool	Monkton
Montessori Manor	Phoenix
Mt Paran Early Learning Center	Randallstown
Odyssey School	Lutherville
Oldfields School	Sparks Glencoe
Open Bible Christian Academy	Kingsville
Our Lady Of Grace School	Parkton
Reedemer Classical Christian School	Kingsville
Right Start	Reisterstown
Saint Johns School	Hydes
Saint Pauls Lutheran School	Kingsville
St Alphonsus Pre-School	Woodstock
St James Academy	Monkton
St James Preschool	Parkton
St John's Lutheran School	Glen Arm
St Pauls School For Girls Main Building	Lutherville
St Stephens School	Kingsville
St Timothys School	Lutherville
The Montessori School	Lutherville
Trinity Church Day School	Glen Arm
Two By Two Preschool	Monkton
Victory Day School	Reisterstown
Ward's Chapel Preschool	Randallstown

1 College

- Stevenson University (Lutherville)

5.4.5 Assessment Analysis

Agricultural Impacts

In total, 4,316 agricultural parcels are especially at risk during a drought event. The total land value for all agricultural parcels is nearly 1.2 billion dollars. These at-risk agricultural parcels are depicted on Map 5-1, below. Potential crop damage to these agricultural parcels is more difficult to determine. The length and intensity of the drought period will determine the extent of damage to crops. Currently, the NCDC reports major damages associated with various natural disasters from 1996 to the present. According to this database, ten drought events occurred during this time period, the majority being between 1997 and 1999. Of these, two of the events caused major crop damages, totaling an estimated 4.2 million dollars.

Vulnerable Populations

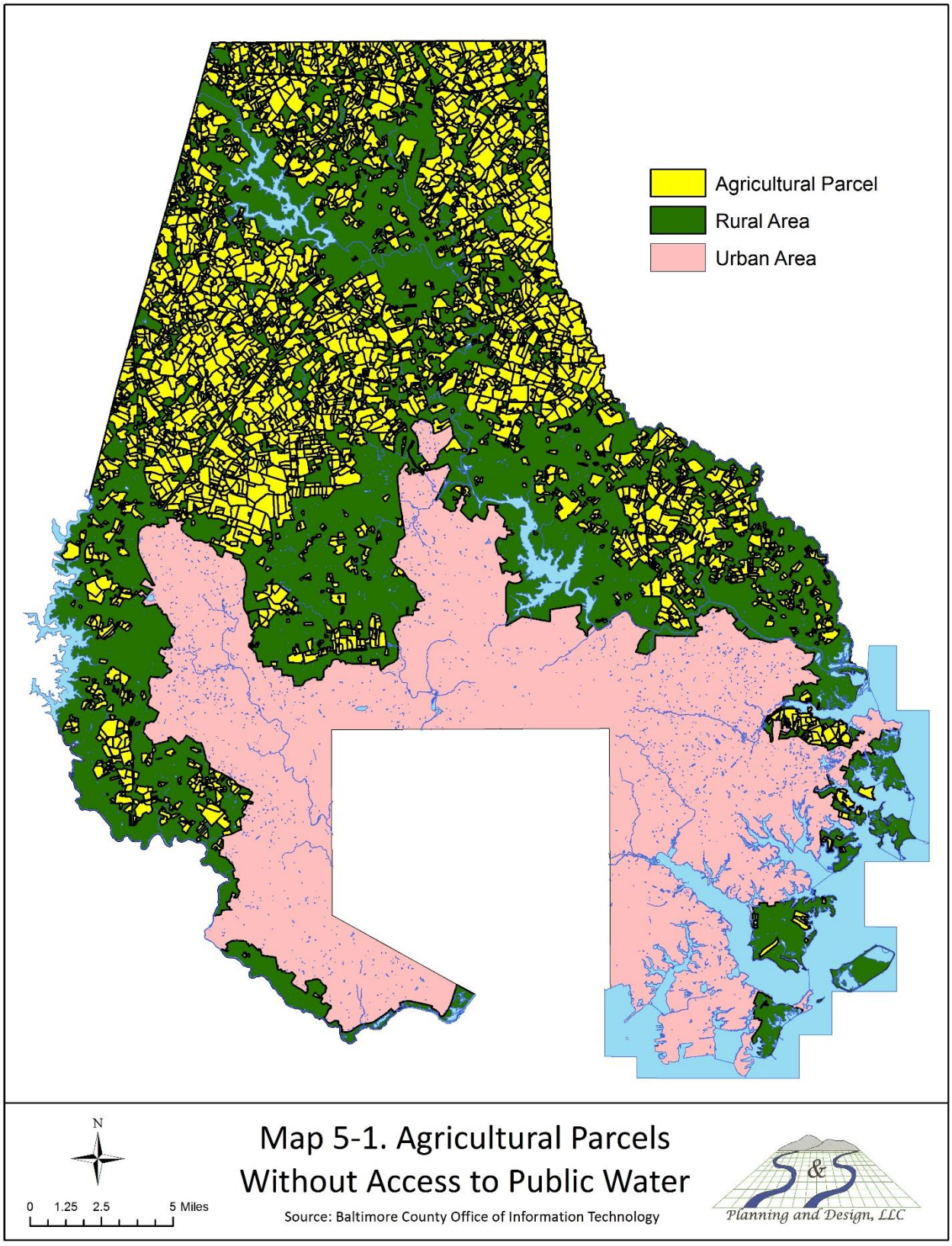
The two most vulnerable populations within Baltimore County during a drought are farmers and residents relying on a well as their primary water supply.

Human Impacts

In total, 30,931 residential structures were found to be outside the extent of the public water supply. According to the 2010 Census, the average household size in Baltimore County is 2.48 persons. Given this information, it can be estimated that a population of just over 76,700 people could be adversely affected in the event of a drought. Due to their reliance on outside water sources, these households would be more at risk for running out of water due to a drought event.

Development Impacts

Baltimore County's designated growth area, Owings Mills, is within the Metropolitan District Line, which means the area is served by public water. Communities, and their residents, within the extent of public water service are less likely to be negatively affected by drought because public officials will be able to set restrictions and manage the water supply if necessary.


Agricultural Parcel
Rural Area
Urban Area
N
0 1.25 2.5 5 Miles
Map 5-1. Agricultural Parcels Without Access to Public Water
Source: Baltimore County Office of Information Technology
S & S
Planning and Design, LLC

5.5 2014 MITIGATION GOALS AND ACTION ITEMS

During the 2014 Plan Update, new mitigation goals and action were added. Additionally, previous mitigation goals and action items from the 2006 Plan were reviewed, and those that were determined to be still in progress or relevant were included.

GOAL 1: Eliminate or reduce human, environmental, social and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Direct new development away from hazard areas	1. Consistently track residential and commercial well failures within the County to determine if a geographic pattern of failures exists.	County	Medium

GOAL 2: Support mitigation measures that show potential for environmental enhancement and cost-effectiveness.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Implement water conservation efforts at County facilities	1. Conduct audits of County facilities to determine whether infrastructure upgrades would improve efficient water use.	County	Medium
	2. Implement a program to upgrade County facilities.	County	Medium

GOAL 3: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about natural hazards risks, preparedness and mitigation	1. Continue to participate in the Green School Program.	County	Medium
	2. Continue to promote water saving tips for homeowners and businesses throughout the year.	County	Medium

5.6 EXISTING DROUGHT MITIGATION ACTIVITIES

- Promote water saving tips for homeowners and businesses on the County's web site.
- Participation in the Green School Program which promotes water conservation as one of its many goals.
- Enacted and enforce fire hydrant connection permit regulations.
- Approved the Ground Water Management and Protection Strategy in July 1993 as an amendment to the Master Plan.
- Established the Well Program, responsible for the enforcement of the Maryland Department of the Environment Well Construction Regulations 26.04.02, which includes the issuance of well drilling permits and surveillance of well construction activities.

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[1] http://www.mde.state.md.us/programs/Water/DroughtInformation/DroughtInfoandIndicators/Pages/index.aspx
[2] http://www.mde.state.md.us/programs/Water/DroughtInformation/DroughtInfoandIndicators/Pages/index.aspx
[3] http://www.nws.noaa.gov/om/csd/graphics/content/outreach/brochures/Weather&Climate_General_Public.pdf
[4] http://www.atmos.umd.edu/~climate/drought.html
[5] http://www.atmos.umd.edu/~climate/drought.html
[6] http://www.atmos.umd.edu/~climate/drought.html
[7] http://www.mde.state.md.us/programs/PressRoom/Pages/280.aspx
[8] http://www.atmos.umd.edu/~climate/drought.html
[9] http://www.atmos.umd.edu/~climate/drought.html
[10] Baltimore Sun reporting, August 21, 2002
[11] NOAA, NCDC Storm Events Database
[12] Baltimore Sun reporting, August 2, 2012

CHAPTER 6: TORNADO

The update process for *Chapter 6: Tornado* as part of the Baltimore County 2014 Hazard Mitigation Plan Update, included researching and integrating the most up-to-date and available data during this planning cycle. Updates to this chapter include: new sections and narratives, updates to existing sections, new tables, new figures, and new formatting. As detailed in the highlighted figure, two new sections have been added, and six sections have been updated in this chapter.

Chapter Highlights

New Sections:
6.1.2 – Enhanced Fujita Scale, including Table 6-1 and Figure 6-1.
6.2.2 Damaging Winds
Updated Sections/New Additions:
6.1 – Updated text.
6.2 – "Tornado Quick-Facts"
6.3 – Updated with most recent events.
6.4 – Updated Vulnerability Assessment
6.5 – New action items for 2014.
6.6 – Added new existing activities.

6.1 HOW ARE TORNADOS A THREAT TO BALTIMORE COUNTY?

Due to the unpredictability of tornado occurrences, it is impossible to categorize geographic areas as high or low risk areas based on the physical attributes of the landscape. A tornado can occur anywhere given the proper conditions. The only way to mitigate for this hazard event is to evaluate the existing property on the land.

There are several types of areas that are particularly susceptible to high loss in the event of a tornado touchdown: mobile homes, high density housing, and structures built prior to 1940.

Mobile homes, due to their lack of foundation and weak structural integrity, are at the highest risk to damage and property loss. Even the weakest of tornados can do considerable damage to a mobile home. In mobile home parks, this potential loss is compounded greatly.

High density residential areas are also at risk for loss. These relatively small geographic areas contain dense housing and other properties, which means these areas have a greater potential for personal injury and death due to the high population densities. For example, a tornado that touches down on a farm in Hereford is less likely to do as much damage as one of the same severity that touches down in a townhouse subdivision in Towson.

In addition to mobile home and high density areas, structures built prior to 1940 are also at significant high risk to tornado damage. Building codes and construction practices, since 1940, have vastly changed and improved the structural integrity of residential and commercial buildings. Generally, it has been determined that buildings built before 1940 are more susceptible to damage than those built after 1940.

6.1.1 Enhanced Fujita Scale for Tornado Damage

Since 2007, tornadoes are rated by the National Weather Service according to the Enhanced Fujita Scale (EF Scale). Ratings vary from EF0, for light damage, to EF5, for total destruction of a

building. A tornado's rating is determined by a combination of wind speed (Table 6-1) and damage estimates to structures. Figure 6-1, below, provides basic FEMA definitions for each category.

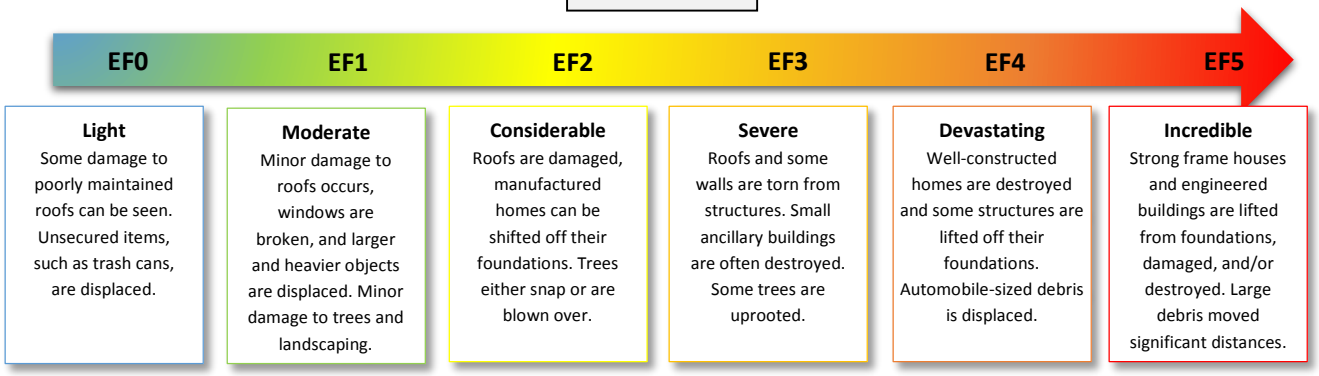
Table 6-1. Enhanced Fujita Wind Scale

EF Number	3 Second Gust (mph)*
0	65-85
1	86-110
2	111-135
3	136-165
4	166-200
5	Over 200

* The three-second gust is the highest sustained gust over a 3 second period having a 1 in 50 probability of being exceeded per year.

Source: NOAA.gov

Figure 6-1.



6.2 CONTRIBUTING FACTORS TO TORNADO RISK

6.2.1 Climate

Tornados are byproducts of cold air moving quickly over a warm air mass. As warm moist air moves upward and the cold air downward, thunderstorms form from the condensation and, depending on the wind speed and rotation, tornados are spawned. Tornados have also been known to form off of fast moving winds generated by hurricanes and large wildfires. Tornadoes are extremely unpredictable and can occur almost anywhere. They are most prevalent in the American mid-west and plains states, due to warm moist air from the Gulf of Mexico and cold air from the Rocky Mountains constantly colliding during the spring and summer months. The traditional tornado season is from March through August, and while the majority of events occur within these months, tornados can strike anytime.

Tornado Quick-Facts

- ✓ Tornados are most likely to occur in the mid-afternoon, between 3:00 p.m. and 6:00 p.m.
- ✓ Tornados predominantly move from the southwest to the northeast.
- ✓ The average tornado path-length is 5 miles, but some tornado paths have exceeded 100 miles.
- ✓ The average tornado path-width is 300 to 400 yards, but may reach up to 1 mile.
- ✓ Tornados travel at an average of 25 to 40 miles per hour (mph), but speeds from 5 to 60 mph have been recorded.

Source: FEMA, 2009

6.2.2 Damaging Winds

According to FEMA, two primary forms of damaging winds occur during a tornado event: rotating vortex winds and straight-line winds. Rotating vortex winds, which define a tornado and create its distinctive shape, are responsible for specific types of damage. These vortex winds are known to rip structures apart, uproot trees, and lift vehicles off of the ground. Tornados also produce straight-line wind, a force typically associated with thunderstorms. The forces from a tornado's straight-line, high velocity winds exert significant pressure, or loads, on structures in their path.[1] These winds are known to tear off all, or part, of a roof, break windows, damage siding, or cause complete structural collapse.

6.2.3 Development

Predicting and mitigating for tornado damage is difficult. NOAA maintains a record of reported tornados and damage reports. Looking at past tornado events in terms of severity and destructiveness at the state and local level can help determine the probability and likelihood of a tornado striking in a given area. However, future frequency, occurrences and/or severity cannot be predicted to any level of accuracy.

6.3 HISTORY OF TORNADOS

From 1990 to 2010, Maryland has averaged 9.9 tornadoes per 10,000 square miles each year, trailing only Florida's 12.2, and Kansas' 11.7 in the 50 states.[2] According to the Weather Channel, Maryland has such a high tornado density because: "It's just east of the Appalachians. The air sinks down off the Appalachians and there's a little bit of low pressure trough that sets up and trigger thunderstorms. It's also close to the Delaware Bay and Atlantic Ocean so there are some local winds the thunderstorms can tap to create tornadoes."

Table 6-2, below, contains NOAA's listing of all verified and recorded tornados that have occurred within Baltimore County.

Table 6-2. Historic Tornadoes With Recorded Damages

Date	Scale	Location	Homes Damaged	Injuries	Damage Amount
April 29, 1807	F2	Gunpowder Falls	17	-	-
October 21, 1939	F2	West of Hereford	1+	1	$75,000
August 26, 1946	F0	Eastern Baltimore Co	-	-	$1,000
June 16, 1973	F2	Towson Area	1	4	$50,000
August 11, 1978	F1	Loch Raven Area	-	0	$4,000
September 5, 1979	F2	Kingsville	2	0	$130,000
June 8, 1990	F0	Monkton	0	0	$3,000
October 18, 1990	F2	Reisterstown	53	59	$9,500,000
October 18, 1990	F0	Monkton	-	0	$100,000
July 6, 1995	F0	Monkton	1	0	$5,000
July 6, 1995	F1	Hereford	2	0	$100,000
July 19, 1996	F1	Tyler	2+	0	$50,000

Date	Scale	Location	Homes Damaged	Injuries	Damage Amount
November 8, 1996	F1	Dundalk	-	1	$750,000
July 30, 1999	F0	Beckleysville	2+	0	$1,000
May 13, 2000	F1	Overlea Area	-	0	$250,000
November 17, 2009	F1	Parkville	6	0	$50,000
April 28, 2011	F0	Trenton (Boring)	0	0	$5,000
April 28, 2011	F0	Evna (West of Hereford)	0	0	$1,000
June 10, 2013	F0	Fork	0	0	$1,000
June 10, 2013	F0	Sparrows Point	0	0	$10,000
Total	-	-	81+	65	$11,086,000

** (-) Indicates None Reported*
Source: NOAA, NCDC

6.4 VULNERABILITY ASSESSMENT

6.4.1 Introduction

It can be difficult to predict monetary damages to structures caused by tornadoes because damages can vary significantly. Depending on wind speed, damages can range from cosmetic to complete structural failure, or anywhere in between. As such, only structures which are most at-risk to damages from tornadoes are included in this assessment; mobile homes and mobile home parks, high density residential structures, and structures built prior to 1940. According to MEMA, these types of structures are more susceptible due to their building materials, lack of bolted-down foundations, and less stringent building codes at the time of their construction (in the case of structures built prior to 1940).

6.4.2 Data Utilization

Areas within Baltimore County at high risk in the event of a tornado were identified using the following sources:

- Structures – Baltimore County Office of Information Technology (2007)
- Parcels – Baltimore County Office of Information Technology (2012)

The estimated economic losses to properties within the County are based on the Maryland Department of Assessments and Taxation Real Property Database for all affected parcels. Economic losses are based on assessed value of property, and do not include contents value or indirect costs related to the damage (economic losses due to business closings).

6.4.3 Assessment Results

<u>Mobile Homes</u>

Number of Structures – 2,315
Value of Structures – $17,826,470
Extent – 68.39 acres

High Density Residential Buildings

Number of Structures – 102,475
Value of Structures – $6,733,576,600
Extent – 13,333 acres

Buildings Constructed Prior to 1940

Number of Parcels with Primary Structure Constructed Prior to 1940 – 35,569
Value of Structures – $2,859,378,493
Acreage of Structures – 1553.25 acres

6.5 2014 MITIGATION GOALS AND ACTION ITEMS

During the 2014 Plan Update, new mitigation goals and action were added. Additionally, previous mitigation goals and action items from the 2006 Plan were reviewed, and those that were determined to be still in progress or relevant were included.

GOAL 1: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about natural hazards risks, preparedness and mitigation.	1. Continue to promote tornado education on the County web site for homeowners and businesses.	County	Medium
	2. Develop targeted public education materials for mobile home residents.	County	Medium
	3. Provide a link on the County website to the FEMA publication "Tornado Protection: Selecting Refuge Areas in Buildings"	County	Medium
2. Continued education for emergency responders and personnel.	1. Provide staff training in the form of a damage assessment course so that emergency personnel are up-to-date on the latest techniques for assessing tornado damage, as well as any other major natural disaster. This course, and those like it, would be beneficial to new staff members, and provide a refresher for current staff.	County	High

6.6 EXISTING TORNADO MITIGATION ACTIVITIES

- Promote tornado education on the County web site for homeowners and businesses.
- As of 2012, minimum design wind loads for buildings are more stringent. They have been changed to 90 mph for Risk Categories I and II, and 101 mph for Risk Categories III and IV.
- Established in 2007, the Emergency Notification System (ENS) notifies citizens and businesses of emergency situations that may require time-sensitive protective action. This system sends a recorded message and/or e-mail to homes and businesses within the County, which provides safety information and instructions.

- Utilization of social media (Facebook and Twitter) to disperse warnings and information prior to and during a severe weather event, such as a tornado.

[1] http://www.fema.gov
[2] http://www.washingtonpost.com/blogs/capital-weather-gang/post/shock-stat-maryland-has-third-highest-tornado-density-in-us/2012/03/26/gIQAReMmgS_blog.html

CHAPTER 7: THUNDERSTORM

During the 2013 Kick-off Meeting for the Baltimore County Hazard Mitigation Plan Update, the Hazard Mitigation Planning Committee (HMPC) determined that a chapter dedicated to Thunderstorm should be added to the Plan Update. This hazard was ranked as 'medium-high' by the HMPC. Contents of this chapter include a profile of the hazard, thunderstorm risk factors, a history of thunderstorm events in Baltimore County, an updated Vulnerability Assessment, and mitigation action items.

7.1 HOW ARE THUNDERSTORMS A THREAT TO BALTIMORE COUNTY?

Thunderstorms are always accompanied by lightning and have the potential to cause damage via flooding, hail, strong winds, and tornadoes. Thunderstorms pose a threat to Baltimore County because they are always accompanied by some combination of the aforementioned. As such, the threats associated with these individual hazards are very real possibilities during a thunderstorm event. The same populations that are threatened by hazards such as tornadoes and flooding are also potentially at risk during a thunderstorm.

The average thunderstorm is 15 miles in diameter and lasts 30 minutes. It is estimated that 100,000 thunderstorms occur in the U.S. per year and, of these, ten percent are considered severe.[1] According to the National Weather Service, a thunderstorm is severe if it produces hail of at least one inch in diameter, winds of 58 miles per hour or stronger, a tornado, or some combination of these events. This chapter will focus only on hail and lightning, as thunderstorm winds, flooding, and tornadoes are explained in more detail in other hazard-specific chapters.

7.2 CONTRIBUTING FACTORS TO THUNDERSTORM RISK

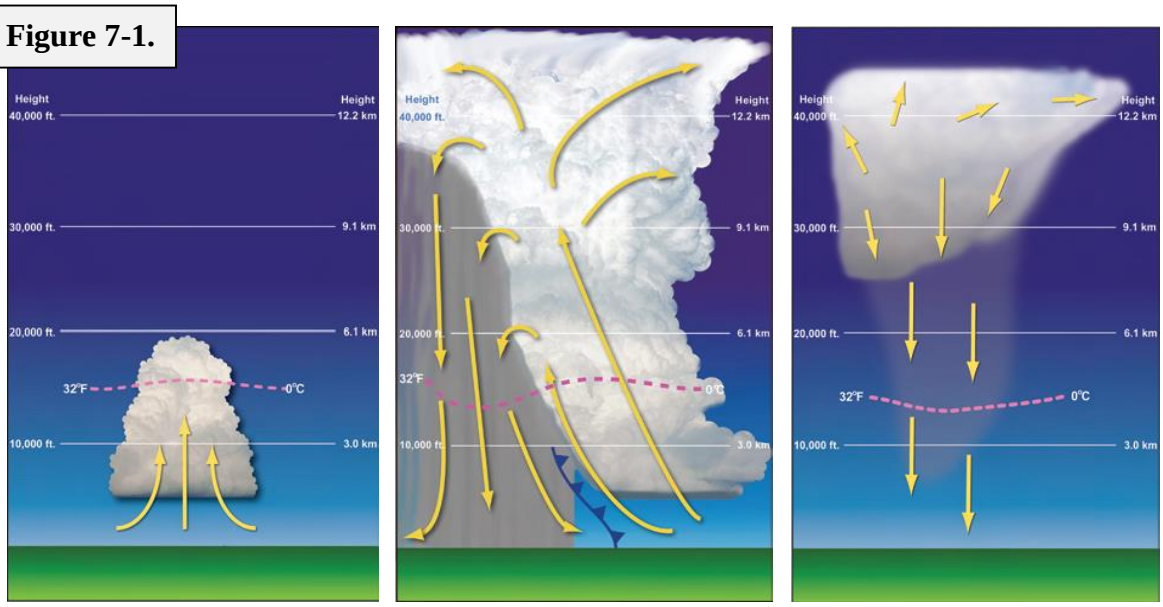
7.2.1 Temperature

Thunderstorms most commonly occur in the afternoon after daytime heating of the land by the sun has caused the lower portion of the troposphere to become unstable from the higher temperatures. Conversely, thunderstorms can form as a result of the upper atmosphere becoming unusually cool due to the approach of an upper air disturbance. Under these circumstances, thunderstorms can form at any time of the day, even when heating of the lower atmosphere has not occurred during the day.[2]

7.2.2 Moisture

In order for a thunderstorm to form, there must be sufficient water vapor since clouds and precipitation originate as water vapor. This water vapor acts as fuel for the thunderstorm; as the storm uses this fuel it is converted into rainfall. Eventually, the thunderstorm uses the excess water vapor, which causes the atmosphere to stabilize as the lower atmosphere cools and the upper atmosphere warms.[3] The full thunderstorm lifecycle is represented in Figure 7-1, following.

Figure 7-1.



Developing Stage
- Towering cumulus cloud indicates rising air
- Usually little if any rain during this stage
- Lasts about 10 minutes
- Occasional lightning

Mature Stage
- Most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes
- Storm occasionally has a black or dark green appearance
- Lasts an average of 10 to 20 minutes but some storms may last much longer

Dissipating Stage
- Downdrafts, downward flowing air, dominate the storm
- Rainfall decreases in intensity
- Can still produce a burst of strong winds
- Lightning remains a danger

Source: NOAA, NWS

7.3 HISTORY OF THUNDERSTORMS

7.3.1 Lightning Events

According to the National Weather Service (NWS), lightning causes an average of 55-60 fatalities and 400 injuries per year. Additionally, lightning occurs with all thunderstorms and damages caused by lightning strikes cost more than $1 billion in insured losses per year.

Table 7-1 contains the severe lightning events recorded by the NCDC that occurred between 1996 and 2012 in Baltimore County. In total, 11 severe events were recorded during the seventeen year period; one included a reported injury, and three reported significant property damages.

Lightning Quick-Facts
- ✓ There is no safe place outdoors when a thunderstorm is nearby.
- ✓ Lightning fatalities are most common during summer afternoons and evenings.
- ✓ Many wildfires in the western U.S. and Alaska are ignited by lightning (see *Chapter 9* for more information regarding wildfires).

Source: NOAA, NWS

Table 7-1. Severe Lightning Events, 1996-2012			
Location	Date	Injuries	Property Damage
Baltimore Metro	7/2/1996	0	$10,000
Hereford	3/29/1997	1	$0
Countywide	6/12/2001	0	$0
Catonsville Manor	6/20/2001	0	$0
Towson	7/1/2001	0	$1,000,000
Baldwin	8/27/2003	0	$0
Towson	8/27/2003	0	$0
Cockeysville	5/17/2004	0	$0
Brooklandville	5/21/2004	0	$0
Reisterstown	7/7/2004	0	$0
Daniels	4/20/2008	0	$15,000
Totals:		1	$1,025,000

Source: NOAA, NCDC

7.3.2 Hail Events

Hail Quick-Facts

- ✓ Hail can be larger than a softball (5 inches in diameter).
- ✓ Large hailstones can fall at speeds greater than 100 mph.
- ✓ The largest hailstone ever recorded in the U.S. was 7 inches wide.
- ✓ Hail causes more than $1 billion in crop and property damage per year.

Source: NOAA, NWS

Hail is created when strong updrafts lift water droplets to such an altitude that freezing occurs. These frozen droplets are held by the updraft until they increase to such as size where the wind is no longer able to keep them suspended, at which point they fall to the ground. In general, hail is larger than sleet and only forms during a thunderstorm. According to the NWS, the severity of hail events is determined by the size of the hailstone; hail equal to or greater than one inch is considered to be severe.

Table 7-2 contains the severe hail events recorded by the NCDC that occurred between 1996 and 2012 in Baltimore County. In total, 39 events were recorded during the seventeen year period; one included a reported injury, and two reported significant property damages.

Table 7-2. Severe Hail Events, 1996-2012				
Location	Date	Magnitude	Injuries	Property Damage
Reisterstown	6/26/1998	1.00 in.	1	$25,000
Hereford	7/30/1999	4.00 in.	0	$0
Cockeysville	7/30/1999	1.75 in.	0	$0
Cockeysville	5/13/2000	1.00 in.	0	$0
Rosedale	7/14/2000	1.75 in.	0	$0
White Marsh	5/13/2002	1.75 in.	0	$0
South Portion	8/3/2002	1.00 in.	0	$0
Towson	8/22/2003	1.75 in.	0	$0
Towson	5/17/2004	1.00 in.	0	$0
Essex	7/1/2004	2.75 in.	0	$0
Towson	6/6/2005	1.00 in.	0	$0
Perry Hall	4/3/2006	1.00 in.	0	$0

Location	Date	Magnitude	Injuries	Property Damage
Dundalk	4/3/2006	1.00 in.	0	$0
Perry Hall	7/2/2006	1.00 in.	0	$0
Catonsville Manor	7/4/2007	1.00 in.	0	$0
Lutherville	6/10/2008	1.00 in.	0	$0
Timonium	6/10/2008	1.75 in.	0	$5,000
Dundalk	7/22/2008	1.75 in.	0	$0
White Marsh	8/2/2008	1.00 in.	0	$0
Baltimore Martin St	8/2/2008	1.00 in.	0	$0
Poplar	6/20/2009	1.25 in.	0	$0
Harewood Park	4/25/2010	1.00 in.	0	$0
Maryland Line	5/14/2010	1.75 in.	0	$0
Rogers Forge	5/14/2010	1.00 in.	0	$0
Halethorpe	5/14/2010	1.00 in.	0	$0
Essex	7/7/2011	1.00 in.	0	$0
Dundalk	7/7/2011	1.00 in.	0	$0
Pleasant Grove	8/18/2011	1.00 in.	0	$0
Middle River	8/19/2011	1.00 in.	0	$0
Carney	8/19/2011	1.00 in.	0	$0
Dundalk	8/21/2011	1.00 in.	0	$0
Dundalk	8/21/2011	1.25 in.	0	$0
Edgemere	8/21/2011	1.00 in.	0	$0
Sunnybrook	6/29/2012	1.00 in.	0	$0
Kenwood	6/29/2012	1.00 in.	0	$0
Parkville	8/14/2012	1.50 in.	0	$0
Carney	8/14/2012	1.00 in.	0	$0
Parkville	8/14/2012	1.00 in.	0	$0
Poplar	8/14/2012	1.00 in.	0	$0
Totals:			1	$30,000

Source: NOAA, NCDC

7.3.3 Severe Thunderstorm Profile: Derecho

On the evening of June 29, 2012 a long-lived line of severe thunderstorms struck Baltimore County with prolific lightning and wind gusts that exceeded 75 miles per hour. Numerous trees and limbs were knocked down onto homes, power lines, and parked vehicles. The majority of the damages observed were in the Towson area. It took over a week to fully restore power to all Baltimore County residents.

7.4 VULNERABILITY ASSESSMENT

Thunderstorms have the potential to impact all of Baltimore County, therefore specific thunderstorm prone areas were not identified. Instead, general safety guidelines, specifically as they relate to hail and lightning, have been outlined. Please see *Chapter 6: Tornadoes* for more information regarding tornadoes as they relate to thunderstorms.

Those who are outside during a thunderstorm event are most at risk for injury or death caused by lightning strikes or sufficiently large hail stones. In fact, there is no safe place outside during a

thunderstorm, regardless of geographic location or time of day. The single most effective strategy for avoiding injury caused by thunderstorms is to stay inside, or seek indoor shelter immediately; the vast majority of lightning victims were going to a safe place but waited too long before seeking safe shelter[4].

If you are unable to reach a sturdy shelter during a thunderstorm event, remember these tips to minimize your risk of being struck by lightning:

- Avoid open areas and stay away from isolated tall trees or other structures that may act as a lightning rod;
- Stay away from metal conductors such as wires or fences.

All structures are at risk of being damaged from lighting or hail during a thunderstorm event, but some are particularly vulnerable depending on several factors. Structures most at risk to a lightning strike are those that are taller, elevated on a hill, have large protrusions (such as a steeple) that may act as a lightning rod, or are in close proximity to trees. A structure would be more vulnerable to hail strikes depending upon the construction materials used for the structure. Buildings that are tall and have large amounts of glass-facing are particularly at risk.

7.5 2014 MITIGATION GOALS AND ACTION ITEMS

During the 2014 Plan Update, new mitigation goals and action were added. Additionally, previous mitigation goals and action items from the 2006 Plan were reviewed, and those that were determined to be still in progress or relevant were included.

GOAL 1: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about natural hazards risks, preparedness and mitigation.	1. Continue to promote thunderstorm education on the County web site for homeowners and businesses.	County	Medium
	2. Target educational material to residents and businesses that meet the criteria for structures which are particularly vulnerable to lightning and hail.	County	Medium
	3. Provide a link on the County website to the NOAA/NWS preparedness guide, "Thunderstorms, Tornadoes, Lightning…."	County	Medium
2. Continued education for emergency responders and personnel.	1. Provide staff training in the form of a damage assessment course so that emergency personnel are up-to-date on the latest techniques for assessing thunderstorm related damage, as well as any other major natural disaster. This course, and those like it, would be beneficial to new staff members, and provide a refresher for current staff.	County	High

GOAL 2: Eliminate or reduce human, environmental, social and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Enforce current building standards.	1. Continue to perform building inspections to ensure compliance with current building standards as they relate to maximum wind loads.	County	Medium

7.6 EXISTING THUNDERSTORM MITIGATION ACTIVITIES

- Established in 2007, the Emergency Notification System (ENS) notifies citizens and businesses of emergency situations that may require time-sensitive protective action. This system sends a recorded message and/or e-mail to homes and businesses within the County, which provides safety information and instructions.
- Utilization of social media (Facebook and Twitter) to disperse warnings and information prior to and during a severe weather event.
- Promotion of lightning safety for all residents on the County website.
- Educational opportunities, including the recent "Skywarn" class offered by the Baltimore County Office of Homeland Security and Emergency Management. The goal of the class is to educate the public on hazardous weather threats and allow them to provide "real-time" observations of tornadoes, hail, rain/snow totals, wind, and cloud formations.

[1] http://www.nws.noaa.gov/om/severeweather/resources/ttl6-10.pdf
[2] NOAA, NWS
[3] NOAA, NWS
[4] http://www.nws.noaa.gov/om/severeweather/resources/ttl6-10.pdf

CHAPTER 8: HIGH WINDS

During the 2013 Kick-off Meeting for the Baltimore County Hazard Mitigation Plan Update, the Hazard Mitigation Planning Committee (HMPC) determined that a chapter dedicated to High Winds should be added to the Plan Update. This hazard was ranked as 'medium-high' by the HMPC. Contents of this chapter include a profile of the hazard, high wind risk factors, a history of high wind events in Baltimore County, a Hazus Level 2 Analysis for Hurricane Winds, and mitigation action items.

8.1 HOW ARE HIGH WINDS A THREAT TO BALTIMORE COUNTY?

Wind poses a threat to Baltimore County in many forms, including winds produced by severe thunderstorms and tropical weather systems, such as hurricanes. The damaging effects of high wind can include blowing debris from trees and structures, interruptions to above ground power and communication systems, and intensified effects of winter weather. Harm may occur to both people and animals, and damage often occurs to property and infrastructure.[1]

8.2 CONTRIBUTING FACTORS TO HIGH WIND RISK

Aside from tropical cyclones, which are discussed in *Chapter 13 Coastal Storm and Flooding*, Baltimore County is most commonly affected by thunderstorm winds. The most prevalent type of wind event associated with thunderstorms is straight-line wind, which is responsible for most thunderstorm wind damage. Straight-line winds, also known as downbursts, are produced by the downward momentum in the downdraft region of a thunderstorm. They earn their name from the fact that, unlike a tornado, which spreads debris in multiple directions, straight-line winds push debris in the same direction that the wind is blowing.[2] These winds can exceed speeds of 125 mph and can cause destruction equal to that of a tornado.[3]

In severe cases, thunderstorms may produce a derecho, which is a type of straight-line wind storm that is widespread, long-lived, and fast-moving. Winds in a derecho can be enhanced by downburst clusters embedded inside the storm. These straight-line winds may exceed 100 miles per hour (mph), and have been known to reach 130 mph; the derecho event that affected Baltimore County in June of 2012 had recorded wind speeds that exceeded 75 mph. Tornadoes sometimes form within derecho events, although such events are often difficult to confirm due to the additional damage caused by straight-line winds in the immediate area.[4]

8.3 HISTORY OF HIGH WIND IN BALTIMORE COUNTY

Between 2003 and 2013, there were 79 severe thunderstorm events recorded in the National Climatic Data Center (NCDC) database for Baltimore County. This translates to an average of 7.9 severe thunderstorm wind events per year within the County. In total, high winds from thunderstorms have caused an estimated $843,500 in damages. This number is likely much higher, as the NCDC database is only able to provide estimates of damages from sources such as news

and property owner reports. Table 8-1 further details these severe thunderstorm wind events, including wind speed, and reported property damages.

Table 8-1. Severe Thunderstorm Wind Events, 2003 to 2013

Location(s)	Date	Wind Speed	Property Damage ($)
Countywide	6/13/2003	58 mph	2,000
Countywide	7/6/2003	58 mph	5,000
North Portion	7/12/2003	58 mph	8,000
Countywide	8/16/2003	58 mph	6,500
Countywide	8/22/2003	58 mph	5,000
Countywide	8/26/2003	63 mph	20,000
Carney, Towson, Kingsville, Woodlawn	5/2/2004	63 mph	18,500
Parkville	5/2/2004	61 mph	2,000
Reisterstown	5/25/2004	69 mph	5,000
Cockeysville	6/14/2004	63 mph	2,000
Bradshaw	6/17/2004	75 mph	2,000
Parkville, White Marsh	7/1/2004	63 mph	3,000
Essex	7/1/2004	67 mph	3,000
Parkville, Perry Hall	7/5/2004	69 mph	24,000
Essex	7/7/2004	66 mph	1,000
White Marsh	7/12/2004	69 mph	1,500
Cockeysville	8/4/2004	63 mph	2,000
Reisterstown	8/12/2004	58 mph	1,500
Jacksonville	8/8/2005	58 mph	4,000
Parkville	7/2/2006	58 mph	10,000
Cockeysville	7/4/2006	58 mph	25,000
Boring	9/28/2006	58 mph	22,000
Freeland	5/16/2007	58 mph	10,000
Upperco	6/12/2007	58 mph	1,000
Cockeysville	6/13/2007	58 mph	2,000
Cockeysville	7/10/2007	58 mph	2,000
Phoenix	7/16/2007	58 mph	10,000
Reisterstown	8/25/2007	58 mph	2,000
Holbrook, Cockeysville, Parkton	3/8/2008	58 mph	17,000
Ruxton, Padonia, Cockeysville, Beckleysville	4/20/2008	58 mph	4,000
Belltown, Dundalk, Upper Falls, Kingsville, Baldwin	6/4/2008	58 mph	115,000
Brooklandville, White Hall, Bentley Springs, White House, Lutherville, Riderwood, Long Green, Timonium, Cockeysville	6/10/2008	58 mph	165,000
Dundalk	7/22/2008	58 mph	3,000
Ashland, Cockeysville	7/30/2008	58 mph	13,000
Milford	7/12/2010	60 mph	1000
Bowleys Quarters	7/18/2010	60 mph	2000
Hydes	9/22/2010	75 mph	5,000
Long Green	9/22/2010	81 mph	5,000
Baldwin	9/22/2010	64 mph	3,000
Parkville	11/17/2010	90 mph	10,000
Parkville	11/17/2010	81 mph	15,000
Pikesville	12/1/2010	58 mph	1,000
Owings Mills	5/27/2011	58 mph	1,000

Location(s)	Date	Wind Speed	Property Damage ($)
Baltimore Co.	6/11/2011	60 mph	1,000
Baltimore Co.	6/11/2011	64 mph	1,000
Dundalk, Turner, Sparks, Brooklandville	7/7/2011	64 mph	24,000
Dundalk	7/7/2011	60 mph	1,000
Dundalk	7/7/2011	76 mph	100,000
Baltimore Highlands	7/7/2011	70 mph	75,000
Cronhardt	7/7/2011	58 mph	2,000
Oakleigh	7/11/2011	58 mph	2,000
Dundalk	8/13/2011	70 mph	5,000
Bentley Springs	8/18/2011	64 mph	2,000
Lynch Pt.	8/19/2011	60 mph	1,000
Dundalk, Ft. Howard	8/21/2011	60 mph	2,000
Oella, Padonia, Fork	6/1/2012	66 mph	3,000
Lutherville	6/1/2012	60 mph	1,500
Padonia	6/1/2012	70 mph	5,000
Rogers Forge	6/1/2012	70 mph	7,500
Manor, Oregon, Cockeysville, Gwynnbrook, Fork	6/3/2012	60 mph	4,000
Reisterstown	6/22/2012	58 mph	2,500
Kingsville, Upper Falls, Catonsville Manor, St. Helena, Parkville, Chesaco Park	6/29/2012	66 mph	13,000
Oella	6/29/2012	76 mph	2,000
Owings Mills, Kenwood	6/29/2012	70 mph	1,000
Kenwood	6/29/2012	60 mph	1,000
Chadwick Manor	7/2/2012	64 mph	15,000
Glencoe	7/5/2012	60 mph	1,000
Fullerton	7/24/2012	60 mph	1,000
Fowblesburg, Cockeysille	7/26/2012	60 mph	2,000
Essex, Baltimore Martin St.	8/5/2012	64 mph	1,000
Belmont	8/9/2012	60 mph	500
Rogers Forge	8/14/2012	60 mph	1,000
Brooklandville	9/1/2012	58 mph	500
Arcadia	9/8/2012	58 mph	500
Oella	9/18/2012	58 mph	500
Woodensburg, Sweet Air	6/13/2013	60 mph	750
Franklinville	6/25/2013	60 mph	250
Beckleysville	7/28/2013	64 mph	2,000
Lutz hill	9/12/2013	58 mph	1,000
Totals:	-	-	$843,500
Note: Only includes those wind events greater than or equal to 58 mph and those causing reported property damage.			

Between 2003 and 2013, there were four (4) severe high wind events recorded in the NCDC database for Baltimore County. This translates to an average of 0.4 severe high wind events per year within the County. In total, severe high wind events have caused an estimated $8,811,000 in damages. This number is likely higher, as the NCDC database is only able to provide estimates of damages from sources such as news and property owner reports. Table 8-2 further details these severe high wind events, including wind speed, and reported property damages.

Table 8-2. Severe High Wind Events, 2003 to 2013			
Location	Date	Wind Speed	Property Damage ($)
Countywide	1/14/2006	58 mph	200,000
Countywide	4/16/2007	58 mph	10,000
Southern Baltimore	2/19/2011	60 mph	1,000
Countywide	10/29/2012	68 mph	8,600,000
Totals:	-	-	8,811,000
Note: Only includes those wind events greater than or equal to 58 mph and those causing reported property damage.			

8.4 HAZUS Level 2 Hurricane Wind Analysis – 2013

8.4.1 Plan Update

As part of the 2014 Plan Update, a HAZUS Level 2 Analysis was conducted for *Chapter 8 High Winds.* Results of this type of analysis include essential facility and general building stock damages, debris generation, shelter requirements, and associated economic losses. This level of analysis is more accurate than a Level 1 Analysis because the data used for the analysis is derived from user-supplied sources, including best-available data specific to Baltimore County, as well as data available in the Hazus database. Examples of user-supplied data utilized for this analysis include:

Table 8-3. HAZUS Default Data v. County Data

Critical Facility Type	HAZUS Default Data (utilized in HAZUS Level 1 Analyses)	County Data Utilized for HAZUS Level 2 Analysis
Fire stations/EMS	16	65
Police Stations	10	20
Schools	132	375
Medical Facilities	0	25
EOC	1	1

- Building stories
- Year built
- Structure value
- Square Footage

U.S. Census Bureau Data Utilization

The HAZUS analysis conducted during the 2014 Plan Update utilized the most recent version of the software (version 2.1), which was released in October of 2013. At the time of this HAZUS Level 2 Analysis for Hurricane Wind, FEMA had not yet integrated 2010 Census data into the Hazus version 2.1 software. This data will be made available with the next release. As such, household numbers and other demographic data has been increased by 5.6% to better represent the total number of households (316,716) in Baltimore County per the 2010 U.S. Census. This percentage increase was derived by determining the percent change in demographic data from 2000 to 2010. For example, the total number of households in Baltimore County has changed from 299,000 in 2000 to 316,715 in 2010, which represents an increase of 17,715 households. This change was calculated as a percentage (5.6%) and related household values were increased by this amount where necessary (see Table 10-6). In the case of population estimates, a 6.3% change was calculated and added to necessary population values.

8.4.2 Introduction

The Hurricane Model allows practitioners to estimate the economic and social losses from hurricane winds. Although the software offers users the opportunity to prepare comprehensive loss estimates, it should be recognized that, even with state-of-the-art techniques, uncertainties are

inherent in any such estimation methodology. The next major hurricane to affect your area will likely be quite different than any "scenario hurricane" anticipated as part of a hurricane loss estimation study. Hence, the results of a scenario analysis should not be looked upon as a prediction but rather as an indication of what the future may hold.

Note: The full report of the HAZUS Level 2 Analysis for Hurricane Wind is included in Appendix B.

8.4.3 County Overview

Baltimore County is roughly 607 square miles and contains 204 census tracts. The region contains 316,715 households and has a total population of 805,029 people (2010 Census Bureau data). There are an estimated 269,655 buildings in the region with a total building replacement value (excluding contents) of 59,023 million dollars (2006 dollars). Approximately 93% of the buildings (and 76% of the building value) are associated with residential housing.

HAZUS Hurricane Wind Parameters

Study Region: Baltimore County
Scenario: Probabilistic (worst-case)
Return Period Analyzed: 1000

The hurricane event selected for this analysis of Baltimore County was the 1000-year event, which represents a worst-case scenario. The chosen storm path, higlighted on Map 8.1 below, represents a storm path that could conceivably cause the highest amount of damage via high winds.

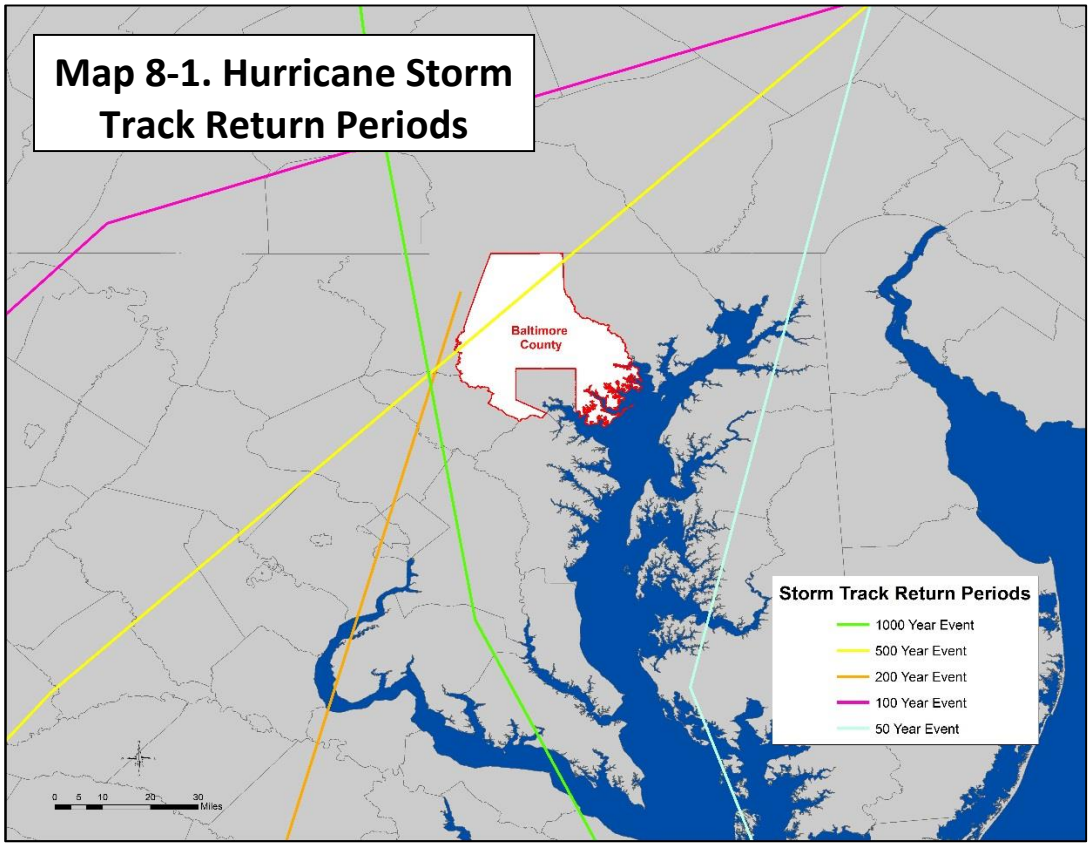


Table 8-4, below, provides building exposure values by occupancy type for the hurricane wind event scenario. The information contained in this table represents only building stock that was determined by HAZUS to have been affected ("exposed") by the hurricane wind event.

Table 8-4. Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	44,564,549	75.5%
Commercial	10,305,313	17.5%
Industrial	1,993,397	3.4%
Agricultural	157,750	0.3%
Religion	974,720	1.7%
Government	334,611	0.6%
Education	692,717	1.2%
Total	**59,023,057**	**100.00%**

Note: Dollar exposure values are produced from the square footage values derived from U.S. Census data, Maryland Property View, and Dun & Bradstreet, by applying the RS Means replacement values for typical building square foot factors and construction for each occupancy type.

Essential Facility Inventory

Critical facilities were broken down into two groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants, and hazardous material sites.

For essential facilities, there are 25 hospitals in the region with a total bed capacity of 1,800 beds. There are 375 schools, 65 fire stations, 20 police stations and 1 emergency operation facilities.

8.4.4 Damage Estimates

General Building Stock Damage

Hazus estimates that about 4,067 buildings will be at least moderately damaged. This is over 2% of the total number of buildings in the region. There are an estimated 123 buildings that will be completely destroyed. Table 8-5, below, summarizes the expected damage by general occupancy for the buildings in the scenario.

Table 8-5. Expected General Building Stock Damage by Occupancy										
	None		Minor		Moderate		Severe		Destruction	
Occupancy	Count	%	Count	%	Count	%	Count	%	Count	%
Agriculture	701	89.39	63	8.06	14	1.73	6	0.75	1	0.07
Commercial	12,382	91.63	939	6.95	175	1.30	18	0.13	0	0.00
Education	446	92.47	32	6.61	4	0.88	0	0.03	0	0.00
Government	331	92.09	24	6.75	4	1.10	0	0.06	0	0.00
Industrial	3,348	91.48	257	7.02	47	1.30	7	0.19	0	0.01
Religion	1,051	92.29	79	6.95	8	0.74	0	0.02	0	0.00
Residential	217,017	86.91	28,918	11.58	3,590	1.44	70	0.03	122	0.05
Total	**235,276**		**30,312**		**3,843**		**101**		**123**	

The majority of damage from hurricane winds is expected to be minor, representing 11.2% of the total building stock within the County. Residential buildings are expected to make up the largest percentage of buildings with minor damage – 11.6%. Map 8-2 depicts regions where minor residential damage is expected to occur, by percentage affected. Minor residential damage is fairly uniform throughout the County, with notable exceptions along the coastline.

Essential Facility Damage

Before the hurricane, Baltimore County had 1,800 hospital beds available for use. On the day of the hurricane, the model estimates that 1,228 will be unavailable for use. After one week, all of the beds are expected to be in service. Table 8-6, below, summarizes the expected damage to essential facilities in Baltimore County due to the proposed hurricane event.

Table 8-6. Expected Damage to Essential Facilities				
Classification	Total	Probability of at Least Moderate Damage > 50%	Probability of Complete Damage > 50%	Loss of Use (< 1 day)
EOCs	1	0	0	1
Fire Station	65	0	0	65
Hospital	25	8	0	13
Police Station	20	0	0	20
School	375	0	0	150

8.4.5 Induced Hurricane Wind Damage

Debris Generation

Map 8-3 represents hurricane wind speed by peak gust. Peak gust is the maximum sustained wind speed for a three second period. Baltimore County can expect the highest wind speeds near its coastal region, with speeds near 100 miles per hour. The map clearly depicts that wind speeds are expected to drop as one moves westward across the county. The most western portion of the county

can expect wind speeds between 85 and 88 miles per hour, which are still significant and dangerous. The wind speeds depicted on Map 8-3 are not a result of the linear path of the hurricane, which is shown on Map 8-1 to be outside of Baltimore County, but rather due to the clockwise rotation of hurricane winds. The most damaging winds from a hurricane typically occur within its northeast quadrant. The 1000-year storm track chosen for this analysis places the northeast quadrant directly over the County, which explains the peak gust patterns depicted on Map 8-3.

Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. 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 314,170 tons of debris will be generated. Of the total amount, 153,219 tons (49%) is Other Tree Debris. Of the remaining 160,951 tons, Brick/Wood comprises 49% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris.

If the building debris tonnage is converted to an estimated number of truckloads, it will require 3,139 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 82,487 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, un-compacted debris.

Map 8-4 depicts the total tonnage of tree debris expected to be generated by location. Areas expected to have the most tree debris include Middle River, areas surrounding Loch Raven Reservoir, and areas around Liberty Reservoir.

8.4.6 Economic Loss

The total economic loss estimated for the hurricane is 543.6 million dollars, which represents 0.92 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage 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 hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 544 million dollars. Two percent of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the

residential occupancies which made up over 90% of the total loss. Table 8-7, below, provides a summary of the losses associated with building property damage, and Table 8-8 provides a summary of business interruption loss estimates.

Table 8-7. Building-Related Property Damage (Thousands of Dollars)					
Type	Residential	Commercial	Industrial	Others	Total
Building	393,025	19,506	5,336	4,175	422,042
Content	65,474	3,910	2,933	930	73,246
Inventory	0.0	116	660	53	830
Total	**458,499**	**23,531**	**8,930**	**5,158**	**496,117**

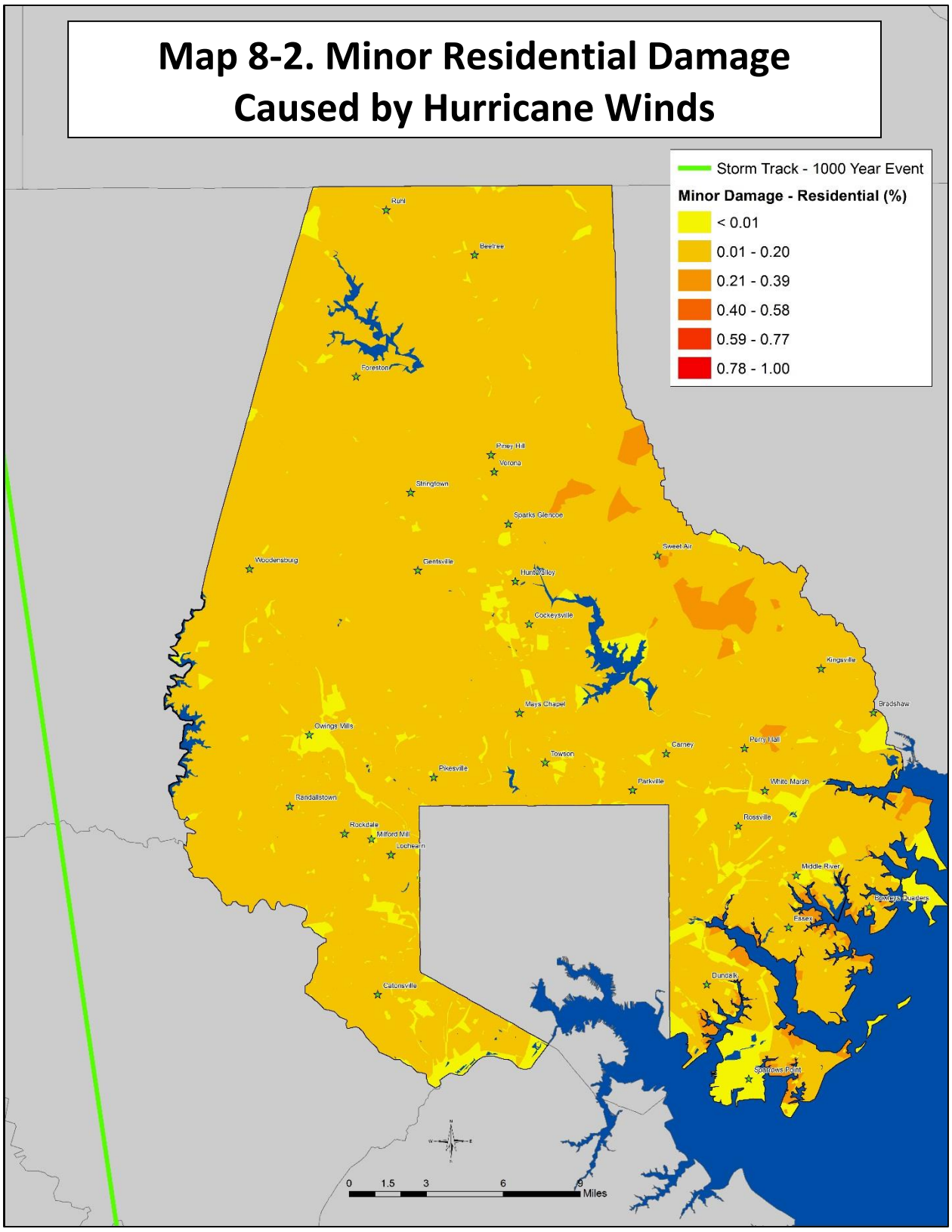
Table 8-8. Business Interruption Loss Estimates (Thousands of Dollars)					
Type	Residential	Commercial	Industrial	Others	Total
Income	0	3,041	63	437	3,541
Relocation	22,141	3,496	306	626	26,569
Rental	10.727	1,739	52	52	12,579
Wage	0	2,475	105	2,266	4,846
Total	**32,868**	**10,750**	**527**	**3,382**	**47,527**

8.4.7 Social Impact

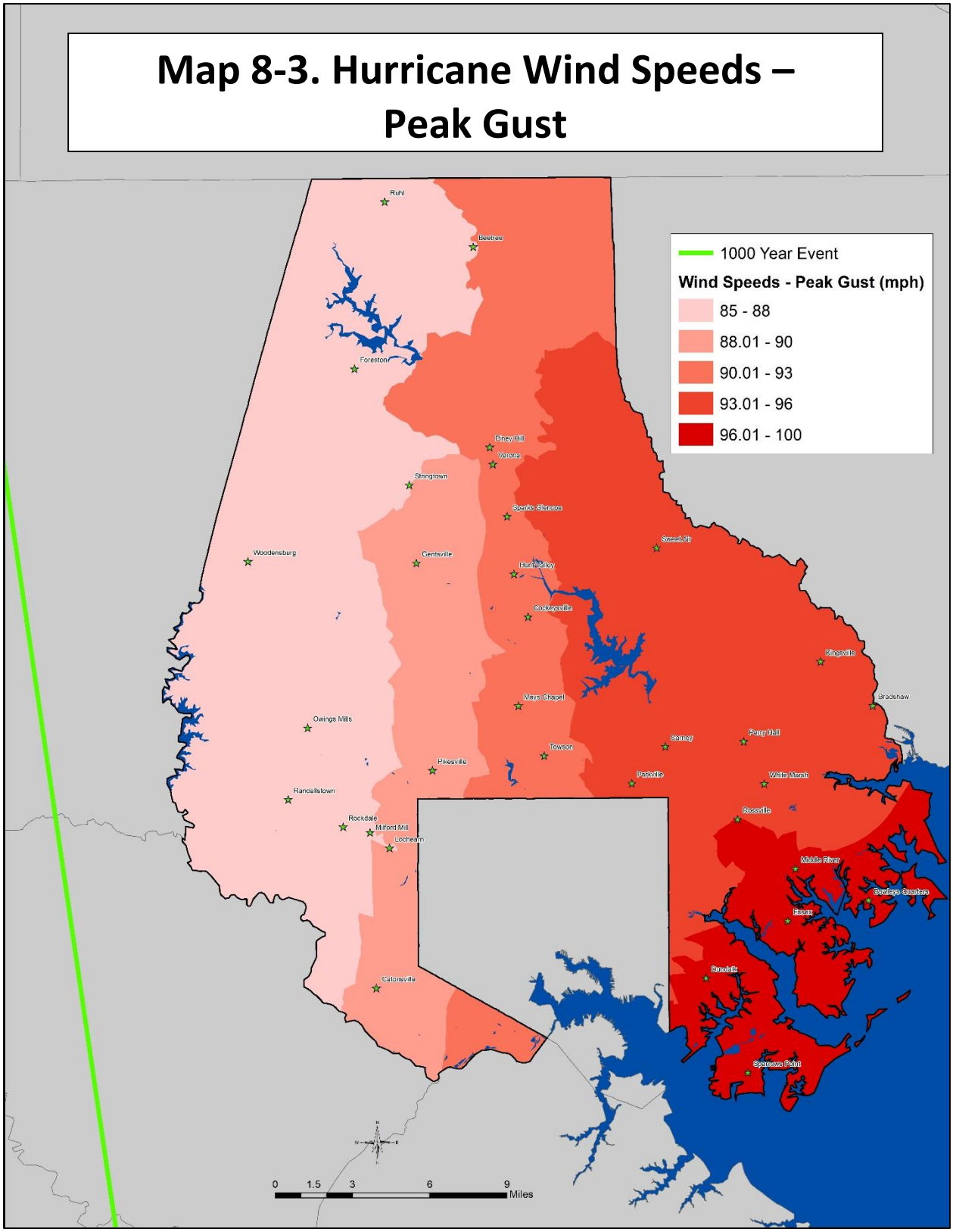
Shelter Requirements

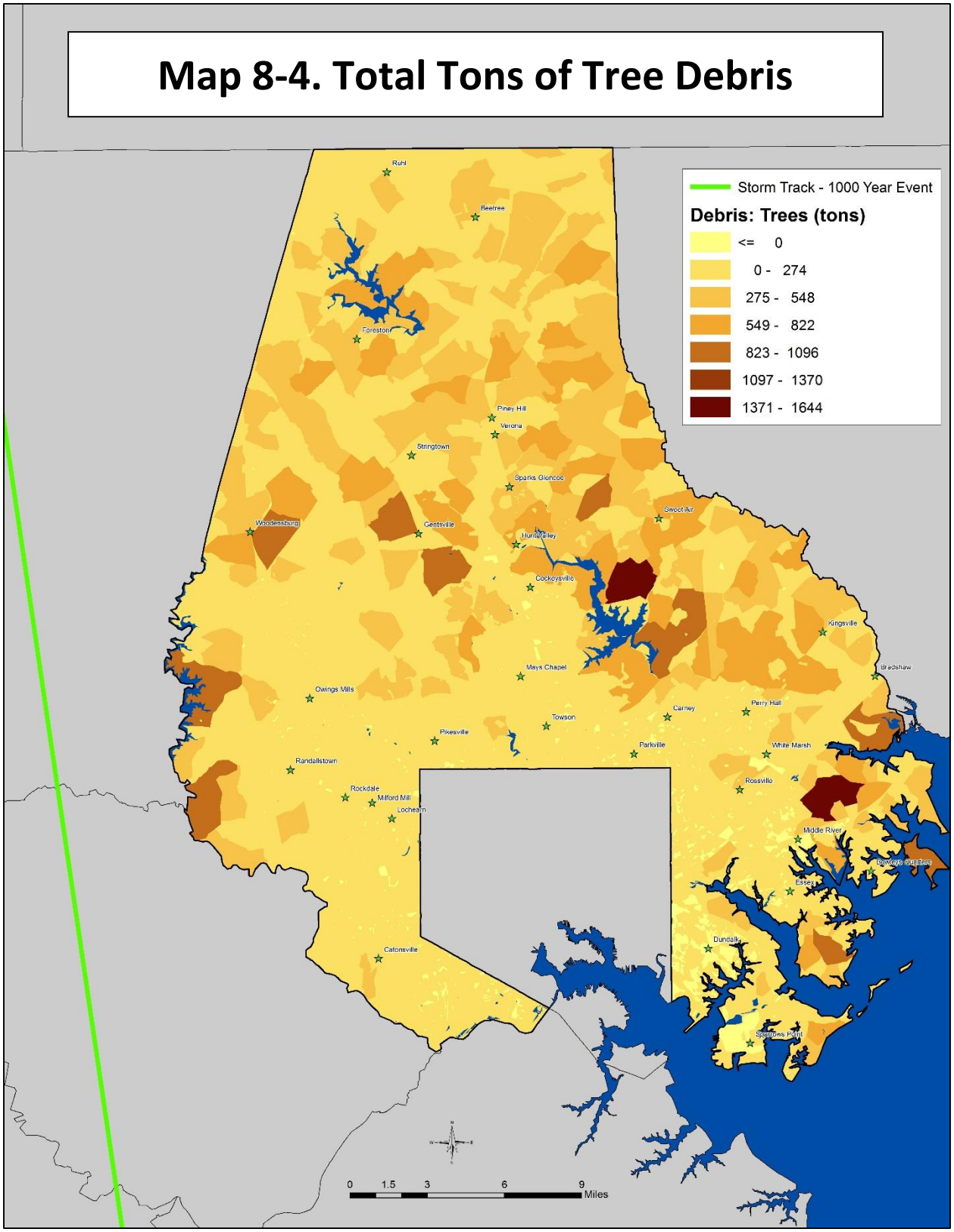
Hazus estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 8 households to be displaced due to the hurricane. Of these, one (1) person (out of a total population of 805,029) will seek temporary shelter in public shelters.

Map 8-2. Minor Residential Damage Caused by Hurricane Winds



Map 8-3. Hurricane Wind Speeds – Peak Gust




Map 8-4. Total Tons of Tree Debris
Storm Track - 1000 Year Event
Debris: Trees (tons)
<= 0
0 - 274
275 - 548
549 - 822
823 - 1096
1097 - 1370
1371 - 1644
Ruhl
Reetree
Foreston
Piney Hill
Veronia
Stringtown
Sparks Glencoe
Sweet Air
Woodensburg
Gentsville
Hunt Valley
Cockeysville
Kingsville
Bradshaw
Mays Chapel
Owings Mills
Towson
Carney
Perry Hall
Pikesville
Parkville
White Marsh
Randallstown
Rockdale
Milford Mill
Lochearn
Rossville
Middle River
Bowleys Quarters
Essex
Dundalk
Catonsville
Sparrows Point
0 1.5 3 6 9
Miles

8.5 2014 MITIGATION GOALS AND ACTION ITEMS

GOAL 1: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about natural hazards risks, preparedness and mitigation.	1. Promote educational material on the County website relating to the dangers of, and differences between, Derechos and Tornadoes.	County	Medium
2. Provide technical assistance for homeowners regarding high winds.	1. Provide information to builders and owners of manufactured and mobile homes regarding tie-downs with ground anchors.	County	Medium
3. Continued education for emergency responders and personnel.	1. Provide staff training in the form of a damage assessment course so that emergency personnel are up-to-date on the latest techniques for assessing high wind damage, as well as any other major natural disaster. This course, and courses like it, would be beneficial to new staff members, and provide a refresher for current staff.	County	Medium

GOAL 2: Eliminate or reduce human, environmental, social and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Enforce current building standards.	1. Continue to perform building inspections to ensure compliance with current building standards as they relate to maximum wind loads.	County	Medium

GOAL 3: Provide outreach to agencies and organizations within Baltimore County regarding hazard mitigation.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Utilize planning documents, reports, and analyses as targeted material for outreach and preparedness efforts.	1. Provide HAZUS hurricane wind data regarding debris generation to the Bureau of Highways for planning and mitigation purposes.	County	Medium
	2. Include HAZUS hurricane wind data regarding debris generation as an amendment to the County's Ten Year Solid Waste Management Plan.	County	Medium

8.6 EXISTING HIGH WIND MITIGATION ACTIVITIES

- As of 2012, minimum design wind loads for buildings are more stringent. They have been changed to 90 mph for Risk Categories I and II, and 101 mph for Risk Categories III and IV.
- The *2012 International Residential Cod*e for Maryland has significantly improved roof uplift provisions, relating to roof tie-down.
- Established in 2007, the Emergency Notification System (ENS) notifies citizens and businesses of emergency situations that may require time-sensitive protective action. This system sends a recorded message and/or e-mail to homes and businesses within the County, which provides safety information and instructions.
- Utilization of social media (Facebook and Twitter) to disperse warnings and information prior to and during a severe weather event, such as a tornado.

- Educational opportunities, including the recent "Skywarn" class offered by the Baltimore County Office of Homeland Security and Emergency Management. The goal of the class is to educate the public on hazardous weather threats and allow them to provide "real-time" observations of tornadoes, hail, rain/snow totals, wind, and cloud formations.

[1] 2011 Maryland State Hazard Mitigation Plan Update
[2] http://www.theweatherprediction.com/habyhints2/406/
[3] http://www.nws.noaa.gov/om/severeweather/resources/ttl6-10.pdf
[4] http://www.erh.noaa.gov/rah/nwsletter/RAHNewsletter_Mar13.pdf

CHAPTER 9: WILDFIRE

The update process for *Chapter 9: Wildfire*, as part of the Baltimore County 2014 Hazard Mitigation Plan Update, included researching and integrating the most up-to-date and available data during this planning cycle. Updates to this chapter include: updates to existing sections and tables, new figures, tables, maps, and new formatting. As detailed in the highlighted figure, six sections have been updated in this chapter.

Chapter Highlights

Updated Sections/New Additions:
9.1 – Updated text, specifically regarding the WUI. Updated Table 9-1 with most recently available data.
9.2 – Expanded information in sections 9.2.1 through 9.2.5. Added Table 9-2.
9.3 – Updated Table 9-3 with most recent wildfire events. Added "Fire Department Facts."
9.4 – Updated vulnerability assessment with latest available data. Added Map 9-1.
9.5 – New action items for 2014.
9.6 – Updated current mitigation activities.

9.1 HOW ARE WILDFIRES A THREAT TO BALTIMORE COUNTY?

Wildfires are a threat to Baltimore County for two primary reasons: First, the amount of development, particularly residential, that has taken place within wooded areas has increased the number of structures that are along the Wildland-Urban Interface (WUI) and within the Wildland-Urban Intermix. Second, wildfires have the ability to interact with other natural hazards, especially drought.

The WUI interface is defined by the National Fire Protection Association (NFPA) as "an area where development and wildland fuels meet at a well-defined boundary." Characteristics of the interface involve structures built adjacent to wildland vegetation. Another term, wildland-urban intermix, refers to "an area where development and wildland fuels meet with no clearly defined boundary." The wildland-urban intermix areas are where individual homes or pockets of structures are surrounded by wildland fuels. This situation is very common in Northern Baltimore County, which increases the number of people that are living in or near forested areas.

As many as 90 percent of wildland fires in the United States are caused by humans. Some human-caused fires result from campfires left unattended, the burning of debris, negligently discarded cigarettes and intentional acts of arson. The remaining 10 percent are started by lightning or lava.[1] Table 9-1, below, details some of these events, and their causes, in the form of the most extensive wildfires in the County from 2005 to 2010.

The number of wildfires can increase dramatically in the presence of other natural hazards, especially extreme heat and drought. Excessive heat and drying can facilitate the start of a fire, and then intensify its behavior depending upon local topography and the types of fuel available.

Table 9-1. Most Extensive Wildfires*, 2005-2010

Date	Cause	Total Acres
3/10/2006	Smoking	3
3/16/2006	Smoking	3
3/21/2006	Smoking	3

Date	Cause	Total Acres
3/29/2006	Smoking	3
4/20/2005	Smoking	4
5/7/2005	Campfire	4
4/12/2010	Arson	4.5
4/4/2005	Railroad	5
4/16/2005	Railroad	5
4/17/2005	Railroad	5
3/29/2008	Arson	5
4/19/2008	Children	5
4/13/2005	Smoking	17.7
* Includes only fires greater than or equal to three (3) acres. Note: Best available data utilized from the Maryland DNR Forest Service.		

Source: Maryland Department of Natural Resources, Maryland Forest Service database 2005-2010

9.2 CONTRIBUTING FACTORS TO WILDFIRE RISK

9.2.1 Type of Fuel

The type and amount of fuel available will affect wildfire potential and behavior. Fuels are classified based on the type of vegetation in a given area, and consist of: ground fuels, surface fuels, and crown fuels. The moisture level within the fuel will also play a role in how it will burn. Large, more continuous areas where fuel is present will increase the potential for larger wildfires. Of the wildfires that have occurred in Baltimore County (Table 9-2), the majority (85%) occurred in woodland environments and utilized hardwood litter as a primary fuel source. The remaining 15% occurred in marshland and utilized tall grass as a primary fuel source. In all cases, these would be considered surface fuels.

Table 9-2. Description of Fuel Types

Fuel Type	Description	Example
Ground fuel	This vegetation is close to the ground or lying on the ground. Ground fuels include dead grass and leaves; needles, dead branches, twigs, and logs.	
Surface fuel	These plants and trees are closer to the ground, but are not actually lying on the ground. They are usually made up of shrubs, grasses, low-hanging branches and anything not located in the high branches of the trees that may burn. They can also be referred to as “ladder fuels,” because fire can move from ground fuels to surface fuels, then on to crown fuels.	

Crown/Aerial fuel	Crown fuels are only in the "crowns" or tops, of the trees. They do not touch the ground and are usually the high branches of trees. When a wildfire burns in the tops of the trees, firefighters call it a "crown fire."	

Source: http://www.idahofirewise.org/science/fuel-types/

9.2.2 Topography

Topography affects the movement of the fire over the ground. Steeper slopes and the general shape of the terrain affect the speed the fire will travel. The topography will also affect the ability for fire fighters and firefighting equipment to access wildfires. In Baltimore County, steeper slopes were identified as slopes 15% and greater. Utilizing ArcGIS and spatial analyst software, it was determined that steep slopes (>15%) comprise 14.6% of the land in Baltimore County. This equates to roughly 94,761 acres of land.

9.2.3 Weather

Weather plays a role in the development of wildfires in the form of temperature, humidity, and wind. At any immediate moment, hot, dry, and windy conditions will directly affect the severity and duration of a fire. For an example, a "dry thunderstorm", one that produces very little precipitation, but does produce lighting and wind, can provide the perfect recipe for a wildfire to start and spread.

9.2.4 Development

Just as with flooding hazards (see *Chapter 4 Flood*), land development patterns over the past several decades have emphasized sprawling suburban communities and homes constructed with little or no attention paid to protection against natural hazards. Building is often permitted in high hazard areas because it satisfies an economic need or locational preference. This increases the potential for property damage due to wildfire as sprawl continues and development increases near the WUI and intermix.

Residential Sprinkler Systems

Beginning January 1, 2011, all single-family homes and duplexes must be equipped with automatic sprinkler systems.

The new regulation is part of the latest edition of the International Residential Code, adopted recently by the Baltimore County Council as part of the Building Code of Baltimore County. The IRC regulates construction requirements for one- and two-family dwellings. (The code has required sprinklers in townhomes and multi-family dwellings since the early 1990s.)

Source: baltimorecountymd.gov

9.2.5 People

Most wildfires are caused by human interaction, whether it be from smoking, campfires, burning debris, or arson. Development, both high and low density, introduces higher levels of human interaction with the forest, increasing the opportunities for accidental and intentional fire.

9.3 HISTORY OF WILDFIRES

Baltimore County does not have an extensive history of high impact wildfires. Most fires to date have been caused by human actions and were quickly brought under control by local emergency response crews.

9.3.1 Time of Year

Baltimore County is more vulnerable to wildfires certain months of the year than others. As demonstrated on Table 9-3 below, March, April, and May are the months where wildfire risk is greatest because of the dry debris covering the ground, the increasing daytime temperatures, and lower relative humidity. Once the tree canopy is established in May, the risk is reduced because the canopy holds in the moisture that would otherwise evaporate during the spring months.

Fire Department Facts

- FY 2012 operating budget: $94.6 million
- 1,051 sworn employees; 36 civilians
- Firefighter's work week: 42 hours. Typical shift: two days, two nights, four days off.
- Engine and ladder company staffing: four, including officers.
- Facilities:
  - 25 career fire stations
  - Fire Department headquarters: 700 East Joppa Road, Towson
  - Fire-Rescue Academy, 1545 Sparrows Point Boulevard, Sparrows Point
  - Logistics, Glen Arm
- 35 independent volunteer fire companies, including an estimated 3,000 responders, fund-raisers, and other members of the volunteer service, provide daily EMS and suppression support to the Fire Department.

Source: baltimorecountymd.gov

Table 9-3. Wildfire Occurrence, 2000-2010

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	**Total**
Jan	1	0	1	0	0	0	0	0	0	0	0	**2**
Feb	0	1	1	0	1	0	0	0	0	0	0	**3**
Mar	4	8	0	0	0	0	8	0	2	1	0	**23**
Apr	4	5	3	2	1	5	3	1	1	0	2	**27**
May	0	2	0	0	0	2	0	1	0	0	0	**5**
Jun	0	0	0	0	0	0	0	0	0	0	1	**1**
Jul	0	2	1	0	0	0	0	1	0	0	0	**4**
Aug	0	0	2	0	0	0	0	0	0	0	0	**2**
Sep	0	0	0	0	0	0	0	0	1	0	1	**2**
Oct	0	4	0	0	0	0	0	0	0	0	0	**4**
Nov	1	8	0	0	0	0	0	0	0	0	0	**9**
Dec	0	0	0	0	1	0	1	0	0	0	0	**2**
Total	**10**	**30**	**8**	**2**	**3**	**7**	**12**	**3**	**4**	**1**	**4**	**84**

Source: Maryland Department of Natural Resources, Maryland Forest Service Database, 2000-2010

9.3.2 Cause

For the 2005 to 2010 time period recorded in DNR's database, smoking and arson caused the most wildfires in Baltimore County. These two causes combined account for approximately half of the wildfires DNR responded to in Baltimore County. Furthermore, wildfires attributed to people (smoking, arson, children, campfire) accounted for nearly 75% of the reported wildfires during this time.

9.3.3 Drought

During the years with documented drought, 2001-2002, the number of wildfires drastically increased in Baltimore County, illustrating the influence one hazard can have on another. Refer to *Chapter 5 Drought* for information regarding this hazard.

9.4 VULNERABILITY ASSESSMENT

9.4.1 Introduction

This vulnerability assessment is directed at properties with the following characteristics: contain structures that are less than 30 feet[2] from continuous vegetation tracts greater than or equal to 20 acres and within areas delineated as being relatively steeper slopes (15% and greater). Generally, these areas follow stream and ridge lines and are more likely to be undeveloped due to their steeper slopes.

9.4.2 Data Utilization

The following data sources and shapefiles were utilized to determine affected land uses, critical facilities, and infrastructure within the wildfire hazard area:

- Continuous forested tracts greater than 20 acres, derived from USGS National Land Cover Database (2006)
- Slopes greater than 15%, derived from 10 meter Digital Elevation Model
- Structures/Parcels – Baltimore County Office of Information Technology (2007/2012)
- Street Centerlines – Baltimore County Office of Information Technology (June 2013)
- Metropolitan District Line – Baltimore County Office of Information Technology (2012)
- Fire Stations, Police Stations, Schools, Colleges, Hospitals/Health Centers – Baltimore County Office of Information Technology (June 2013)
- Communication Towers – Federal Communications Commission (2010)
- Above Ground Storage Tanks, Underground Storage Tanks – MEMA (2011)
- Hazardous Waste Generators (also includes: transporters, treaters, storers and disposers) – Environmental Protection Agency (2013)

9.4.3 Method

Data listed in section 9.4.2 was analyzed using ArcMap 10.1, a geographic information system (GIS). This program allows various data layers, such as shapefiles, to be overlaid and spatially compared.

To determine vulnerable land uses, critical facilities, and infrastructure within the County, each shapefile (bridges, roadways, etc.) was intersected with the hazard area shapefile as previously described. Critical facilities, structures, and infrastructure were deemed to be vulnerable to wildfire if they were within (intersected) this hazard area.

The estimated economic losses to residential, commercial, industrial, agricultural, and tax-exempt land uses within the County due to the wildfire hazards are based on the Maryland Department of Assessments and Taxation Real Property Database for all affected parcels. Tax Exempt properties include but are not limited to Public, County, State, or Federal owned Hospitals, Schools, Museums, Airports, Police Stations, and/or Fire Departments. Also included are church properties and other non-profit or charitable organizations. Economic losses are based on assessed value of property, and do not include contents value or indirect costs related to wildfires (economic losses due to business closings).

9.4.4 Assessment Results

In total, 82,376 acres of land in Baltimore County is considered to be prone to wildfire. This means that these areas are on continuous tracts of vegetation greater than 20 acres in size, and that they are on land with a 15% or greater slope. Map 9-1, located at the end of this section, depicts these wildfire hazard areas, forested areas that are greater than 20 acres, and affected structures. Table 9-4, below, lists the buildings and parcels that are in these wildfire prone areas and their associated estimated damages.

Buildings/Structures

Table 9-4. Land Uses Within Wildfire Hazard Area

Land Use	Buildings Affected	Value of Structures	Value of Parcels
Residential	4,829	$678,411,700	$3,218,564,062
Institutional	135	$19,638,280	$145,313,120
Agricultural	-	-	$1,175,534,821
Commercial	69	$25,076,720	$211,471,600
Commercial/Residential	-	-	$11,360,390
Apartments	-	-	$182,729,790
Exempt	-	-	$55,868,097
Exempt Commercial	-	-	$161,008,260
Country Club	-	-	$74,437,700
Garage	549	-	-
Building Under Construction	5	$242,160	-
Storage Tank	15	-	-
Silo	1	-	-
Miscellaneous Structure	2,563	$87,646,668	-
Total	**8,166**	**$811,015,528**	**$5,236,287,840**

Major Bridges

There are about 537 bridges within Baltimore County. Of these, only 4 major bridges are within the wildfire hazard area. Table 9-5, below, lists total bridges within the hazard area and their location.

Table 9-5. Total Impacted Bridges by Location	
Road/River Name	Total Bridges
Blackrock Run	1
Jones Falls	1
Little Falls	1
NCR Trail	1

Roadways

In total, there are roughly 9,789 roadways within Baltimore County. Of these, 604 are within the wildfire hazard area. This translates to over 812 miles (20% of total road miles) of roadway within the hazard area. Tables 9-6 and 9-7, below, list the most impacted roads by total miles, and communities by number of affected roadways, respectively. For the most part, the greatest amount of impacted roadway miles include Driveways, Bentley Road, and Falls Road.

Table 9-6. Most Impacted Roadways by Total Miles Within the Wildfire Hazard Area			
Road Name	Total Miles	Road Name	Total Miles
Driveway	78.86	Cotter Rd	6.84
Bentley Rd	21.03	Powells Run Rd	6.57
Falls Rd	19.22	Kirkwood Shop Rd	6.24
Spooks Hill Rd	18.91	Slab Bridge Rd	6.12
Furman Ln	17.93	Carroll Rd	6.02
Road	15.58	Alberton Rd	6.00
Harris Mill Rd	14.25	Matthews Rd	5.97
Gunpowder Rd	13.47	Summit Ave	5.76
Dover Rd	10.16	Bee Tree Rd	5.60
Reynolds Rd	8.76	Blue Mount Rd	5.52
Miller Rd	8.69	Stringtown Rd	5.49
Ridge Rd	8.25	Marriottsville Rd	5.47
Ensor Rd	7.81	Mount Zion Rd	5.32
Lentz Rd	7.70	Thistle Rd	5.06
Wards Chapel Rd	7.66	Phoenix Rd	5.04
Gore Mill Rd	7.42	Notchcliff Rd	5.02
Pickall Dr	7.33	Duncan Hill Rd	4.76
Jordan Sawmill Rd	7.16	Piney Grove Rd	4.52
Wilson Rd	6.95	Green Glade Rd	4.50
Loch Raven Dr	6.90	Tanyard Rd	4.37
Note: A list of all roadways within the wildfire hazard area is included in Appendix C.			

Table 9-7. Communities by Number of Affected Roadways			
Community	Affected Roadways	Community	Affected Roadways
Owings Mills	56	Towson	11
Reisterstown	56	Parkville	9
Parkton	41	Halethorpe	8
Cockeysville	37	Manchester	8
Phoenix	35	Baldwin	7
Lutherville	34	Upperco	6
Sparks Glencoe	30	Gwynn Oak	5

Community	Affected Roadways	Community	Affected Roadways
Glen Arm	27	Hydes	4
Monkton	25	Nottingham	4
Pikesville	25	Oella	4
Kingsville	21	Perry Hall	4
Loch Raven	21	Hampstead	3
Catonsville	20	Govans	2
Freeland	20	Marriottsville	2
White Hall	17	Rosedale	2
Mount Washington	15	White Marsh	2
Randallstown	13	Fork	1
Windsor Mill	13	Middle River	1
Woodstock	12	Roland Park	1

Communication Towers

6 Communication

- KNRT (Glyndon)
- WNUT (Towson)
- WPJK (Baltimore)
- WPLA (Halethorpe)
- WPWR (Cockeysville)
- WPXZ (Worthington Valley)

Critical Facilities

1 School

- Maryvale Preparatory School (Lutherville)

2 Above Ground Storage Tanks That House/Generate Industrial/Hazardous Materials

- Valvoline Instant Oil Change (Cockeysville)
- Rittenhouse Fuel Company (Parkton)

11 Underground Storage Tanks

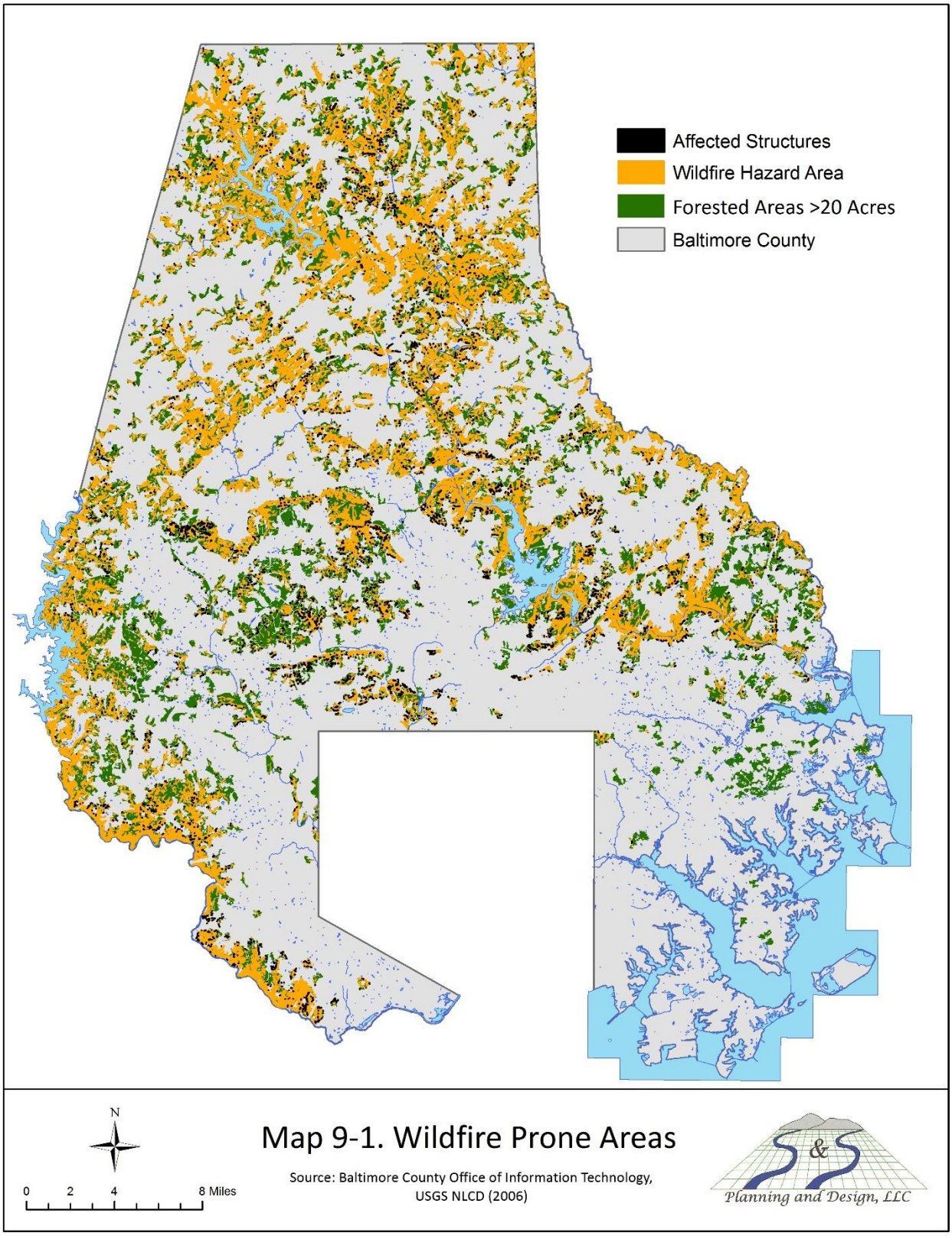
- 6 Currently In Use
- 5 Permanently Out of Use

3 Hazardous Waste Generators

- Columbia Technologies (Halethorpe)
- Lewis Cleaners (Woodlawn)
- Maryvale Preparatory School (Lutherville)

Development Impacts

Wildfire events are largely unpredictable, which means all development within the hazard area has the potential to experience damage caused by a wildfire. In terms of future growth and development, Owings Mills is the designated Growth Area in the County. Parts of Owings Mills are within the wildfire hazard area and it is the most impacted community in terms of roadways within the hazard area.


Affected Structures
Wildfire Hazard Area
Forested Areas >20 Acres
Baltimore County
N
0
2
4
8 Miles
Map 9-1. Wildfire Prone Areas
Source: Baltimore County Office of Information Technology, USGS NLCD (2006)
S & S
Planning and Design, LLC

9.5 2014 MITIGATION GOALS AND ACTION ITEMS

During the 2014 Plan Update, new mitigation goals and action were added. Additionally, previous mitigation goals and action items from the 2006 Plan were reviewed, and those that were determined to be still in progress or relevant were included.

GOAL 1: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about natural hazards risks, preparedness and mitigation	1. Develop and execute targeted fire prevention and safety efforts for elderly residents.	County	Medium
	2. Distribute information regarding fire-resistant landscape materials, targeted to residents within the WUI.	County/Residents within WUI	Medium
	3. Work cooperatively with residents of established communities to locate or improve firefighting water sources.	County	Medium

GOAL 2: Continue to support both career and volunteer fire departments via training, funding, and technological upgrades.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Strengthen Volunteer Fire Service.	1. Continue to support volunteer fire companies through financial contributions, training, and technical assistance.	County	Medium
	2. Assist volunteer fire companies with outreach and fundraising.	County	Medium
2. Utilize State-of-the-art equipment with on-going maintenance and improvement for effective communication for emergency responders.	1. Use the FMARS (Fire Mutual Aid Radio) high band radio.	County	Medium
	2. Enable patching capabilities within Fire communications.	County	Medium

9.6 EXISTING WILDFIRE MITIGATION ACTIVITIES

- Life Safety Code - 2012 NFPA 101 - adopted/amended by Baltimore County Bill 48-10, Effective: December 29, 2013
- Fire Prevention Code – 2012 Edition NFPA 1 - adopted/amended by Baltimore County Bill 48-10, Effective: December 29, 2013
- Other NFPA Codes and Standards - adopted/amended by Baltimore County Bills 48-10, Effective: December 29, 2013
- Effective January 1, 2011, all single-family homes and duplexes must be equipped with automatic sprinkler systems.

- Baltimore County has installed numerous 30,000 gallon underground rural water supply tanks for rural fire fighting. These tanks are listed in Appendix D.
- Participation in the Firewise program.
- Observance of and activities for Fire Prevention Week including the Fire Expo focusing on fire safety awareness and education.
- Continual public education efforts focusing on fire safety and injury prevention
- The Baltimore County Volunteer Fireman's Association has established a very active Water Resource Committee dealing with rural water sources, and tanker strike teams for rural fire fighting. They have identified and established water sources and installed drafting connections.
- Baltimore County was evaluated by the Insurances Service Office (ISO) for Municipal Grading in their rural communities. As a result, Baltimore County went from an ISO Class 9 public protection classification in their rural areas to an ISO Class 6; subject to being within five road miles of a fire station.

[1] http://www.nps.gov/fire/wildland-fire/learning-center/fire-in-depth/wildfire-causes.cfm
[2] National Wildfire Coordinating Group, www.firewise.org

CHAPTER 10: EARTHQUAKE

The update process for *Chapter 10: Earthquake*, as part of the Baltimore County 2014 Hazard Mitigation Plan Update, included researching and integrating the most up-to-date and available data during this planning cycle. Updates to this chapter include: new sections and narratives, new tables, figures, and maps, updates to existing sections and tables, and new formatting. As detailed in the highlighted figure, six new sections have been added, and four have been updated. Additionally, a HAZUS Level II analysis was conducted for this hazard and is included in section 10.4.

Chapter Highlights

Updated Sections:
10.1 – Text additions relating to earthquakes with epicenters in the County.
10.2 – Added Figure 10-1. Enhanced sections 10.2.1 through 10.2.3. Updated Table 10-1 to include magnitude and frequency.
10.3 – Updated with most recent earthquake events.
10.5 – New 2014 Action Items.

New Section(s):
10.4 – HAZUS Level 2 Earthquake Analysis

10.1 HOW ARE EARTHQUAKES A THREAT TO BALTIMORE COUNTY?

The USGS estimates that several million earthquakes occur in the world each year. Many are not felt by humans or are not detected because of their small magnitude. Baltimore County is not in a geographic location that is prone to powerful or severe earthquakes, however earthquakes do affect the County. Ten earthquakes with epicenters in Baltimore County have been recorded starting in 1906. These were considered minor earthquakes and caused minimal property damage. Buildings and infrastructure most vulnerable to earthquake damage in Baltimore County are older structures built prior to the adoption of modern building codes. Additionally, older structures may suffer from seismic activity resulting in cracking and crumbling of aged building material. Falling debris from these structures could result in both property damage and life safety of residents and/or pedestrians.

10.2 CONTRIBUTING FACTORS TO EARTHQUAKE RISK

Earthquakes are caused by the release of stress and tension on the Earth's tectonic plates. This release is usually in the form of a crack or a break in the rock plates underground. The magnitude of the released energy and the proximity to the surface determines how strong the earthquake is felt on the surface and how much damage is incurred. The area directly over the stress release is called the epicenter, which receives the most direct damage and dissipates the further away from this location. The released energy travels in the form of waves which result in ground motion at the Earth's surface. These aforementioned processes are depicted on Figure 10-1, on the following page. There are several different ways of measuring an earthquakes destructive force: a Richter Magnitude, a Modified Mercalli Intensity (MMI), and Peak Ground Acceleration (PGA). Each of these measuring techniques is further described in the sections to come.

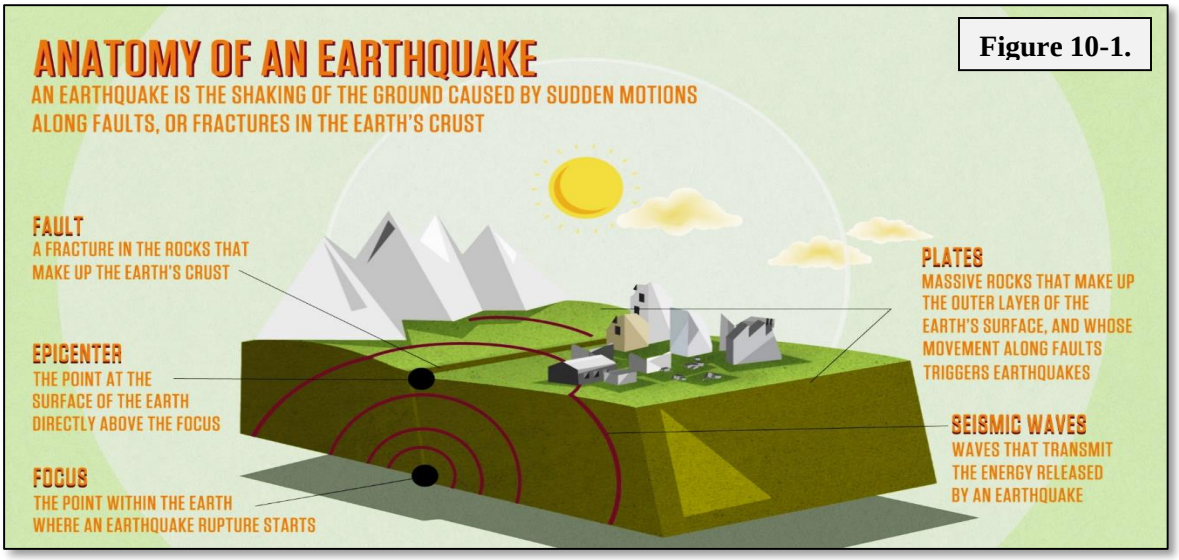


Figure 10-1.

Source: science.kqed.org

10.2.1 Richter Magnitude

The Richter Scale is used to measure the magnitude of earthquakes and is not used to express damage incurred by an earthquake. The Richter Scale is the result of a mathematical formula that determines magnitude through the logarithm of the amplitude of waves, recorded by seismographs. Seismographs record the seismic waves (or vibrations) that pass through the Earth from an earthquake. On the Richter Scale, the magnitude of the earthquake is expressed in whole numbers and decimals fractions such as 6.5.[1]

10.2.2 Modified Mercalli Intensity

The Modified Mercalli Scale describes the severity of earthquake effects. It is a ranking based on observed effects that people will experience and can relate to.[2] Table 10-1, below, describes the Mercalli Intensity Scale values:

Table 10-1. Mercalli Intensity Scale Value Descriptions

Richter Magnitude	Mercalli Intensity	Description	Average Estimated Frequency
< 2.0	I	Microearthquakes, not felt, or felt rarely by sensitive people; recorded by seismographs.	Continual/several million per year
2.0–2.9	I to II	Felt slightly by some people, especially on upper floors of buildings. No damage to buildings.	Over one million per year
3.0–3.9	II to IV	Often felt by people, but very rarely causes damage. Shaking of indoor objects can be noticeable.	Over 100,000 per year
4.0–4.9	IV to VI	Noticeable shaking of indoor objects and rattling noises. Felt by most people in the affected area; slightly felt outside. Generally causes none to minimal damage. Moderate to significant damage very unlikely. Some objects may fall off shelves or be knocked over.	10,000 to 15,000 per year

Richter Magnitude	Mercalli Intensity	Description	Average Estimated Frequency
5.0–5.9	VI to VIII	Can cause damage of varying severity to poorly constructed buildings. At most, none to slight damage to all other buildings. Felt by everyone. Casualties range from none to a few.	1,000 to 1,500 per year
6.0–6.9	VII to X	Damage to a moderate number of well-built structures in populated areas. Earthquake-resistant structures survive with slight to moderate damage. Poorly-designed structures receive moderate to severe damage. Felt in wider areas; up to hundreds of miles/kilometers from the epicenter. Strong to violent shaking in epicentral area. Death toll ranges from none to 25,000.	100 to 150 per year
7.0–7.9	VIII or greater	Causes damage to most buildings. Well-designed structures are likely to receive damage. Felt across great distances with major damage mostly limited to 250 km from epicenter. Death toll ranges from none to 250,000.	10 to 20 per year
8.0–8.9		Major damage to buildings, structures likely to be destroyed. Will cause moderate to heavy damage to sturdy or earthquake-resistant buildings. Damaging caused to large areas; felt in extremely large regions. Death toll ranges from 1,000 to 1 million.	One per year
9.0 and greater		Near or total destruction - severe damage or collapse to all buildings. Heavy damage and shaking extends to distant locations. Permanent changes in ground topography. Death toll usually over 50,000.	One per 10 to 50 years

Sources: USGS, 2011 Maryland State Hazard Mitigation Plan

10.2.3 Peak Ground Acceleration

Baltimore County is located in 'Peak Ground Acceleration Zone 3' as identified by the United States Geological Survey. This means that in a 50 year period there is a 10% chance that Baltimore County will experience an earthquake with a PGA of .03.

Source: USGS, 2008

Peak Ground Acceleration (PGA) is a method that measures the horizontal ground velocity compared to normal gravity. The back and forth movement of the ground during an earthquake does the most damage to structures, but it is the acceleration stoppage and reversal of this movement that determines how much damage is actually incurred. Depending on the PGA zone, building codes require the structure to account for this PGA force to withstand. PGA is expressed as a decimal, and represents the areas strongest earthquake most likely to occur within the next 50 years. If you live in a PGA zone 4, that areas PGA rating is 0.04 which means within the next 50 years there is a 1 in 10 chance of an earthquake with 4/10ths the PGA of gravity. Conversely, if you live in zone 1, with a PGA rating of 0.01, you have a 1 in 10 chance of an earthquake with $1/10^{th}$ the acceleration of gravity. This force must be taken into account when designing the structural integrity of a building. The 2012 International Building Code, which have been adopted by the County, takes this force into consideration by including seismic building zone maps.

10.3 HISTORY OF EARTHQUAKES

While the impacts to person and property have been minimal, Baltimore County does have a noteworthy history of earthquakes. In the last hundred years, the County has experienced ten earthquake events with the epicenter located in the County. This history, as recorded by the Maryland Geological Survey, is presented in Table 10-2, below.

Table 10-2. Recorded Earthquakes with Epicenters in Baltimore County

Date	Location	Modified Mercalli Intensity	Richter Scale Reading
10/13/1906	Catonsville, MD	III	2.7
4/24/1910	Catonsville, MD	III	2.7
6/22/1939	Phoenix, MD	III	2.7
11/18/1939	Phoenix, MD	IV	3.1
11/26/1939	Phoenix, MD	V	3.5 - 3.7
1/13/1990	Randallstown, MD	III-V	2.5 – 2.6
4/4/1990	Randallstown, MD	III	1.7
9/28/1991	Randallstown, MD	II	2.4
2/23/2005	Dundalk, MD	II-III	2.0-2.1
9/29/2009	Catonsville, MD	I	1.6

Source: http://www.mgs.md.gov/esic/fs/fs13.html

10.4 HAZUS Level 2 EARTHQUAKE Analysis – 2013

10.4.1 Plan Update

As part of the 2014 Plan Update, a HAZUS Level 2 Analysis was conducted for *Chapter 10 Earthquake*. Results of this type of analysis include essential facility and general building stock damages, debris generation, shelter requirements, and associated economic losses. This level of analysis is more accurate than a Level 1 Analysis because the data used for the analysis is derived from user-supplied sources, including best-available data specific to Baltimore County, as well as data available in the Hazus database. Examples of user-supplied data utilized for this analysis include:

Table 10-3. HAZUS Default Data v. County Data

Critical Facility Type	HAZUS Default Data (utilized in HAZUS Level 1 Analyses)	County Data Utilized for HAZUS Level 2 Analysis
Fire stations/EMS	16	65
Police Stations	10	20
Schools	132	375
Medical Facilities	0	25
EOC	1	1

- Building stories
- Year built
- Structure value
- Square Footage

U.S. Census Bureau Data Utilization

The HAZUS analysis conducted during the 2014 Plan Update utilized the most recent version of the software (version 2.1), which was released in October of 2013. At the time of this HAZUS Level 2 Analysis for Earthquake, FEMA had not yet integrated 2010 Census data into the Hazus version 2.1 software. This data will be made available with the next release. As such, household numbers and other demographic data has been increased by 5.6% to better represent the total number of households (316,716) in Baltimore County per the 2010 U.S. Census. This percentage increase was derived by determining the percent change in demographic data from 2000 to 2010. For example, the total number of households in Baltimore County has changed from 299,000 in 2000 to 316,715 in 2010, which represents an increase of 17,715 households. This change was calculated as a percentage (5.6%) and related household values were increased by this amount where necessary (see Table 10-6). In the case of population estimates, a 6.3% change was calculated and added to necessary population values.

10.4.2 Introduction

The earthquake-related hazards considered by the methodology in evaluating casualties, damage, and resultant losses are collectively referred to as potential earth science hazards (PESH). Most

damage and loss caused by an earthquake is directly or indirectly the result of ground shaking. Thus, it evaluates the geographic distribution of ground shaking resulting from the specified scenario earthquake and expresses ground shaking using several quantitative parameters, ex. peak ground acceleration and spectral acceleration.

Uncertainties are inherent in any loss estimation methodology, which arise from several factors, some of which include:

- Incomplete scientific knowledge concerning earthquakes and their effects upon buildings and facilities;
- The approximations and simplifications that are necessary for comprehensive analyses;
- Incomplete or inaccurate inventories of the built environment, demographics, and economic parameters.

These factors can result in a range of uncertainty in loss estimates produced by the HAZUS Earthquake Model, possibly by, at best, a factor of two or more.

Note: The full report of the HAZUS Level 2 Analysis for Earthquake is included in Appendix B.

10.4.3 County Overview

Baltimore County is roughly 607 square miles and has over 316,715 households in the region which have a total population of 805,029 people (2010 Census Bureau data). There are an estimated 269,000 buildings in the county with a total building replacement value (excluding contents) of 59,023 (millions of dollars). Approximately 93% of the buildings (and 76% of the building value) are associated with residential housing. The replacement value of the transportation and utility lifeline systems is estimated to be 4,696 and 5,599 (millions of dollars), respectively.

HAZUS Earthquake Parameters

Longitude of Epicenter:	*-76.80*
Latitude of Epicenter:	*39.36*
Earthquake Magnitude:	*5.0*
Depth (Km):	*10.0*
Attenuation Function:	*Central & East US (CEUS 2008)*

Critical Facility Inventory

Critical facilities were broken down into two groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants, and hazardous material sites.

For essential facilities, there are 25 hospitals in the region with a total bed capacity of 1,800 beds. There are 375 schools, 65 fire stations, 20 police stations and 1 emergency operation facilities.

With respect to high potential loss facilities, there are 11 dams identified within the region. Of these, 4 of the dams are classified as 'high hazard'. The inventory also includes 66 hazardous material sites.

Transportation and Utility Lifeline Inventory

The lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power, and communications.

The total value of the lifeline inventory is over 10,295 (millions of dollars). This inventory includes over 507 kilometers of highways, 449 bridges, and 11,839 kilometers of pipes.

Epicenter

As depicted on Map 10-1, the chosen epicenter and magnitude was based upon an historical earthquake which occurred near Randallstown on 9/28/91 and was of magnitude 2.4. For this analysis, the magnitude of the earthquake was doubled to five (5) in order to provide a worst case scenario.

10.4.4 Damage Estimates

Building Damage

Hazus estimates that about 22,754 buildings will be at least moderately damaged. This is over 8% of the buildings in Baltimore County. There are an estimated 843 buildings that will be damaged beyond repair. Table 10-3, below, summarizes the expected damage by general occupancy for the buildings in the county.

Table 10-4. Expected Building Damage by Occupancy Type

Occupancy	None		Minor		Moderate		Extensive		Complete	
	Count	%	Count	%	Count	%	Count	%	Count	%
Agricultural	601	0.29	99	0.27	63	0.36	17	0.42	3	0.35
Commercial	9,866	4.69	1,782	4.91	1,374	7.75	417	9.97	75	8.92
Education	344	0.16	66	0.18	54	0.30	15	0.37	3	0.35
Government	246	0.12	50	0.14	46	0.26	14	0.35	3	0.32
Industrial	2,769	1.31	419	1.15	348	1.96	106	2.53	19	2.22

Other Residential	19,106	9.07	3,344	9.21	1,805	10.18	439	10.50	76	8.97
Religion	830	0.39	162	0.45	108	0.61	32	0.77	6	0.73
Single Family	176,824	83.97	30,392	83.69	13,932	78.58	3,140	75.10	659	78.14
Total	210,586	100	36,314	100	17,731	100	4,180	100	843	100

Essential Facility Damage

Before the earthquake, the region had 1,800 hospital beds available for use. On the day of the earthquake, the model estimates that only 993 hospital beds (55%) will be available for use by patients already in the hospital and those injured by the earthquake. After one week, 74% of the beds will be back in service. By thirty days, 90% will be operational.

Table 10-5. Expected Damage to Essential Facilities

Classification	Total	Number of Facilities		
		At Least Moderate Damage > 60%	Complete Damage > 50%	With Functionality > 50% on Day 1
Hospitals	25	4	0	17
Schools	375	53	0	215
EOC	1	0	0	0
Police Stations	20	2	0	13
Fire Stations	65	3	0	48

Transportation and Utility Lifeline Damage

The following tables provide information on the damage to transportation and utility lifeline systems. Table 10-5 provides expected damage to transportation systems, and Table 10-6 provides expected potable water and electric power system performance. Hazus indicates that damage to transportation systems will be minimal, and nearly all the systems are expected to have greater than 50% functionality a day after the disaster.

Table 10-6. Expected Damage to Transportation Systems						
System	Component	Number of Locations				
		Locations/ Segments	With at Least Moderate Damage	With Complete Damage	With Functionality > 50%	
					After Day 1	After Day 7
Highway	Segments	331	0	0	331	331
	Bridges	449	14	1	435	445
	Tunnels	0	0	0	0	0
Railway	Segments	160	0	0	160	160
	Bridges	2	0	0	2	2
	Tunnels	0	0	0	0	0
	Facilities	6	0	0	6	6
Light Rail	Segments	23	0	0	23	23
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	17	3	0	17	17
Bus	Facilities	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	13	0	0	13	13
Airport	Facilities	1	0	0	1	1
	Runways	1	0	0	1	1
Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only.						

Table 10-6, below, represents the number of households expected to be without electric power and/or potable water service. Hazus indicates that potable water will be available to all households, while nearly 25% of all households will be without electric power at day one of the earthquake event. However, after seven days this figure is expected to drop dramatically and only 5% of households will be without electric power.

Table 10-7. Number of Households without Service						
	At Day 1	At Day 3	At Day 7	At Day 30	At Day 90	Total # of Households
Potable Water	0	0	0	0	0	316,715
Electric Power	77,577	46,407	16,669	2,618	2,618	

10.4.5 Induced Earthquake Damages

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the potential lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be one (1) ignitions that will burn about 0.18 sq. mi (0.03% of the county's total area.) The model also estimates that the fires will displace about 298 people and burn about 26 (millions of dollars) of building value.

How It Works…

The Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values—a probability distribution—for any factor that has inherent uncertainty. It then calculates results repeatedly, each time using a different set of random values from the probability functions. Depending upon the number of uncertainties and the ranges specified for them, a Monte Carlo simulation could involve thousands or tens of thousands of recalculations before it is complete.

Source: www.palisade.com

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. 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 0.81 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 60% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 32,400 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Total tons of debris is depicted by census block on Map 10-2. Areas with the greatest debris generation tend to be closest to the epicenter. Based on the results, the Owings Mills area would have the greatest amount of debris generation.

10.4.6 Economic Losses

The total economic loss estimated for the earthquake is 2,598.85 (millions of dollars), which includes building and lifeline related losses based on the county's available inventory. The following sections provide more detailed information about these losses.

Building-Related Losses

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 earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.
The total building-related losses were 2,394.19 (millions of dollars); 20% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 63% of the total loss.

10.4.7 Social Impacts

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 2,506 households to be displaced due to the earthquake. Of these, 1,548 people (out of a total population of 805,029) will seek temporary shelter in public shelters.

These short-term shelter needs are depicted by census block on Map 10-3. Areas with the greatest short term shelter needs tend to be closest to the epicenter.

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows:

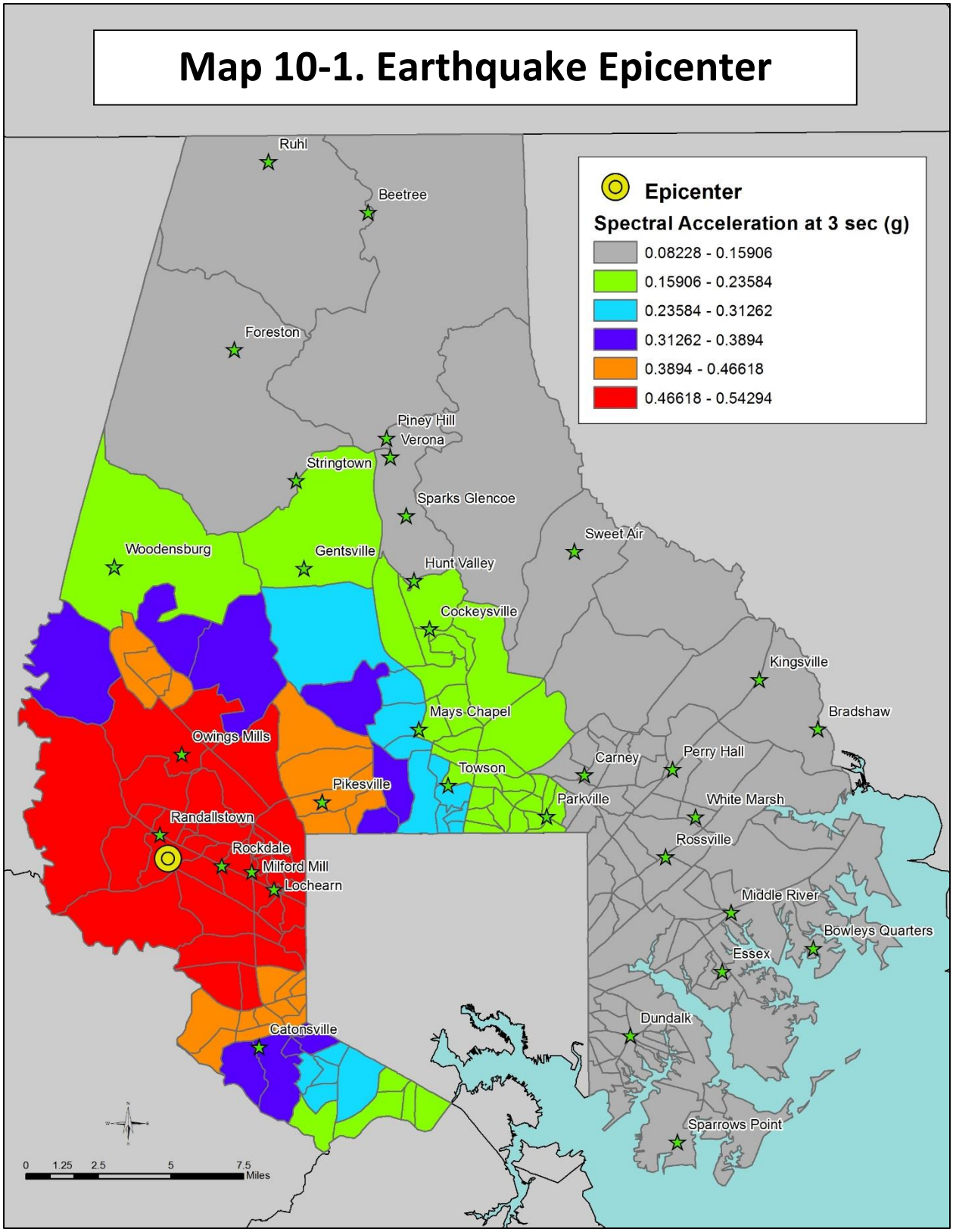
- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.

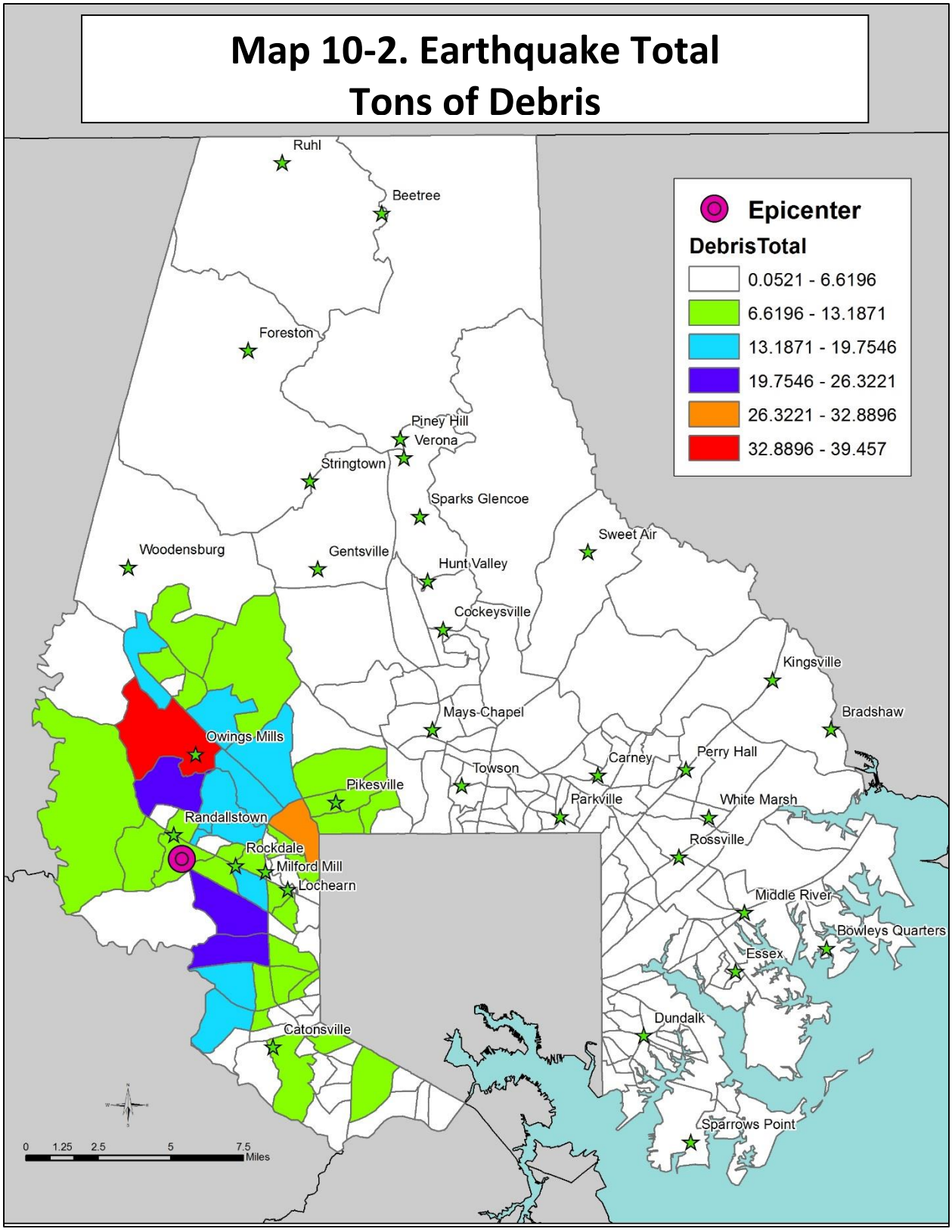
- Severity Level 4: Victims are killed by the earthquake.

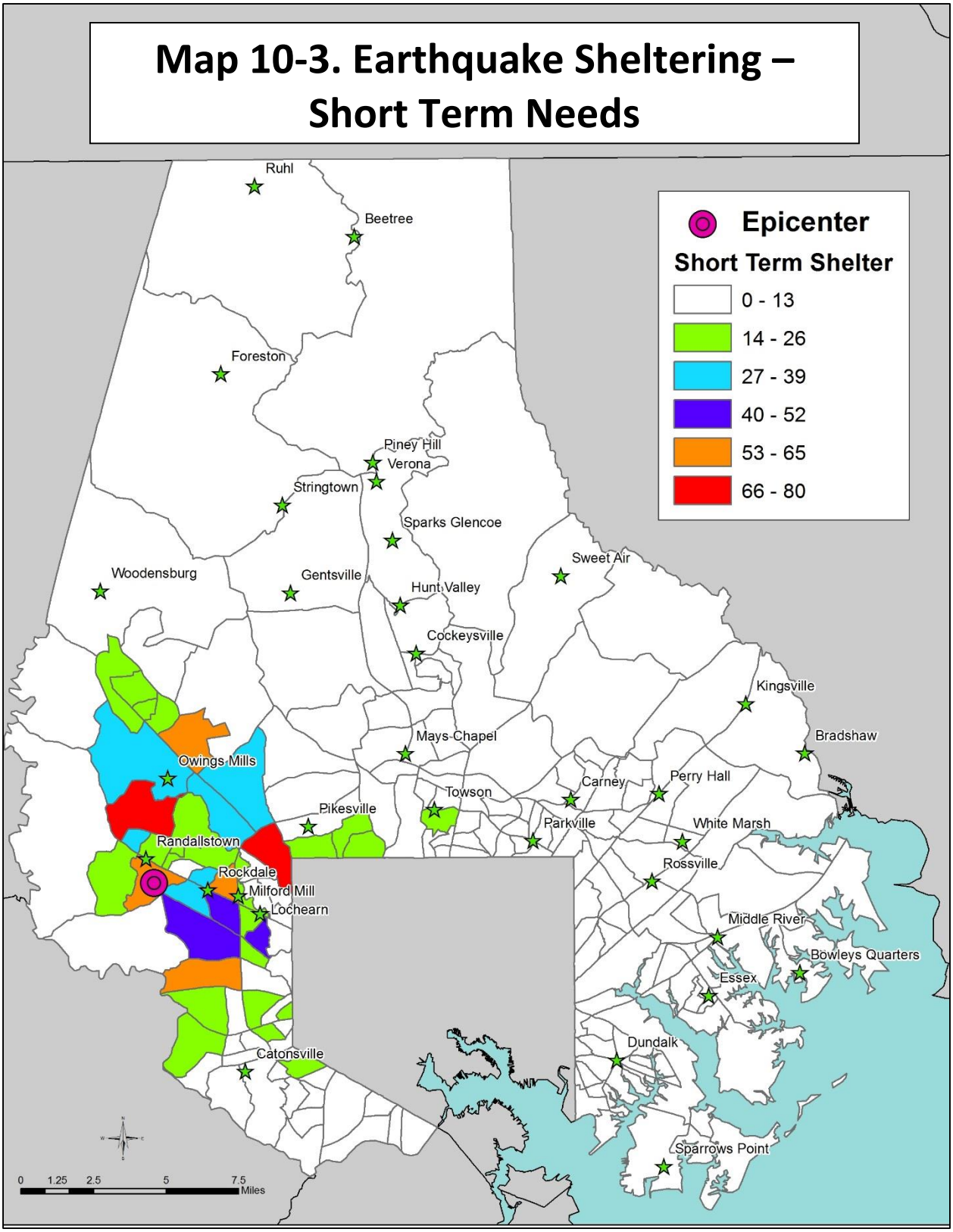
The casualty estimates (Table 10-7) are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is at maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are at maximum and 5:00 PM represents peak commute time.

Table 10-8. Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	6	1	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	5	1	0	0
	Other-Residential	152	30	4	7
	Single Family	524	103	12	24
	Total	**689**	**135**	**17**	**32**
2 PM	Commercial	352	70	8	16
	Commuting	1	1	2	0
	Educational	88	18	2	5
	Hotels	0	0	0	0
	Industrial	39	7	1	2
	Other-Residential	27	5	1	1
	Single Family	90	18	2	4
	Total	**596**	**120**	**17**	**28**
5 PM	Commercial	263	53	6	12
	Commuting	31	37	68	13
	Educational	14	3	0	1
	Hotels	0	0	0	0
	Industrial	24	5	1	1
	Other-Residential	60	12	2	3
	Single Family	209	42	5	10
	Total	**602**	**152**	**83**	**40**


Map 10-1. Earthquake Epicenter
Epicenter
Spectral Acceleration at 3 sec (g)
0.08228 - 0.15906
0.15906 - 0.23584
0.23584 - 0.31262
0.31262 - 0.3894
0.3894 - 0.46618
0.46618 - 0.54294
Ruhl
Beetree
Foreston
Piney Hill
Verona
Stringtown
Sparks Glencoe
Sweet Air
Woodensburg
Gentsville
Hunt Valley
Cockeysville
Kingsville
Bradshaw
Mays Chapel
Owings Mills
Carney
Perry Hall
Towson
Pikesville
Parkville
White Marsh
Randallstown
Rockdale
Milford Mill
Lochearn
Rossville
Middle River
Bowleys Quarters
Essex
Dundalk
Catonsville
Sparrows Point
0 1.25 2.5 5 7.5
Miles


Map 10-2. Earthquake Total Tons of Debris
Epicenter
DebrisTotal
0.0521 - 6.6196
6.6196 - 13.1871
13.1871 - 19.7546
19.7546 - 26.3221
26.3221 - 32.8896
32.8896 - 39.457
Ruhl
Beetree
Foreston
Piney Hill
Verona
Stringtown
Sparks Glencoe
Sweet Air
Woodensburg
Gentsville
Hunt Valley
Cockeysville
Kingsville
Bradshaw
Mays Chapel
Owings Mills
Carney
Perry Hall
Towson
Pikesville
Parkville
White Marsh
Randallstown
Rossville
Rockdale
Milford Mill
Lochearn
Middle River
Bowleys Quarters
Essex
Dundalk
Catonsville
Sparrows Point
0 1.25 2.5 5 7.5
Miles


Map 10-3. Earthquake Sheltering – Short Term Needs
Epicenter
Short Term Shelter
0 - 13
14 - 26
27 - 39
40 - 52
53 - 65
66 - 80
Ruhl
Beetree
Foreston
Piney Hill
Verona
Stringtown
Sparks Glencoe
Woodensburg
Gentsville
Hunt Valley
Sweet Air
Cockeysville
Kingsville
Bradshaw
Mays Chapel
Owings Mills
Carney
Perry Hall
Towson
Pikesville
Parkville
White Marsh
Randallstown
Rossville
Rockdale
Milford Mill
Lochearn
Middle River
Bowleys Quarters
Essex
Dundalk
Catonsville
Sparrows Point
0 1.25 2.5 5 7.5
Miles

10.5 2014 MITIGATION GOALS AND ACTION ITEMS

During the 2014 Plan Update, new mitigation goals and action were added. Additionally, previous mitigation goals and action items from the 2006 Plan were reviewed, and those that were determined to be still in progress or relevant were included.

GOAL 1: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about natural hazards risks, preparedness and mitigation.	1. Provide information on the County's web site about earthquake risk and vulnerability.	County	Low
2. Provide technical assistance for homeowners regarding earthquakes.	1. Develop a technical assistance information program for homeowners to teach them how to seismically strengthen their homes. The program could include providing local government building departments with copies of existing strengthening and repair information for distribution to homeowners. Other potential distribution sources include insurance companies, realtors, homeowner associations, and libraries.	County	Low

GOAL 2: Eliminate or reduce human, environmental, social and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Enforce current building standards.	1. Continue to perform building inspections to ensure compliance with current building standards.	County	Medium
	2. Strengthen Seismic Design from Category A to Category B.	County	Medium
2. Take steps to "harden" infrastructure.	1. Identification and hardening of critical lifeline systems, i.e., critical public services such as utilities and roads, to meet "Seismic Design Guidelines and Standards for Lifelines," or equivalent standards, may distinguish a manageable earthquake from a social and economic catastrophe.	County	Medium

GOAL 3: Provide outreach to agencies and organizations within Baltimore County regarding hazard mitigation.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Utilize planning documents, reports, and analyses as targeted material for outreach.	1. Provide HAZUS earthquake data to fire companies within the projected high hazard earthquake zone within the County.	See Map 10-1	Medium
	2. Provide HAZUS earthquake data regarding shelter requirements to Emergency Preparedness for planning and mitigation purposes.	County	Low
	3. Provide HAZUS earthquake data regarding debris generation to the Bureau of Highways for planning and mitigation purposes.	County	Low

10.6 EXISTING EARTHQUAKE MITIGATION ACTIVITIES

- Adoption of 2012 International Building Code, with amendments (effective July 1, 2012)

[1] http://earthquake.usgs.gov/learn/topics/richter.php
[2] http://earthquake.usgs.gov/learn/topics/mercalli.php

CHAPTER 11: SINKHOLE

The update process for *Chapter 11: Sinkhole*, as part of the Baltimore County 2014 Hazard Mitigation Plan Update, included researching and integrating the most up-to-date and available data during this planning cycle. Updates to this chapter include: new sections and narratives, new tables, figures, and maps, updates to existing sections and tables, and new formatting. As detailed in the highlighted figure, four sections have been heavily updated, including a Vulnerability Assessment which utilizes the most recent and available data.

Chapter Highlights

Updated Sections/New Additions:
11.1 Updated text, specifically regarding definitions of collapse sinkholes.
11.2 Updated text and added sections *11.2.1 Groundwater Erosion* and *11.2.2 Human Factors.* Added Figure 11-1.
11.4 Completely reformatted and updated Vulnerability Assessment with most recent and available data. Added Map 11-2.
11.6 New action items for 2014.

11.1 HOW ARE SINKHOLES A THREAT TO BALTIMORE COUNTY?

Sinkholes, like landslides, are a form of ground movement that occur with little warning and can cause major damage. Sinkholes are common in karst terrain, where the rock below the land surface is limestone, carbonate rock, salt beds, or rocks that can naturally be dissolved by ground water circulating through them. As the rock dissolves, spaces and caverns develop underground. Sinkholes are dramatic because the land usually stays intact for a while until the underground spaces just get too big, then a sudden collapse occurs. These collapses can be small and have little impact on people, or they can be huge and can occur where a house, road, or other structure is on top.[1]

Baltimore County is well known for its Cockeysville Marble geologic formation, a carbonate rock, characterized by its disrupted surface drainage due to loss of surface water to the subsurface. Areas that are underlain by this carbonate rock and others like it make Baltimore County susceptible to collapse sinkholes. These Cockeysville Marble formations are depicted in light blue on Map 11-1.

11.2 CONTRIBUTING FACTORS TO SINKHOLE RISK

11.2.1 Groundwater Erosion

The formation of sinkholes involves the natural processes of erosion, or gradual removal of slightly soluble bedrock (limestone, carbonate rock, salt beds, etc.) by percolating water, the collapse of a cave roof, or a lowering of the water table. Sinkholes often form through the process of suffosion. For example, groundwater may dissolve the carbonate cement holding sandstone particles together and then carry away the soft particles, gradually forming a void.[2] Figure 11-1, on the following page, provides a visual aid for better understanding the formation of sinkholes.

11.2.2 Human Factors

New sinkholes have been correlated to land-use practices, especially from groundwater pumping and from construction and development practices. Sinkholes can also form when natural water-drainage patterns are changed and new water-diversion systems are developed. Some sinkholes form when the land surface is changed, such as when industrial and runoff-storage ponds are created. The substantial weight of the new material can trigger an underground collapse of supporting material, thus causing a sinkhole.

The overburden sediments that cover buried cavities in the aquifer systems are delicately balanced by ground-water fluid pressure. The water below ground is actually helping to keep the surface soil in place. Groundwater pumping for urban water supply and for irrigation can produce new sinkholes in sinkhole-prone areas. If pumping results in a lowering of groundwater levels, then underground structural failure, and thus, sinkholes, can occur.[3]

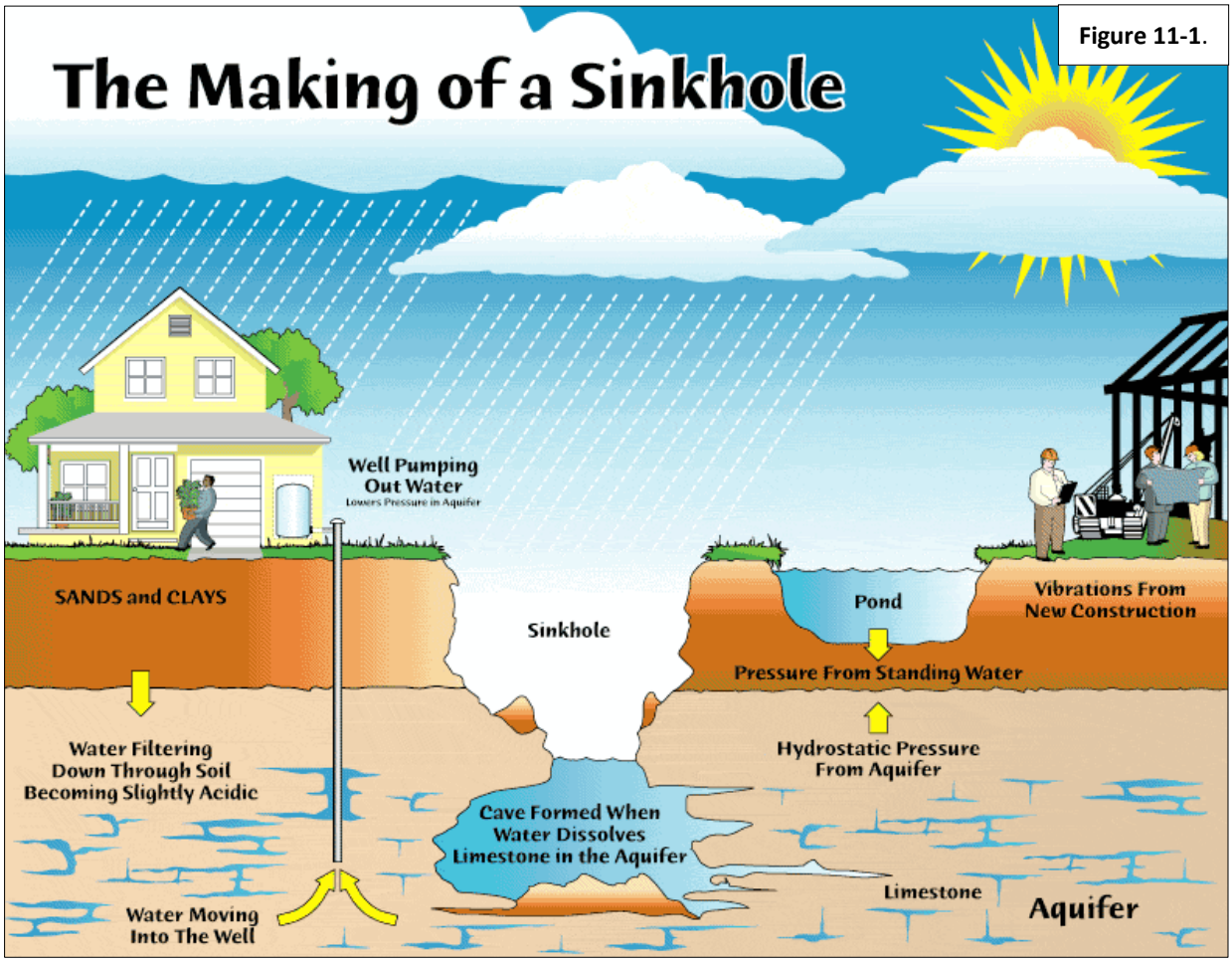
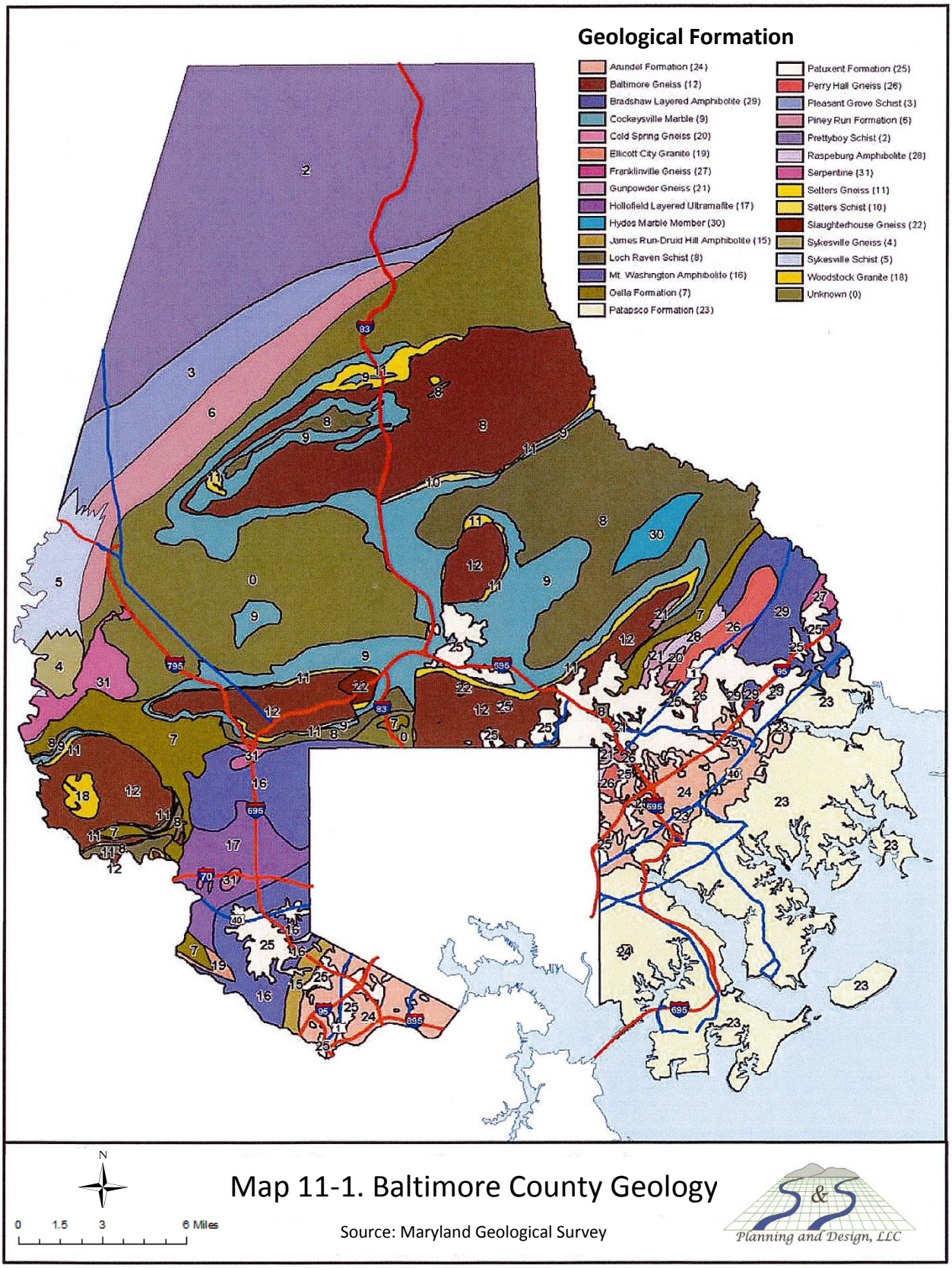


Figure 11-1.

Source: www.lakecountyfl.gov


Geological Formation
Arundel Formation (24)
Baltimore Gneiss (12)
Bradshaw Layered Amphibolite (29)
Cockeysville Marble (9)
Cold Spring Gneiss (20)
Ellicott City Granite (19)
Franklinville Gneiss (27)
Gunpowder Gneiss (21)
Hollofield Layered Ultramafite (17)
Hydes Marble Member (30)
James Run-Druid Hill Amphibolite (15)
Loch Raven Schist (8)
Mt. Washington Amphibolite (16)
Oella Formation (7)
Patapsco Formation (23)
Patuxent Formation (25)
Perry Hall Gneiss (26)
Pleasant Grove Schist (3)
Piney Run Formation (6)
Prettyboy Schist (2)
Raspeburg Amphibolite (28)
Serpentine (31)
Setters Gneiss (11)
Setters Schist (10)
Slaughterhouse Gneiss (22)
Sykesville Gneiss (4)
Sykesville Schist (5)
Woodstock Granite (18)
Unknown (0)
N
0 1.5 3 6 Miles
Map 11-1. Baltimore County Geology
Source: Maryland Geological Survey
S&S Planning and Design, LLC

11.3 HISTORY OF SINKHOLES

There is no authoritative source for sinkhole locations and causes in Baltimore County. The Maryland State Highway Administration (SHA) maintains some records of sinkhole locations on state-owned properties and right of ways within the County, but it is not an all-inclusive history of sinkhole occurrences. The 14 sinkhole locations identified are consistent with locations of carbonate rock.

11.4 VULNERABILITY ASSESSMENT

11.4.1 Introduction

Areas in Baltimore County identified as moderate for land subsidence in the 2011 Maryland State Hazard Mitigation Plan Update were considered as hazard areas for this vulnerability assessment. These areas are entirely underlain by Cockeysville Marble, which makes them susceptible to collapse sinkholes, and are represented on map 11-2.

11.4.2 Data Utilization

The following data sources and shapefiles were utilized to determine affected land uses, critical facilities, and infrastructure within the hazard area:

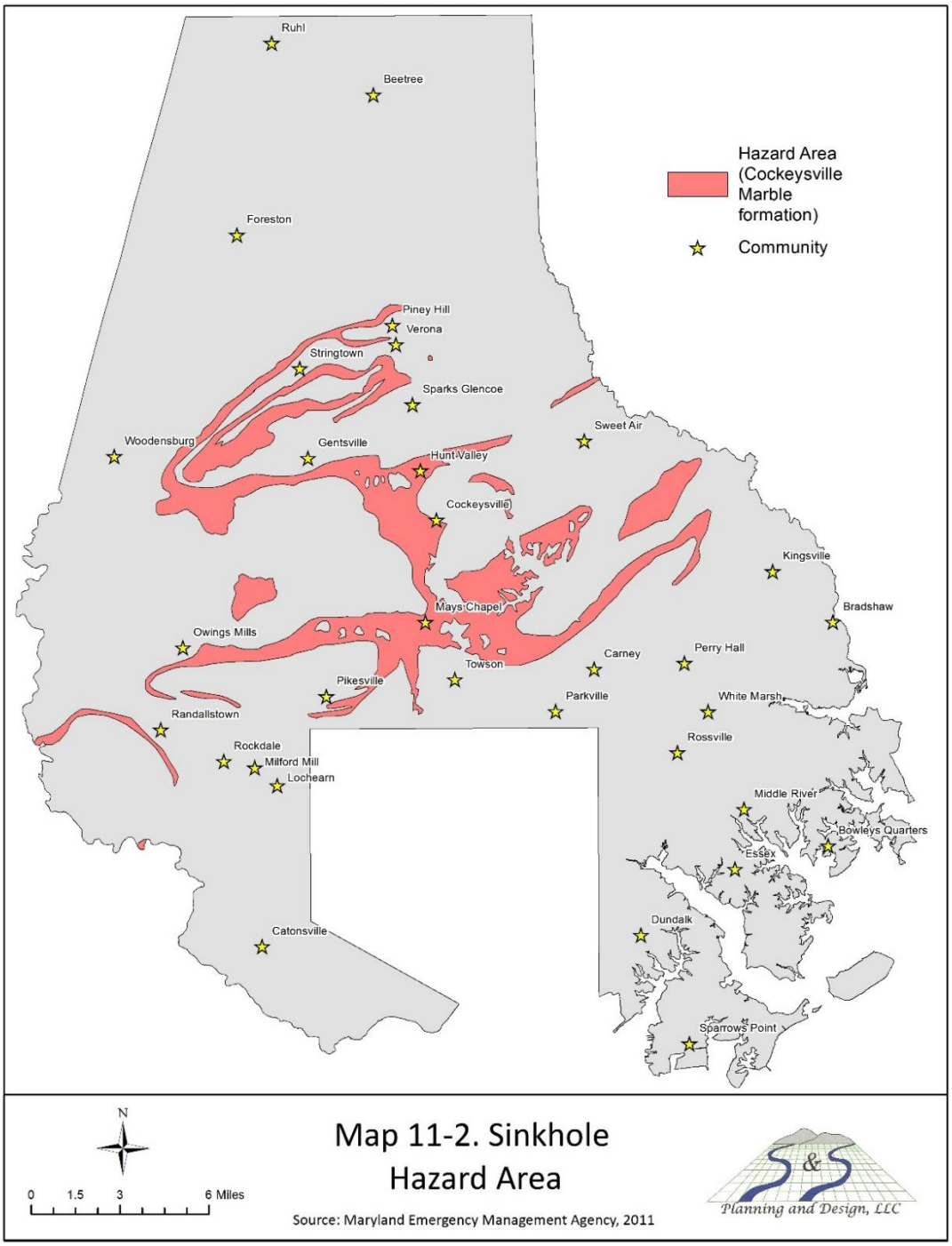
- Sinkhole Hazard Area – MEMA (2011)
- Bridges – Baltimore County Office of Information Technology (2011)
- Street Centerlines – Baltimore County Office of Information Technology (June 2013)
- Sewer Lines – Baltimore County Department of Public Works (2014)
- Communication Towers – Federal Communications Commission (2010)
- Structures/Parcels – Baltimore County Office of Information Technology (2007/2012)
- Above Ground Storage Tanks, Underground Storage Tanks – MEMA (2011)
- Hazardous Waste Generators (also includes: transporters, treaters, storers and disposers) – Environmental Protection Agency (2013)
- Fire Stations, Police Stations, Schools, Colleges – Baltimore County Office of Information Technology (June 2013)

11.4.3 Method

Data listed in section 11.4.2 was analyzed using ArcMap 10.1, a geographic information system (GIS). This program allows various data layers, such as shapefiles, to be overlaid and spatially compared. The hazard layer for this assessment was based upon areas determined to have moderate risk for land subsidence in the 2011 Maryland State Hazard Mitigation Plan Update. These areas coincide with instances of Cockeysville Marble formations.

To determine vulnerable land uses, critical facilities, and infrastructure within the County, each shapefile (bridges, roadways, etc.) was intersected with the hazard area shapefile as previously described. Critical facilities, structures, and infrastructure were deemed to be vulnerable to sinkholes if they were within (intersected) this hazard area.

The estimated economic losses to residential, commercial, industrial, agricultural, and tax-exempt land uses within the County due to the sinkhole hazards are based on the Maryland Department of Assessments and Taxation Real Property Database for all affected parcels. Tax Exempt properties include but are not limited to Public, County, State, or Federal owned Hospitals, Schools, Museums, Airports, Police Stations, and/or Fire Departments. Also included are church properties and other non-profit or charitable organizations. Economic losses are based on assessed value of property, and do not include contents value or indirect costs related to damage caused by the hazard (i.e. economic losses due to business closings).



11.4.4 Assessment Results

Based on the 2014 assessment, the following structures, critical facilities, and infrastructure were determined to be within the sinkhole hazard area:

Extent of Sinkhole Hazard Area
32,616 Acres

Major Bridges

In total, there are about 537 bridges within Baltimore County. Of these, 79 major bridges are within the sinkhole hazard area. Table 11-1, below, lists total bridges within the hazard area and their location. Locations with the greatest amount of impacted bridges include I-83, I-695, and Jones Falls.

Table 11-1. Total Impacted Bridges by Location

Road/River Name	Total Bridges	Road/River Name	Total Bridges
I-83	15	Branch of Gwynns Falls	1
I-695	5	Branch of Roland Run	1
Jones Falls	5	Deep Run	1
MD 25, Jones Falls	4	Greene Branch	1
Painters Mill Rd, Gwynns	4	Gwynns Falls	1
Shawan Rd. Ebr	3	Haystack Branch	1
Shawan Rd. Wbr	3	I-83 Sbr & Jones Falls	1
Beaverdam Run	2	Light Rail	1
Goodwin Run	2	Long Green Creek	1
I-695 & Light Rail	2	Long Quarter Branch	1
I-83 Nbr	2	Mcgill Run	1
I-83 Ramp 'C'	2	MD 940	1
MD 25a	2	North Branch	1
Padonia Rd.	2	Oregon Branch	1
Roland Run	2	Ramp 'N' From Parking Lot	1
Timonium Rd.	2	Slade Run	1
Western Run	2	Slaughterhouse Branch	1
Branch of Long Green Creek	1	Thornton Rd.	1
Branch of Beaverdam Run	1		

Roadways

In total, there are roughly 9,789 roadways within Baltimore County. Of these, 901 are within the sinkhole hazard area. This translates to over 200 miles (5% of total road miles) of roadway within the hazard area. Tables 11-2 and 11-3, below, list the most impacted roads by total miles, and communities by number of affected roadways, respectively. For the most part, the greatest amount of impacted roadway miles include driveways, ramps, and miscellaneous “roads”, which make up over 50 miles of roadway, or a fourth of the total impacted roadway miles within the sinkhole hazard area.

Table 11-2. Most Impacted Roadways by Total Miles Within the Sinkhole Hazard Area			
Road Name	Total Miles	Road Name	Total Miles
I-83	20.54	Bellona Ave.	2.55
Driveway	17.87	W Seminary Ave.	2.53
Ramp	16.90	Long Green Pike	2.28
Road	16.78	Cold Bottom Rd.	2.28
I-695	14.05	W Warren Rd.	2.22
Parking	9.79	Long Ln.	2.22
Dulaney Valley Rd.	7.81	E Seminary Ave.	2.07
Butler Rd.	7.42	Park Heights Ave.	2.05
Falls Rd.	5.94	Mantua Mill Rd.	2.02
York Rd.	5.55	Jarrettsville Pike	2.00
Greenspring Valley Rd.	4.71	Greenspring Ave.	1.96
Belfast Rd.	4.61	Harford Rd.	1.91
Beaver Dam Rd.	4.30	Goucher College Dr.	1.89
Tufton Ave.	3.88	Old Court Rd.	1.89
Paper Mill Rd.	3.53	Pot Spring Rd.	1.86
Shawan Rd.	3.43	Piney Grove Rd.	1.85
Marriottsville Rd.	3.28	Hydes Rd.	1.84
Western Run Rd.	3.28	Longnecker Rd.	1.83
Glen Arm Rd.	2.86	Dover Rd.	1.81
I-795	2.78	E Timonium Rd.	1.80

Table 11-3. Communities by Number of Affected Roadways			
Community	Affected Roadways	Community	Affected Roadways
Lutherville	327	Reisterstown	15
Cockeysville	152	Phoenix	14
Towson	100	Hunt Valley	10
Loch Raven	94	Hydes	6
Owings Mills	60	Baldwin	5
Randallstown	36	Monkton	4
Mt. Washington	22	Windsor Mill	2
Glen Arm	19	Parkville	1
Sparks Glencoe	18	Woodstock	1
Pikeville	15		

Sewer System

Including active gravity main lines and active pressurized main lines, the sewer system in Baltimore County consists of roughly 2,099 miles of sewer line. Of this amount, a total of 187 miles (9%) is within the sinkhole hazard area. These affected sewer lines are further detailed below. Additionally, five sewer pump stations were determined to be within the hazard area.

5,236 Active Gravity Main Lines = 178 miles total

Number of Pipes @ Pipe Diameter:

- 1 @ 4.0”
- 16 @ 6.0”
- 4,231 @ 8.0”
- 162 @ 10.0”
- 227 @ 12.0”
- 186 @ 15.0”
- 42 @ 16.0”
- 131 @ 18.0”
- 35 @ 21.0”
- 92 @ 24.0”
- 55 @ 27.0”
- 91 @ 30.0”
- 1 @ 32.0”
- 7 @ 33.0”
- 48 @ 36.0”
- 11 @ 39.0”
- 22 @ 42.0”
- 14 @ 48.0”
- 8 @ 54.0”
- 4 @ 60.0”
- 9 @ 66.0”
- 1 @ 72.0”

79 Active Pressurized Main Lines = 9.0 miles total

Number of Pipes @ Pipe Diameter:

- 4 @ 1.25”
- 22 @ 1.5”
- 25 @ 2.0”
- 2 @ 4.0”
- 2 @ 6.0”
- 1 @ 8.0”
- 1 @ 12.0”
- 2 @ 24.0”
- 5 @ 30.0”
- 1 @ 33.0”
- 13 @ 36.0”
- 1 @ 42.0”

5 Active Sewer Pump Stations

- Campus Hills
- Cockeysville
- Longquarter
- Montrose Ave.
- Texas

<u>Communication Towers</u>

5 Communication

- WPWR (Lutherville Timonium)
- WQHX (Lutherville Timonium)
- WPPS (Timonium)
- WPKW (Owings Mills)
- WPHG (Hunt Valley)

3 Broadcast

- WCBM (Owings Mills)
- WPYH (Owings Mills)
- WLIF (Towson)

1 AM Radio

- WVIE (Pikesville)

Buildings/Structures

Table 11-4. Land Uses Within the Sinkhole Hazard Area			
Land Use	Buildings Affected	Value of Structures	Value of Parcels
Residential	10,898	$185,968,936	$116,025,682
Residential Condo	-	$6,251,540	$3,788,700
Industrial	-	$195,923,170	$164,960,190
Institutional	390	-	-
Agricultural	-	$97,984,590	$47,425,540
Commercial	1,215	$845,892,270	$483,360,520
Exempt Commercial	-	$32,279,100	$15,477,810
Exempt	-	$7,710,240	$6,539,159
Country Club	-	$5,927,600	$4,345,800
Apartment	-	$264,517,990	$85,764,830
Garage	1,022	-	-
Water Tower	1	-	-
Storage Tank	79	-	-
Silo	50	-	-
Miscellaneous	3,482	-	-
Total	**17,137**	**$1,642,455,436**	**$927,688,231**

Critical Facilities

4 Fire Stations

- Fire Dept. Station 14 – Brooklandville
- Fire Dept. Station 19 – Garrison
- Fire Dept. Station 17 – Texas
- Fire Dept. Station 49 – Butler

2 Police Stations

- Police Precinct 7 – Cockeysville
- Police Substation Precinct 7 - Lutherville

23 Schools

Table 11-5. Schools Within the Sinkhole Hazard Area	
School	Location
Public	
Baltimore County Board of Education	Lutherville
Cockeysville Middle School	Cockeysville
Cromwell Valley Magnet Elementary School	Loch Raven
Lutherville Laboratory Elementary School	Lutherville
Padonia International Elementary School	Cockeysville
Riderwood Elementary School	Towson
Ridgley Middle School	Towson
Sparks Elementary School	Sparks Glencoe

School	Location
Timonium Elementary School	Lutherville
Private	
Apple Tree Children's Center	Cockeysville
Auburn School	Lutherville
Baltimore Lutheran School	Loch Raven
Bridges Montessori	Towson
Dayspring Christian Academy	Lutherville
Garrison Forest High School	Owings Mills
Hunt's Church Preschool	Towson
Impact Middle School	Cockeysville
Notre Dame Preparatory School	Towson
St. Joseph's School	Cockeysville
The Montessori School	Lutherville
The Park School	Pikesville
The Trellis School	Cockeysville
Villa Maria School	Cockeysville

3 Colleges

- Community College of Baltimore County Hunt Valley Extension
- Community College of Baltimore County Owings Mills Extension
- Goucher College (Towson)

12 Above Ground Storage Tanks That House/Generate Industrial/Hazardous Materials

416 Underground Storage Tanks

- 104 Currently In Use
- 312 Permanently Out of Use

186 Hazardous Waste Generators

Table 11-6. Hazardous Waste Generators by Community			
Community	Number of HWG	Community	Number of HWG
Cockeysville	71	Glen Arm	2
Hunt Valley	30	Baldwin	1
Timonium	21	Glyndon	1
Towson	21	Long Green	1
Owings Mills	14	Lutherville-Timonium	1
Lutherville	10	Phoenix	1
Lutherville Timonium	7	Randallstown	1
Brooklandville	3	Sparks	1

Development Impacts

Given the unpredictable nature of a sinkhole event, all development within the hazard area has the potential to experience damage caused by a sinkhole. In terms of future growth and development, Owings Mills is the designated Growth Area in the County. Parts of Owings Mills are within the

sinkhole hazard area, and it is the fifth most impacted community in terms of roadways within the hazard area.

11.5 2014 MITIGATION GOALS AND ACTION ITEMS

During the 2014 Plan Update, new mitigation goals and action were added. Additionally, previous mitigation goals and action items from the 2006 Plan were reviewed, and those that were determined to be still in progress or relevant were included.

GOAL 1: Eliminate or reduce human, environmental, social and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Direct new development away from hazard areas.	1. Regulate the location, type, and intensity of new development in areas most susceptible to sinkhole formation. Areas with the greatest amount of infrastructure within the sinkhole hazard area include: Lutherville, Cockeysville, Towson, Loch Raven, and Owings Mills.	Lutherville, Cockeysville, Towson, Loch Raven, Owings Mills	Medium
2. Develop and improve upon hazard data using GIS as the technical foundation for sinkhole hazard planning.	1. Evaluate and broaden inventory of infrastructure, demographic, and property statistics in areas susceptible to sinkhole formation.	County	Medium

GOAL 2: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about natural hazards risks, preparedness and mitigation.	1. Provide information on the County's web site about sinkhole risk and vulnerability.	County	Low

11.6 EXISTING SINKHOLE MITIGATION ACTIVITIES

The Maryland Geological Survey, supported by the Baltimore County Department of Environmental Protection and the Department of Public Works, as needed, performs current sinkhole mitigation and investigation activities.

- The Maryland Geological Survey (MGS), located nearby in Baltimore City, offers immediate investigative services anytime a sinkhole has been identified in Baltimore County.
- Corrective measures are immediately performed anytime a sinkhole is located as to prevent it from impacting nearby structures, roads, bridges, and other critical infrastructure.

[1] http://nationalatlas.gov/articles/geology/a_geohazards.html#four
[2] http://www.mgs.md.gov/geology/geohazards/engineering_problems_in_karst.html
[3] http://ga.water.usgs.gov/edu/sinkholes.html

CHAPTER 12: WINTER WEATHER

The update process for *Chapter 12: Winter Weather*, as part of the Baltimore County 2014 Hazard Mitigation Plan Update, included researching and integrating the most up-to-date and available data during this planning cycle. Updates to this chapter include: new sections and narratives, new figures, updates to existing sections and tables, and new formatting. As detailed in the highlighted figure, there have been four new additions, two of which are sections, and five sections have been updated.

Chapter Highlights

New Additions:
Section 12.1.1 Freezing Rain and Sleet
Section 12.1.3 Extreme Cold and Wind Chill
"Baltimore County Snow Removal Facts"
Figure 12-1.

Updated Sections:
12.1, 12.3, 12.4, 12.5, 12.6

12.1 HOW IS WINTER WEATHER A THREAT TO BALTIMORE COUNTY?

Baltimore County has a long history of winter weather events that have caused property loss, personal injury, and in some cases, fatalities. Winter weather most commonly takes the form of snowfall, but it can also take the form of freezing rain, sleet, or extreme cold. These conditions, which are further explained below, may occur individually or simultaneously in any combination. Such events create dangerous travel conditions, power outages, property damage, and other hazardous conditions.

12.1.1 Freezing Rain and Sleet

Freezing rain is rain that falls onto a surface with a temperature below freezing, causing it to form a coating or glaze of ice. Sleet is defined as rain drops that freeze into ice pellets before reaching the ground.

Even small accumulations of ice can be hazardous to pedestrians and motorists. Significant accumulations of ice can fell trees and power lines, resulting in loss of power and communication. To produce this amount of ice, freezing rain usually has to fall for several hours.[1]

12.1.2 Extreme Cold and Wind Chill

Exposure to extreme cold, even for short periods of time, can result in hypothermia, frostbite, or even death. Wind greatly increases the dangers of frostbite and hypothermia by drawing heat away from the body. [2]

Baltimore County Snow Removal Facts: 2013-2014

Roadways
There are 9,789 roadways within the County. Of these roadways, 166 are snow emergency routes, and each route has 50 to 60 roads.

Snow Removal
In total, there are 300 snow removal trucks with 400 personnel working from 11 locations. Drivers follow specific routes with no special lists or preferred customers. Roads are cleared in this order: collector, arterials, and development subdivisions.

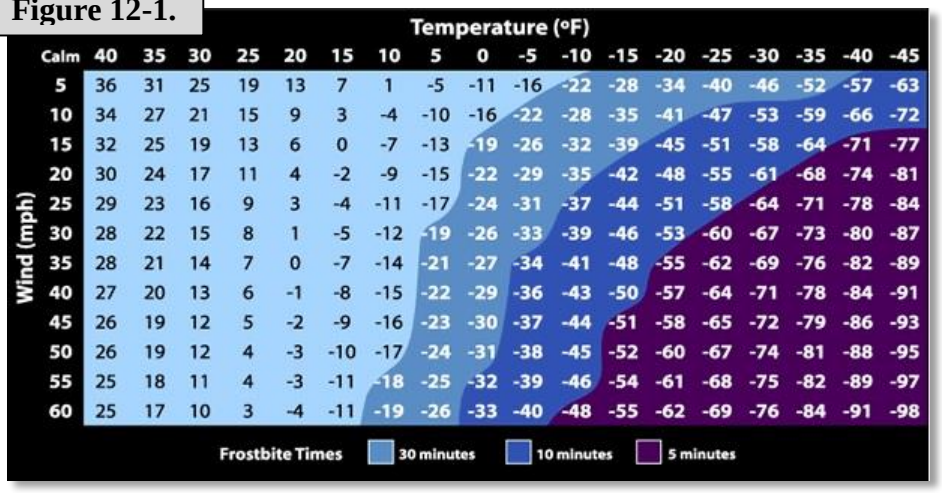
Cost
$5,987,025 has been budgeted for snow removal in 2013-2014.

Salting costs about $108,415 per hour, and takes 4-6 hours. Plowing costs about $37,032 per hour, and takes 18-24 hours.

Source: baltimorecountymd.gov

Wind chill describes the rate of heat loss on the human body resulting from the combined effect of low temperature and wind. As winds increase, heat is carried away from the body at a faster rate, driving down both the skin temperature and eventually the internal body temperature. Exposure to low wind chills can be life threatening to both humans and animals alike.[3] Figure 12-1, created by the National Weather Service (NWS), demonstrates the relationship between temperature, wind speed, and frostbite.

Figure 12-1.



Source: National Weather Service

12.2 CONTRIBUTING FACTORS TO WINTER WEATHER RISK

12.2.1 Weather Patterns

The climate and weather patterns of the Mid-Atlantic region makes for often unpredictable weather conditions during the late fall, winter, and early spring months in Baltimore County. There are several common weather patterns that can occur that bring winter weather to the area, but the results of those patterns are variable, and therefore sometimes unpredictable. The following describes weather patterns that have resulted in winter weather events in Baltimore County[4]:

- Areas of low pressure that track across the region from the west;
- Upper level jet stream interacting with a cold dome of arctic air;
- Combination of low pressure over the southern Ohio Valley, a cold high pressure ridge extending over the region from south-central Canada, and warm air aloft;
- Low and mid-level lift ahead of an Alberta Clipper;
- An Alberta Clipper, moving southeast from the upper Midwest into the Deep South, can link up with subtropical moisture along the southeast US coast to develop a classic nor'easter. As the area of low pressure intensifies, it wraps Atlantic moisture well to the west, where modified arctic air is pouring in from southern Canada; and
- Strong surface high pressure over New England can push a shallow layer of subfreezing air into Maryland.

12.2.2 Temperature

Slight variations in temperature can be the difference between a rain, snow, mixed precipitation or ice event. In some cases, a rain event can become extremely dangerous if ground temperatures are below freezing causing rain to freeze on contact with the ground resulting in "black ice" conditions. In contrast, the dangers of mixed precipitation weather events that occur during busy travel times, in some cases, can minimize the amount of ice accretion damage. This occurs because the contact of tires to pavement helps to keep the roadway temperature elevated so as to not form additional ice accumulations. It should be noted that traveling during these mixed precipitation events is not encouraged, and the warming of the roadway is a benefit of conditions where the roadways are already being heavily traveled during the event, such as peak hour travel.

12.2.3 Physical Terrain

The physical terrain can put certain areas at risk to winter weather events. Areas of high terrain, such as the northern and western parts of the County, can result in colder temperatures and more frequent icy conditions. Valleys are also vulnerable because temperatures cool faster than in the more urbanized areas of the County, which can lead to increased ice on the roads as pooled water freezes more rapidly.

12.3 HISTORY OF WINTER WEATHER

Baltimore County's history of winter weather events is diverse, but winter storm and heavy snow events comprise the majority of weather events during the winter season. Table 12-1, below, identifies the winter storm and heavy snow events that have led to the greatest snow accumulations within the County.

Table 12-1. Significant Winter Weather Events in Baltimore County

Date	Total Snowfall
Feb. 15-18, 2003	28.2 inches
Jan. 27-29, 1922	26.5 inches
Feb. 12-14, 2014	26.0 inches
Feb. 5-6, 2010	24.8 inches
Feb. 11, 1983	22.8 inches
Jan. 7-8, 1996	22.5 inches
Mar. 29-30, 1942	22.0 inches
Feb. 11-14, 1899	21.4 inches
Dec. 18-19, 2009	21.1 inches
Feb. 18-19, 1979	20.0 inches
Feb. 9-10, 2010	19.5 inches

Source: NOAA, NWS

The following are brief descriptions of some of the most significant winter weather events that have affected Baltimore County in recent years:

"Snowmageddon" – February 2010

Baltimore County was paralyzed by back-to-back blizzard events that led to significant accumulations of snow across the region. According to NOAA, total snow accumulation by the end of February at BWI Airport was 50 inches.

President's Day Storm – February 2003

A total of 28.2 inches of snow fell during this storm, which made it the top snow storm on record. A dozen structures including car ports, a factory, and an office building collapsed due to the excessive snowfall. Additionally, a man in his twenties died from carbon monoxide poisoning while trapped in a snowbound car.

Blizzard – January 1996

Baltimore County recorded over 22 inches of snow, the entire state was paralyzed, and the Federal Government remained shut down after a month-long furlough. As road crews worked to clear the snow, another storm moved through on Tuesday, January 9 dumping an additional 3 to 5 inches from Washington northeast through Baltimore. Plows that would have been working on secondary roads and residential areas were sent back to the primary roads. The government remained closed for 4 days that week and many schools and businesses announced their closure for the entire week. A third storm struck on Friday, January 12 dumping another 4 to 6 inches over the metro areas. By the week's end approximately 3 to 4 feet of snow had fallen in the region.

12.4 VULNERABILITY ASSESSMENT

Winter weather hazards can affect all parts of Baltimore County. The northern and western parts of the County have a history of slightly cooler temperatures than other parts of the County, mainly due to the increase in elevation, and less urbanized development.

Infrastructure

All public infrastructure is vulnerable to winter weather events. Transportation systems including roadways, bus service, light rail, Metro, heavy rail, and airports can be adversely impacted during snow, mixed precipitation, and ice events. Particularly, bridges and overpasses become vulnerable because they freeze before roadways due to the materials from which they are constructed.

Extreme cold also has adverse impacts on the public utility infrastructure. Utility line and valve breaks are known to occur when temperatures are extremely low and then warming temperatures cause soil movement that resulting in the shifting of utility lines. This results in breaks mainly to water lines but can also affect stormwater and sewer utilities.

Power outages are also a common result of ice storms and heavy snow. Heavy snow can form on trees limbs which results in breaks and downed power lines. However, with ice accumulations, power lines can be downed without the intervention of trees, due to the heavy burden of ice accumulations on the lines. When these outages occur many residents turn to their gas-powered generators to power their homes. This creates a new risk of carbon monoxide poisoning if not used properly or without proper ventilation.

Building Stock

Structures are also vulnerable to heavy snow events. Older housing is generally not able to support large amounts of snow, and roof collapses are known to occur to these structures. Structures with flat roofs are particularly vulnerable because the melting snow can form pools on rooftops with minimal ability for the water to drain effectively. This is not only the case for residential properties, but businesses and other manufacturing facilities as well. For all structures, gutters can be torn off from homes as a result of "ice dams", which can also cause interior leaks in the structure.

Vulnerable Populations

Winter weather places a heavy toll on residents throughout the County. The elderly and other special needs populations are particularly vulnerable because of their need to have access to medications and other medical necessities, public transportation, meal delivery, and home care support. Because of the weather conditions, emergency responders are not able to reach these populations in an emergency as quickly as they would during normal conditions.

Livestock and pets are also at risk during extreme cold. Many residents do not account for the needs of their pets during winter weather events and leave pets outside for inappropriate amounts of time. In contrast, the farming community tends to be more attentive to the needs of livestock during extreme cold.

12.5 2014 MITIGATION GOALS AND ACTION ITEMS

During the 2014 Plan Update, new mitigation goals and action were added. Additionally, previous mitigation goals and action items from the 2006 Plan were reviewed, and those that were determined to be still in progress or relevant were included.

GOAL 1: Eliminate or reduce human, environmental, social and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Provide those residents in need with shelter during cold weather.	1. Continue to provide, and possibly increase, warming center locations within Baltimore County.	County	High

GOAL 2: Reduce vulnerabilities to future natural hazards; guide and facilitate post-storm recovery.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Enforce current winter weather policy and procedure.	1. Continue to maintain the Baltimore County Snow Emergency Plan.	County	High

GOAL 3: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about natural hazards risks, preparedness and mitigation.	1. Continue to promote winter weather survival tips to citizens throughout the fall and winter seasons on the County website.	County	Medium
	2. Make FEMA's "Emergency Supply List" available on the County's website.	County	Medium
	3. Make SHA's "The Three P's of Safe Winter Driving" available on the County's website.	County	Medium

12.6 EXISTING WINTER WEATHER MITIGATION ACTIVITIES

- The Bureau of Highways Snow Center is manned 24-hours a day during storms. The Snow Center coordinates between plow crews, emergency services and the community.
- "Snow Fighter" is an online resource, available on the County website, which provides timely updates regarding the status of salting, plowing, and general road conditions within Baltimore County.
- The 2012 Baltimore County Building Code mandates: Ground Snow Load – 30 PSF; Roof Snow Load- 30 PSF.

- Every year the Baltimore County Department of Public Works conducts a winter weather emergency coordination meeting to bring together all the participants in winter weather emergency response. Action items include:
    - Maintenance of the Baltimore County Snow Emergency Plan
    - Recently expanded the number of salt storage facilities to increase capacity and to enhance rapid salt deployment
    - Snow plows utilize GPS tracking to optimize routes and performance.

[1] 2011 Maryland State Hazard Mitigation Plan Update
[2] 2011 Maryland State Hazard Mitigation Plan Update
[3] http://www.crh.noaa.gov/ddc/?n=windchill
[4] http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

CHAPTER 13: COASTAL STORM AND FLOODING

The update process for *Chapter 13: Coastal Storm and Flooding*, as part of the Baltimore County 2014 Hazard Mitigation Plan Update, included researching and integrating the most up-to-date and available data during this planning cycle. Updates to this chapter include: new sections and narratives, new tables, figures, and maps, updates to existing sections and tables, and new formatting. As detailed in the highlighted figure, six new sections have been added, and four have been updated. Additionally, a HAZUS Level II analysis was conducted for this hazard and is included in section 13.6.

Chapter Highlights

New Sections:
13.4 National Flood Insurance Program
13.4.1 Coastal Flood Mapping
13.4.2 Community Rating System
13.6 HAZUS Level 2 Analysis
13.7 Coastal Flood Hazard Assessment - Infrastructure
13.8 2014 Mitigation Goals & Action Items

Updated Sections:
13.1, 13.2, 13.3, 13.5

13.1 HOW ARE COASTAL STORMS AND FLOODING A THREAT TO BALTIMORE COUNTY?

Tropical cyclones are rotating weather systems (counter clockwise in the northern hemisphere) over tropical or subtropical waters. They bring with them powerful winds, rain, flooding and tornadoes. The three most common types of tropical cyclones are: tropical depressions, tropical storms, and hurricanes. The Atlantic hurricane season begins in June and continues through November, with most hurricane activity occurring in late summer and early fall.[1]

Tropical Depression - An organized system of clouds and thunderstorms with a defined circulation and maximum sustained winds of 38 mph (33 knots) or less.

Tropical Storm - An organized system of strong thunderstorms with a defined circulation and maximum sustained winds of 39 to 73 mph (34-63 knots).

Hurricane - An intense tropical weather system with a well-defined circulation and maximum sustained winds of 74 mph (64 knots) or higher. In the western Pacific, hurricanes are called "typhoons," and similar storms in the Indian Ocean are called "cyclones."

Source: baltimorecountymd.gov

Hurricanes are products of warm tropical oceans and the atmosphere. Powered by heat from the sea, they are steered by the easterly trade winds and the temperate westerlies, as well as by their own ferocious energy. Around their core, winds grow with great velocity, generating violent seas. Moving ashore, they sweep the ocean inward, often spawning tornadoes and producing torrential rains and floods. They begin to die once they move over land and lose the moisture from the ocean.[2]

Baltimore County has approximately 175 miles of shoreline along the Patapsco, Back, Middle, and Gunpowder Rivers. This eastern coastal shoreline has been vulnerable to hurricanes and tropical systems as their recorded histories in section 13.3 indicates. These storms have caused intense coastal flooding and shoreline erosion resulting in extensive loss of property, injuries, and even loss of life.

13.2 CONTRIBUTING FACTORS TO COASTAL STORM AND FLOODING RISK

13.2.1 High Winds

The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous, however, and require preventative measures. In the western North Pacific, the term "super typhoon" is used for tropical cyclones with sustained winds exceeding 150 mph.[3]

Table 13-1. Saffir-Simpson Hurricane Wind Scale

Category Wind Speed	Damage/Effects
Category 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.
Category 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.
Category 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.
Category 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.
Category 5 >157 mph	**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.

Source: National Hurricane Center, NWS

While hurricanes are ranked according to the strength of their winds, a hurricane does not need to be a Category 4 or 5 to cause serious damage. A tropical system's heavy rains and flooding usually cause the most damage and loss of life.

In 1972, Hurricane Agnes was a weak Category 1 when it came ashore, but its heavy rains caused flooding that resulted in billions of dollars in damage and killed 129 people.[4]

13.2.2 Heavy Rainfall

Tropical cyclones often produce widespread, torrential rains in excess of 6 inches, which may result in deadly and destructive floods. In fact, flooding is the major threat from tropical cyclones

for people living inland. Flash flooding, defined as a rapid rise in water levels, can occur quickly due to intense rainfall. Longer term flooding on rivers and streams can persist for several days after the storm.

Rainfall amounts are not directly related to the strength of tropical cyclones but rather to the speed and size of the storm, as well as the geography of the area. Slower moving and larger storms produce more rainfall. In addition, mountainous terrain enhances rainfall from a tropical cyclone

13.2.3 Storm Surge and Storm Tide

Isabel was the worst hurricane to affect the Chesapeake Bay region since 1933. Storm surge values of more than 8 feet flooded rivers that flowed into the bay across Virginia, Maryland, Delaware, and Washington, D.C.

Source: NWS, NOAA

Storm surge and large waves produced by hurricanes pose the greatest threat to life and property along the coast. Storm surge is an abnormal rise of water generated by a storm's winds. Storm surge can reach heights well over 20 feet, span hundreds of miles of coastline, and penetrate several miles inland. Storm tide is the water level rise during a storm due to the combination of storm surge and the astronomical tide.

The destructive power of storm surge and large battering waves can result in loss of life, destruction of property, beach and dune erosion, and road and bridge damage along the coast. In estuaries and bayous, salt water intrusion endangers public health and the environment.[5]

13.2.4 Sea Level Rise and Shoreline Erosion

Within the Chesapeake Bay, shorelines have been continuously eroding since the formation of the Bay roughly 10,000 years ago. Over the long term, sea-level rise is one of the primary causes of this shoreline erosion. In the short term, waves and storm events are the primary cause of changes in the shoreline.[6] While localized human activities, such as coastal development, have played a part in shoreline erosion, global climate change is also an important factor. Warmer global temperatures mean two events occur: 1) loss of land-based ice, such as glaciers and polar ice caps, and 2) thermal expansion, which simply means that water expands and takes up more space as it warms. These two factors are major causes of sea-level rise, which in turn causes shoreline erosion.[7]

Currently, sea-level rise averages about 3-4 mm a year in Maryland, or one foot per century. According to NOAA, this is a "significantly larger rate than the sea-level rise averaged over the last several thousand years." In the 2013 report, *Updating Maryland's Sea-level Rise Projections,* sea-level rise estimates for Maryland are determined by the National Research Council relative to global mean sea-level rise. These estimates are included in Table 13-2, below.

Table 13-2. Estimated Sea-Level Rise in Maryland

Maryland Relative Sea-level Rise	Thermal (m)	Glaciers (m)	Greenland (m)	Antarctica (m)	Dynamic (m)	VLM (m)	SLR Total	
							meters	feet
2050 best	0.10	0.05	0.03	0.09	0.09	0.075	0.4	1.4
2050 low	0.04	0.05	0.02	0.04	0.07	0.065	0.3	0.9
2050 high	0.19	0.06	0.05	0.16	0.10	0.085	0.7	2.1

2100 best	0.24	0.13	0.10	0.30	0.17	0.15	1.1	3.7
2100 low	0.10	0.12	0.08	0.10	0.13	0.13	0.7	2.1
2100 high	0.46	0.17	0.17	0.58	0.19	0.17	1.7	5.7

Source: Updating Maryland's Sea-level Rise Projections, 2013

Including tidal shoreline and low-lying rural and urban lands, Maryland has 3,100 miles of shoreline[8], 175 miles of which are in Baltimore County. Efforts to protect these coastlines are ongoing and consist of multiple erosion control methods, the preferred method being living shorelines. In fact, The Living Shorelines Act of 2008 requires that living shorelines be considered for erosion control unless the Maryland Department of the Environment (MDE) grants a waiver.[9]

In Baltimore County, living shoreline stabilization projects have occurred in Essex Skypark and Watersedge Park.[10] The Essex Skypark project, which began in June of 2011, included enhancements to 2,610 linear feet of severely eroded shoreline.

Living shoreline projects utilize a variety of structural and organic materials, such as wetland plants, submerged aquatic vegetation, oyster reefs, coir fiber logs, sand fill, and stone. The benefits of living shorelines include:

- Stabilization of the shoreline.
- Protection of surrounding riparian and intertidal environment.
- Improvement of water quality via filtration of upland run-off.
- Creation of habitat for aquatic and terrestrial species.

Source: NOAA

The shoreline of Watersedge Park **before** construction of the shoreline stabilization project.

The shoreline of Watersedge Park **after** construction of the shoreline stabilization project.

Shoreline protection measures are critical for another reason: the relationship between sea-level rise and storm surge. As a result of global warming, highly intense storms are projected to become more common in higher latitudes along the Mid-Atlantic during the 21st century. Add to this that sea-level rise will cause a general deepening of the Bay, one is presented with higher and more intense storm surges along coastlines.

13.3 HISTORY OF COASTAL STORMS AND FLOODING

Baltimore County has a broad history of coastal storms resulting in coastal flooding events. Table 13-3 provides a list of the most significant tropical storms that have occurred during the last 100 years. Descriptions of these storms are provided to show the intensity and devastation caused by coastal storms and their resultant flooding.

Table 13-3. Significant Tropical Storms/Hurricanes Affecting Baltimore County

- Chesapeake-Potomac, 1933
- Hazel, 1954
- Agnes, 1972
- Gloria, 1985
- Bertha, 1996
- Fran, 1996
- Dennis, 1999
- Floyd, 1999
- Isabel, 2003
- Irene, 2011
- Sandy, 2013

Sandy – October 2012

Compared to many locations in the Northeast, Baltimore County avoided disaster in terms of damage from Sandy. With the exception of flooding on the Eastern Shore that destroyed parts of the Ocean City boardwalk, and heavy snowfall in Western Maryland that shutdown I-68, most of central Maryland was left relatively unscathed. In total, about 300,000 BGE customers lost power starting on October 28; a rather light number compared to the June Derecho and Hurricane Irene, which each had about 750,000 reported power outages.[11]

Tropical Storm Lee – September 2011

On the heels of Hurricane Irene, Tropical Storm Lee set up in a north/south orientation across Maryland from Charles County into Baltimore County on September 7. Rainfall rates of 2 to 3 inches per hour occurred for several hours within this region, causing numerous high water rescues, road closures, and flooded homes. Of note was a rain gauge in Bowie, MD, that observed 4.57 inches of rain in 3 hours, which is an amount that only has a 0.5 percent chance of occurring in a given year. Across much of the Baltimore region, the storm dumped more rain than Hurricane Irene did, but lighter winds meant that far fewer people lost electrical service. About 66,000 BGE customers lost service for a time; and almost 6,000 were still in the dark into the following morning.[12]

Irene – August 2011

Hurricane Irene tracked up the Mid-Atlantic Coast during the evening hours of August 27th through the early morning hours of the 28th. Irene passed by just to the east of Ocean City, Maryland during the early morning hours of the 28th. The minimum central pressure was 958 millibars and maximum sustained winds were 80 mph, making Irene a category one hurricane. Irene produced tropical storm conditions across portions Maryland near and east of the Interstate 95 Corridor. The worst conditions were near the Chesapeake Bay. As with most of the state,

Baltimore County did not receive the amount of damage and flooding that had been predicted. However, high winds did lead to downed trees and power lines, which caused some 130,000 reported power outages throughout the county.[13]

Isabel – September 2003

Areas adjacent to the Chesapeake Bay and its tributaries were particularly hard hit, with storm surge exceeding the previous record levels set by the Chesapeake-Potomac Hurricane of 1933. In Baltimore County alone, $3 million in damage is estimated to have occurred from erosion of the shoreline. Residential areas of Millers Island, Edgemere, North Point, Bowley's Quarters and Turners Station were hard hit with more than 400 people being rescued from their homes and over 300 buildings destroyed. Marinas were also destroyed or severely damaged. Baltimore County was estimating 3189 tons of debris to be hauled from the storm. While most people had their power back in a week, some locations took up to two weeks. Many injuries and three fatalities occurred from carbon monoxide poisoning from people improperly running generators in their houses. Other injuries were related to chain saws and the clean-up of debris. Heavy rains, several days after Isabel, added to localized and flash flooding throughout the County. The State was declared a Federal Disaster Area on September 19, 2003. 4,113 Baltimore County residents have registered with the federal government for disaster relief. For the entire State of Maryland, the amount of claims reported to the National Flood Insurance program totaled approximately $122 million.

Floyd – September 1999

The highest rainfall reports ranged from 5 – 6 inches throughout the County. Across Baltimore County, 57,000 customers lost power. Winds gusted to 69 MPH at Martin State Airport, and hundreds of trees fell in Gunpowder State Park. Countywide, fallen trees damaged homes, sheds, fences, and cars, and closed 125 roads. Officials reported 6 rapid water rescues and 350 flooded basements. A 10 year old boy was swept into a storm drain and carried 300 feet in a buried pipe before fire fighters opened a manhole cover and rescued him uninjured. The impact of Floyd was compounded by the effects of Hurricane Dennis which had produced rainfall on the Atlantic coast one week prior to Floyd's arrival. This resulted in already saturated conditions in the region.

Agnes – June 1972

Agnes is a reminder that we cannot assume that the size and category of hurricane tells the whole picture. Agnes evolved from a weak Category 1 hurricane at landfall on the Gulf of Mexico, to a tropical depression as it moved eastward. Total storm damage in the United States from Agnes was estimated at just under $3.5 billion with a death toll of 122 lives. Total storm damage in Maryland and the District of Columbia was estimated at $110 million. In Maryland heavy rains in less than 24 hours resulted in severe flooding. Just west of Baltimore County, the highest total rainfall was 14.68 inches at Westminster and 13.85 inches at Woodstock. The heavy rains caused disastrous flash flooding of creeks and streams. Flooding along the Patapsco River broke all existing records, inundating the chronically flooded Ellicott City and Oella regions of Baltimore and Howard Counties with flood waters cresting almost 15 feet above Main Street in Ellicott City. The American Red Cross in Maryland reported 103 houses destroyed and 1,930 damaged, 17 farm buildings destroyed and 44 damaged, and 82 small businesses destroyed. Damage to residential,

farm, and business structures was estimated at $48.5 million.[14] Damage to State roads and bridges in Maryland was estimated to be $6.5 million and to county roads and bridges, $25 million.[15] Flooding along the larger streams and rivers severely damaged or destroyed crops through erosion or silt deposition. Excessive runoff into the Chesapeake Bay decreased salinity levels and severely affected the shellfish industry.[16]

Hurricane of 1933

Prior to Agnes, this storm was the storm of record in terms of flooding. The storm caused 13 deaths statewide and $12.3 million in damages.

13.4 NATIONAL FLOOD INSURANCE PROGRAM

The National Flood Insurance Program (NFIP) was enacted by the Federal government in 1968 to facilitate citizens' access to affordable flood insurance and shift the burden of private property flood losses from taxpayers to floodplain property owners. The program is also designed to guide development away from flood hazard areas and requires new design and construction to be carried out in a way that minimizes or prevents flood damage.[17]

Baltimore County NFIP Policy and Claim Information (as of 10/31/2013)

Number of policies in force: 4,654
Total coverage value: $1,091,896,600
Annual premium: $5,167,225
Number of claims: 2,970
Total claim value: $64,186,927
Average claim value: $21,612

Source: bsa.nfipstat.fema.gov

13.4.1 Coastal Flood Mapping

A Flood Insurance Rate Map (FIRM), created for floodplain management insurance purposes, is an official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community. Digital versions of these maps are called DFIRMS, which are compatible with Geographic Information Systems (GIS). The improvements in spatial accuracy provided by the new base map, and the availability of electronic floodplain information should greatly enhance the ability to use the maps for planning, permitting, and insurance applications.[18]

The State of Maryland in conjunction with the Federal Emergency Management Agency (FEMA) has been systematically updating Flood Insurance Rate Maps (FIRMs) for communities over the past several years. As of December 2013, the Preliminary Map date for coastal flooding is November 2012, and the Targeted Effective Map date is May 2014.[19]

13.4.2 Community Rating System

The NFIP's Community Rating System (CRS) is a voluntary incentive program that recognizes communities for implementing floodplain management practices that exceed the Federal minimum requirements of the NFIP to provide protection from flooding.

In exchange for a community's proactive efforts to reduce flood risk, policyholders can receive reduced flood insurance premiums for buildings in the community. These reduced premiums reflect the reduced flood risk resulting from community efforts toward achieving the three CRS goals:

1. Reduce flood damage to insurable property;
2. Strengthen and support the insurance aspects of the NFIP;
3. Encourage a comprehensive approach to floodplain management.

Participation in the Community Rating System (CRS) is voluntary. By participating, communities earn credit points that determine classifications. There are 10 CRS Classes: Class 1 requires the most credit points and provides the largest flood insurance premium reduction (45 percent), while Class 10 means the community does not participate in the CRS or has not earned the minimum required credit points, and residents receive no premium reduction. The CRS Classes are based on completion of 19 creditable activities organized into 4 categories:

1. Public Information
2. Mapping and Regulations
3. Flood Damage Reduction
4. Warning and Response

Baltimore County's 5-year CRS Forecast

The County's five year CRS plan is an aggressive effort to continue to update codes, inspections, and record keeping in order to stay up to date on the County's floodplain management program.

Flood Plain Regulations found in the Baltimore County Code ARTICLE 32, TITLE 8 Floodplain Management, as well as the Baltimore County Building Code Bill 40-12 usually meet or exceed FEMA requirements as well as the Insurance Services Office who perform the CRS survey.

The County received their Community Assistance Visit (CAV) in September of 2013. Recommendations once received will be reviewed to be incorporated into the 2015 Baltimore County Building Code based on the proposed 2015 edition of the International Building Code with local amendments.

13.5 REPETITIVE LOSS PROPERTIES

Repetitive loss properties are the biggest drain on this country's Flood Insurance Fund. According to the NFIP, a property is considered a repetitive loss property when there are two or more losses reported and $1,000 or more was paid on each loss. The two losses must be within ten years of each other and be at least ten days apart; only losses proceeding January 1, 1978 are considered. Additionally, a property may be considered a 'severe repetitive loss property' if it meets the following criteria:

- Has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or
- For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.
- For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.

As of July 31, 2013, Baltimore County has 121 repetitive loss properties, 27 of which are non-residential. Of these 121 properties, 71 are coastal, which represents nearly 60% of the repetitive loss properties in the County. Table 13-4, below, details these coastal properties.

Table 13-4. Coastal Repetitive Loss Properties

Street Name	Community	Street Name	Community
4th St	Sparrows Point	Greenbank Rd	Middle River
8th St	Sparrows Point	(2) Hinton Ave	Sparrows Point
(2) 9th St	Sparrows Point	Kingston Rd	Middle River
(3) Bay Dr	Middle River	(2) Middle River Ave	Middle River
(2) Bayside Rd	Essex	Nannette Ln	Middle River
Beach Dr	Middle River	New Section Rd	Middle River
Beach Rd	Middle River	Northview Rd	Dundalk
(2) Beech Dr	Middle River	Oakdene Rd	Middle River
Bird River Grove Rd	White Marsh	Poplar Rd	Essex
Briar Pt Rd	Middle River	Red Rose Farm Rd	Middle River
Bullneck Rd	Dundalk	(11) River Drive Rd	Sparrows Point
(2) Burke Rd	Middle River	River Drive Rd*	Sparrows Point
Chesapeake Ave	Sparrows Point	(2) Sandy Plains Rd	Dundalk
Chestnut Rd	Middle River	Schaadts Rd	Middle River
(2) Clarks Point Rd	Middle River	Searles Rd	Dundalk
(2) Cold Spring Rd	Middle River	Shore Rd	Middle River
Cornwall Rd	Dundalk	Thruway	Dundalk
Cove Rd	Dundalk	Transverse Ave	Middle River
Cuckold Point Rd	Sparrows Point	Watersedge Rd	Dundalk
Dundalk Ave	Dundalk	Willow Spring Rd	Dundalk
Ella Ave	Sparrows Point	(2) Wilson Point Rd	Middle River
Fairgreen Rd	Dundalk		
(2) Frog Mortar Rd	Middle River		
(2) Galloway Rd	Middle River		
Glenwood Rd	Middle River		
Grace Rd	Sparrows Point		

Note: (#) Indicates number of RLP on street.
* Indicates a Severe Repetitive Loss Property

13.6 HAZUS Level 2 COASTAL FLOOD Analysis – 2013

13.6.1 Plan Update

As part of the 2014 Plan Update, a HAZUS Level 2 Analysis was conducted for *Chapter 13 Coastal Storm and Flooding*. Results of this type of analysis include essential facility and general building stock damages, debris generation, shelter requirements, and associated economic losses. This level of analysis is more accurate than a Level 1 Analysis because the data used for the analysis is derived from user-supplied sources, including best-available data specific to Baltimore County, as well as data available in the Hazus database. Examples of user-supplied data utilized for this analysis include:

Table 13-5. HAZUS Default Data v. County Data

Critical Facility Type	HAZUS Default Data (utilized in HAZUS Level 1 Analyses)	County Data Utilized for HAZUS Level 2 Analysis
Fire stations/EMS	16	65
Police Stations	10	20
Schools	132	375
Medical Facilities	0	25
EOC	1	1

- Building stories
- Year built
- Structure value
- Square Footage

U.S. Census Bureau Data Utilization

The HAZUS analysis conducted during the 2014 Plan Update utilized the most recent version of the software (version 2.1), which was released in October of 2013. At the time of this HAZUS Level 2 Analysis for Coastal Flood, FEMA had not yet integrated 2010 Census data into the Hazus version 2.1 software. This data will be made available with the next release. As such, household numbers and other demographic data has been increased by 5.6% to better represent the total number of households (316,716) in Baltimore County per the 2010 U.S. Census. This percentage increase was derived by determining the percent change in demographic data from 2000 to 2010. For example, the total number of households in Baltimore County has changed from 299,000 in 2000 to 316,715 in 2010, which represents an increase of 17,715 households. This change was calculated as a percentage (5.6%) and related household values were increased by this amount where necessary (see Table 10-6). In the case of population estimates, a 6.3% change was calculated and added to necessary population values.

13.6.2 Introduction

The HAZUS Flood Model analyzes both riverine and coastal flood hazards. Flood hazard is defined by a relationship between depth of flooding and the annual chance of inundation to that

depth. Depth, duration and velocity of water in the floodplain are the primary factors contributing to flood losses. The coastal flood model does not estimate the losses due to storm surge at this time.

Note: The full report of the HAZUS Level 2 Analysis for Coastal Flood is included in Appendix B.

13.6.3 County Overview

Baltimore County is roughly 599 square miles and contains 7,879 census blocks. The region contains 316,715 households and has a total population of 805,029 people (2010 Census Bureau data). There are an estimated 269,655 buildings in the region with a total building replacement value (excluding contents) of 59,023 million dollars (2006 dollars). Approximately 93% of the buildings (and 76% of the building value) are associated with residential housing.

HAZUS Coastal Flood Parameters

Study Region: Baltimore County
Scenario: Coastal Flood
Return Period: 100

Table 13-6, below, provides building exposure values by occupancy type for the coastal flood event scenario. The information contained in this table represents only building stock that was determined by HAZUS to have been affected ("exposed") by the coastal flood event.

Table 13-6. Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	1,477,380	80.7%
Commercial	239,978	13.1%
Industrial	59,684	3.3%
Agricultural	3,352	0.2%
Religion	14,650	0.8%
Government	17,971	1.0%
Education	17,824	1.0%
Total	**1,830,839**	**100.00%**

Note: Dollar exposure values are produced from the square footage values derived from U.S. Census data, Maryland Property View, and Dun & Bradstreet, by applying the RS Means replacement values for typical building square foot factors and construction for each occupancy type.

Essential Facility Inventory

Critical facilities were broken down into two groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police

stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants, and hazardous material sites.

For essential facilities, there are 25 hospitals in the region with a total bed capacity of 1,800 beds. There are 375 schools, 65 fire stations, 20 police stations and 1 emergency operation center.

13.6.4 Damage Estimates

General Building Stock Damage

Hazus estimates that about 89 buildings will be at least moderately damaged, which is defined as damage to the interior of structures from water and some physical damage to building components. This is over 27% of the total number of buildings in the scenario. It is estimated that no buildings will be completely destroyed during this event. Table 13-7, below, summarizes the expected damage by general occupancy for the buildings in the scenario.

Essential Facility Damage

Before the flood event analyzed in this scenario, Baltimore County had 1,800 hospital beds available for use. On the day of the scenario flood event, the model estimates that all of these hospital beds will remain available for use. Table 13-8, below, summarizes the expected damage to essential facilities in Baltimore County due to the proposed flood event.

Table 13-7. Expected Damage to Essential Facilities

Classification	Total	At Least Moderate Damage	At Least Substantial Damage	Loss of Use
Fire Station	65	0	0	0
Hospital	25	0	0	0
Police Station	20	0	0	0
School	375	0	0	0

13.6.5 Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick,

etc.) and 3) 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 1,145 tons of debris will be generated. Of the total amount, Finishes comprises 97% of the total, and Structure comprises 1% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 46 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Total tons of debris, by census block, generated by the coastal storm event is depicted on Map 13-1. Based on the results, the Essex, Dundalk, Middle River, and Bowleys Quarter areas will have the greatest amount of debris.

13.6.6 Economic Loss

The total economic loss estimated for the flood is 14.42 million dollars, which represents 0.79 % of the total replacement value of the scenario buildings.

Building-Related Losses

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 14.27 million dollars. Less than 1% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 62% of the total loss. Table 13-9, below, provides a summary of the losses associated with the building damage.

Table 13-8. Building-Related Economic Loss Estimates (Millions of Dollars)

Type	Residential	Commercial	Industrial	Others	Total
Building	5.78	1.03	0.17	0.13	7.10
Content	3.17	2.93	0.19	0.81	7.11
Inventory	0.00	0.02	0.04	0.00	0.06
Total	**8.95**	**3.98**	**0.40**	**0.94**	**14.27**

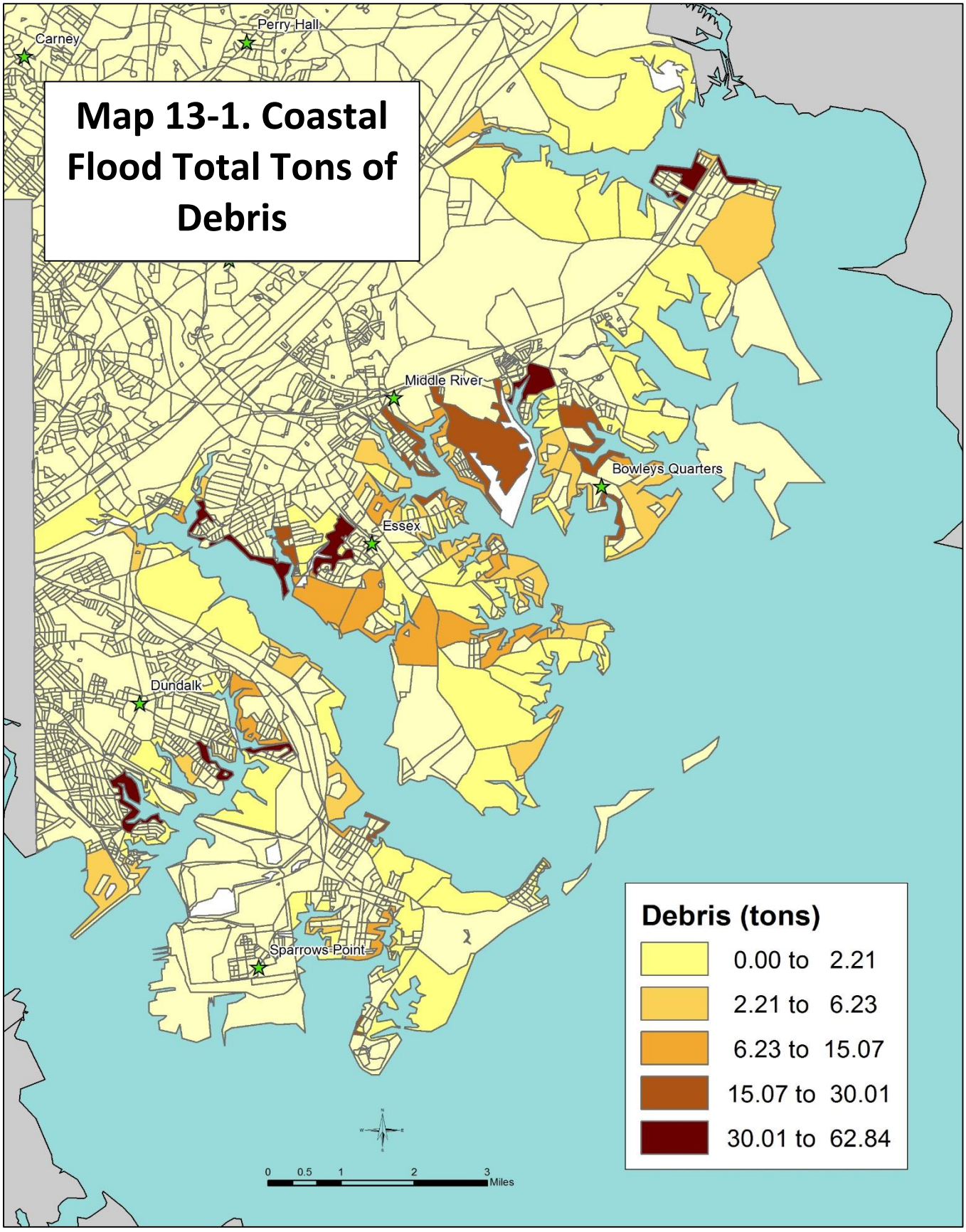
Building-related economic losses are depicted on Map 13-2. Based on the results, the Essex, Dundalk, Middle River, and Bowleys Quarter areas will have the greatest amount of building loss.

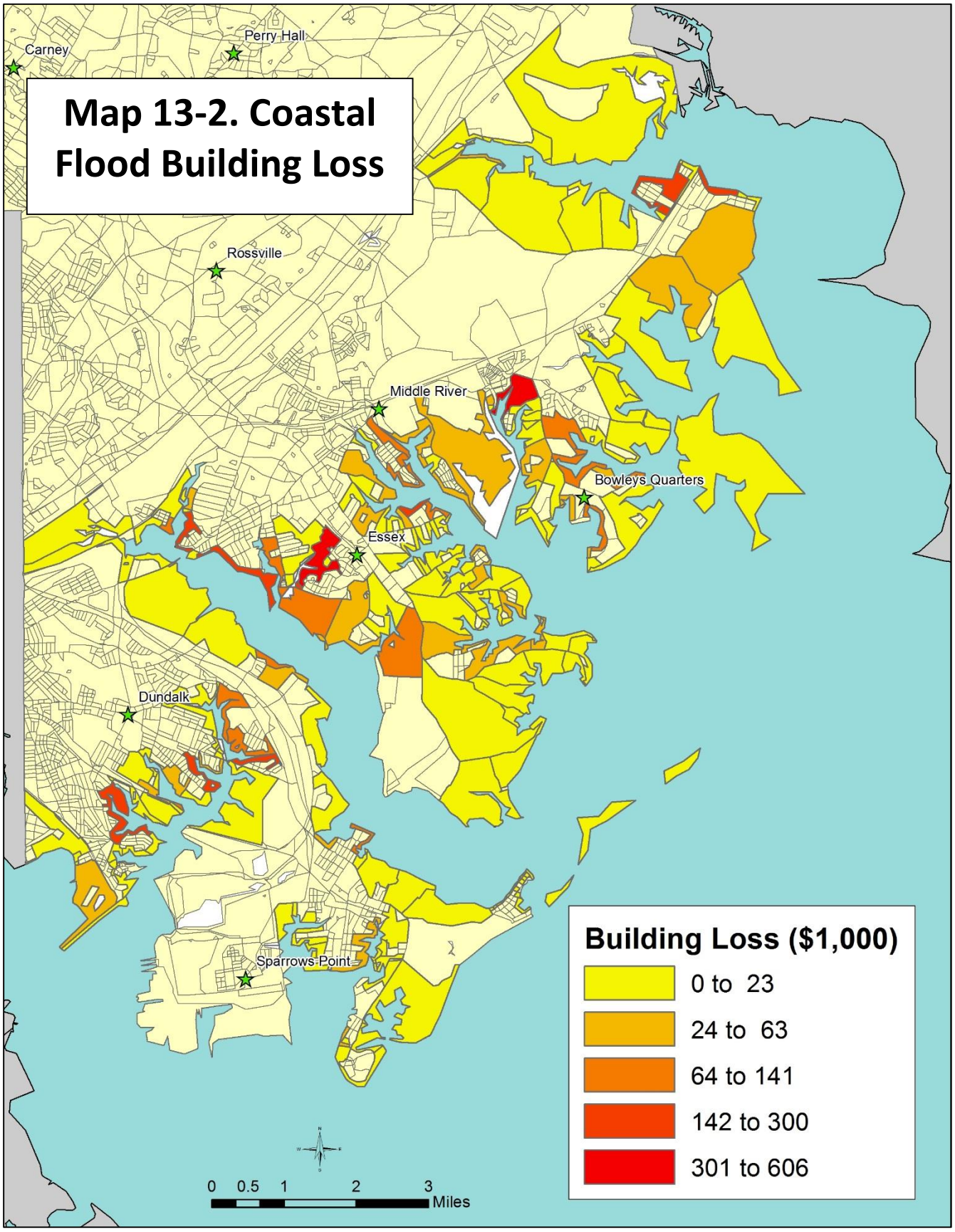
13.6.7 Social Impact

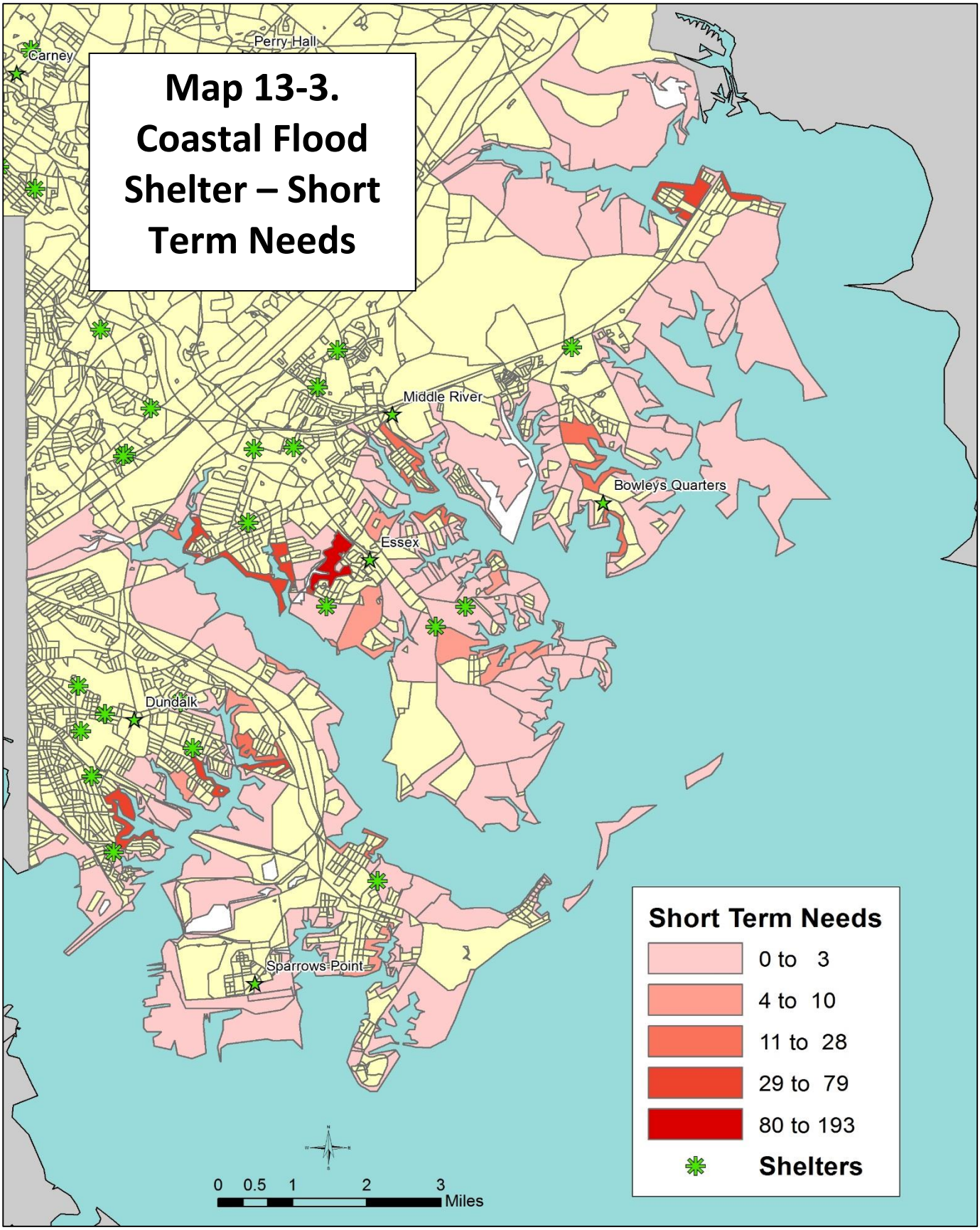
Shelter Requirements

Hazus estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. Hazus also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 611 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 1,069 people (out of a total population of 805,029) will seek temporary shelter in public shelters.

These short-term shelter needs are depicted by census block on Map 13-3. Based on the results, the Essex, Dundalk, Middle River, and Bowleys Quarters areas will have the highest demand for short term sheltering.


Map 13-1. Coastal Flood Total Tons of Debris
Carney
Perry Hall
Middle River
Bowleys Quarters
Essex
Dundalk
Sparrows Point
Debris (tons)
0.00 to 2.21
2.21 to 6.23
6.23 to 15.07
15.07 to 30.01
30.01 to 62.84
0 0.5 1 2 3
Miles


Map 13-2. Coastal Flood Building Loss
Carney
Perry Hall
Rossville
Middle River
Bowleys Quarters
Essex
Dundalk
Sparrows Point
Building Loss ($1,000)
0 to 23
24 to 63
64 to 141
142 to 300
301 to 606
0 0.5 1 2 3
Miles


Map 13-3.
Coastal Flood
Shelter – Short
Term Needs
Carney
Perry Hall
Middle River
Bowleys Quarters
Essex
Dundalk
Sparrows Point
Short Term Needs
0 to 3
4 to 10
11 to 28
29 to 79
80 to 193
Shelters
0 0.5 1 2 3
Miles

13.7 COASTAL FLOOD HAZARD ASSESSMENT – INFRASTRUCTURE

13.7.1 Introduction

In the Baltimore County 2006 Multi-Hazard Mitigation Plan, infrastructure within the FEMA mapped 100-year coastal floodplain were identified. Identified infrastructure included: roadways and bridges.

The HAZUS Level 2 Analysis for Coastal Flood primarily considered impacts to residential, commercial, and industrial structures, and essential and critical facilities. Impacts to infrastructure were not included in the HAZUS Level 2 Analysis.

Therefore, in order to complete the 2014 Plan Update, infrastructure within the 100-year coastal flood zone (based upon the most recent FEMA 2013 Preliminary Coastal Firm maps), as well as infrastructure impacted by a Category 3 Hurricane, were identified.

A Category 3 hurricane scenario was selected for this assessment. According to the Maryland State Archives hurricanes rarely directly hit the State (only twice since recording began in 1851), and a major hurricane (category 3 or higher) has never directly hit.[20] Presumably, this means that Maryland has only ever been struck by Category 1 and 2 hurricane events. However, in order to provide a realistic "worst case" scenario, a Category 3 hurricane event was selected.

For this assessment, infrastructure includes: roadways, bridges, culverts, and communication towers.

13.7.2 Data Utilization

The following shapefiles (sources included) were utilized to determine hazard areas and affected infrastructure:

- 100-year coastal flood zone (VE) – FEMA DFIRM Preliminary (As of: September 23, 2013)
- Storm Surge Category 3 Hurricane – Baltimore County Office of Information Technology (2010)
- Bridges – Baltimore County Office of Information Technology (2011)
- Culverts – FEMA DFIRM Database (8/2/2011)
- Street Centerlines – Baltimore County Office of Information Technology (June 2013)
- Communication Towers – Federal Communications Commission (2010)

13.7.3 Method

Data listed in section 13.7.2 was analyzed using ArcMap 10.1, a geographic information system (GIS). This program allows various data layers, such as shapefiles, to be overlaid and spatially compared. To determine vulnerable infrastructure within the County, each infrastructure shapefile (bridges, roadways, etc.) was intersected with the 100-year coastal floodplain and the Category 3

hurricane storm surge shapefile. Infrastructure was deemed to be vulnerable to coastal flood if it was within (intersects) either of these layers.

13.7.4 Assessment Results

Based on the 2014 assessment, the following structures were determined to be within the FEMA defined 100-year coastal flood zone and/or the Category 3 hurricane storm surge area:

Bridges within FEMA 100-year coastal flood zone (VE)

In total, there are about 537 bridges within Baltimore County. Of these, none (0) were determined to be within the 100-year coastal flood zone.

Bridges Affected by Category 3 Hurricane

It is estimated that 9 bridges will be impacted by storm surge from a Category 3 Hurricane. Table 13-9, below, details these bridges. Map 13-4 depicts these bridges.

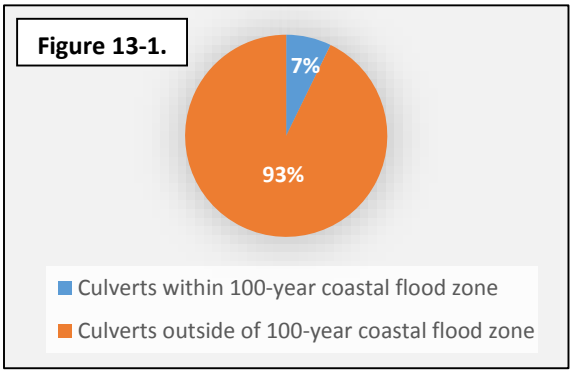
Table 13-9. Bridges Impacted by Storm Surge from Category 3 Hurricane

Roadway	River Crossing
(3) Southeast Blvd	Northeast Creek
S. Marlyn Ave	Deep Creek
Pulaski Hwy	Gunpowder Falls
Harbor Tunnel Thruway	Patapsco River
Ebenezer Rd	White Marsh Run
Balto Annapolis Blvd	Patapsco River
Baltimore Washington Pkwy	Patapsco River

Note: (#) If relevant, indicates the number of bridge structures on the same roadway.

Culverts within FEMA 100-year coastal flood zone (VE)

In total, there are about 13,566 culverts within Baltimore County. Of these, 981 are within the 100-year coastal flood zone. Figure 13-1 further highlights this relationship. Map 13-5 illustrates culverts in the county within the 100-year coastal flood zone.



Culverts Affected by Category 3 Hurricane

Of the 13,566 culverts within Baltimore County, only 2,573 will be impacted by storm surge from a Category 3 hurricane. Map 13-5 illustrates these culverts.

Roadways within FEMA 100-year coastal flood zone (VE)

In total, there are about 9,789 roadways within Baltimore County. Of these, 19 are within the 100-year coastal flood zone. This translates to over 8.5 miles (<1% of total road miles) of roadway within the 100-year coastal flood zone. Tables 13-10 and 13-11 list the roadways by total miles impacted, and communities by number of affected roadways, respectively. Map 13-6 illustrates roadways in the county within the 100-year coastal flood zone.

Table 13-10. Roadways by Total Miles Impacted Within 100-year Coastal Flood Zone (VE)

Road Name	Total Miles
Key Brg	2.23
Carroll Island Rd	1.43
Hart Miller Isl Dike	1.02
Road	0.88
Sandy Bech Dr	0.69
Phillips Rd	0.39
Baltimore Yacht Club Rd	0.32
13th St	0.21
North Point Rd	0.20
Road	0.43
14th St	0.19
Service Rd	0.19
G St	0.14
Wharf Rd	0.09
Chesapeake Ave	0.08
Schaffers Rd	0.08
11th St	0.04
Susquehanna Rd	0.03
Cuckold Point Rd	0.03

Table 13-11. Communities by Number of Affected Roadways Within 100-year Coastal Flood Zone (VE)

Community	Affected Roadways
Dundalk	7
Sparrows Point	6
Middle River	3
Essex	3

Roadways Affected by Category 3 Hurricane

In total, there are about 9,789 roadways within Baltimore County. Of these, 516 are within the 100-year coastal floodplain. This translates to over 171 miles (3.8% of total road miles) of roadway within the 100-year coastal flood zone. Tables 13-12 and 13-13 list roadways most impacted by storm urge by total miles, and communities by number of affected roadways, respectively. Map 13-6 illustrates these roadways.

Table 13-12. Roadways Most Impacted by Storm Surge from Category 3 Hurricane			
Road Name	Total Miles	Road Name	Total Miles
I 695	9.01	Seneca Park Rd	1.18
Alley	8.16	Bowleys Quarters Rd	1.16
Road	7.79	River Drive Rd	1.14
Hart Miller Isl Dike	5.54	Red Lion Rd	1.08
Driveway	3.59	Marshy Point Rd	1.06
Peninsula Expy	2.56	I 895	1.06
Pulaski Hwy	2.55	Eastern Ave	1.03
Key Brg	2.23	Southeast Blvd	1.02
Ramp	2.08	Wilson Point Rd	1.01
Ore Pier Rd	1.39	Greenbank Rd	1.01
Wharf Rd	1.29	Chesapeake Ave	0.97
Shore Rd	1.22	North Point Rd	0.97
Holly Neck Rd	1.20	Carroll Island Rd	0.96
Wire Mill Rd	1.19		
Bird River Grove Rd	1.19		

Table 13-13. Communities by Number of Roadways Impacted by Storm Surge from Category 3 Hurricane	
Community	Affected Roadways
Dundalk	131
Essex	152
Middle River	124
Sparrows Point	89
White Marsh	5
Halethorpe	6
Highlandtown	3
Rosedale	3
Brooklyn	2
Gunpowder	1

Communication Towers within FEMA 100-year coastal floodplain
None

Communication Towers Inundated by Category 3 Hurricane

1 Communication
- Maryland Transportation Authority (Dundalk)

1 AM Radio
- WBGR (Rosedale)

13.7.5 Assessment Analysis

Transportation Impacts

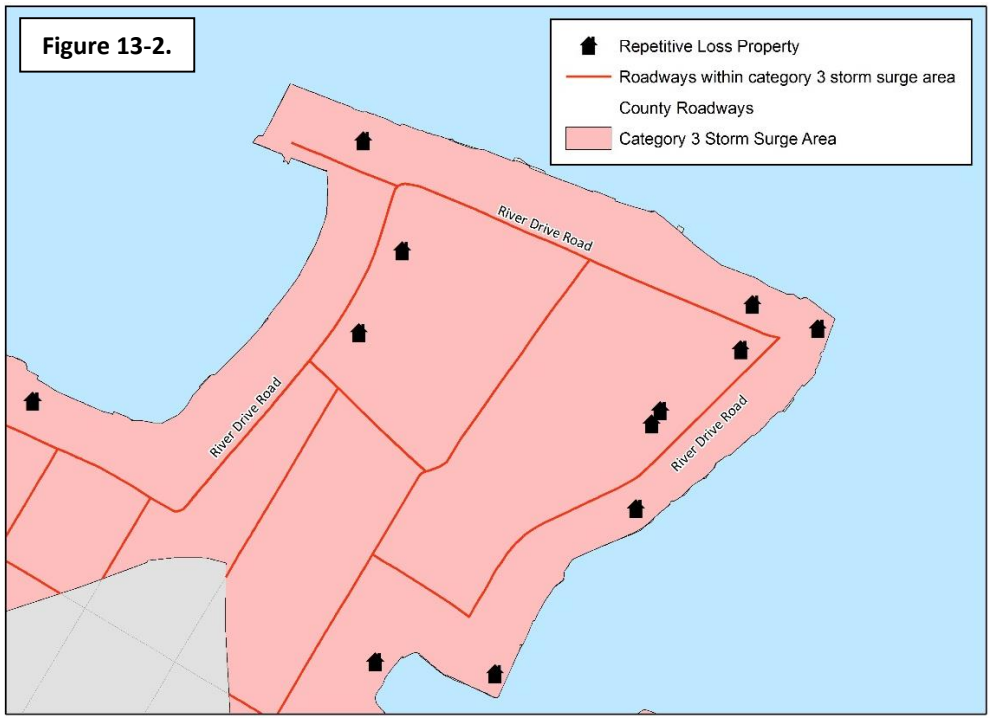
The analysis indicates that only 19 roadways are within the 100-year coastal flood zone. The majority of these roadways, over half, are in the Dundalk and Sparrows Point communities. The

amount of roadways within the category 3 hurricane storm surge area is much higher, with 516 roads being affected. Communities with the greatest density of roadways within the category 3 storm surge area are: Dundalk, Essex, Middle River, and Sparrows Point. Roadways in these four regions comprise 96% of all the impacted roadways in the coastal communities of Baltimore County.

River Drive Road

Coastal repetitive loss properties were identified in section 13.5 of this chapter. The roadway with the greatest amount of repetitive loss properties, 12, was River Drive Road. This roadway has been identified as one of the most impacted roadways from storm surge associated with a category 3 hurricane. It would be prudent for Baltimore County to focus coastal flood mitigation efforts in this location.

Figure 13-2.



Source: S&S Planning and Design, LLC

Development Impacts

According to Baltimore County's Master Plan 2020, Owings Mills is the County's designated Growth Area, Middle River is a Redevelopment Area, and Pulaski Highway is also a Redevelopment Area.

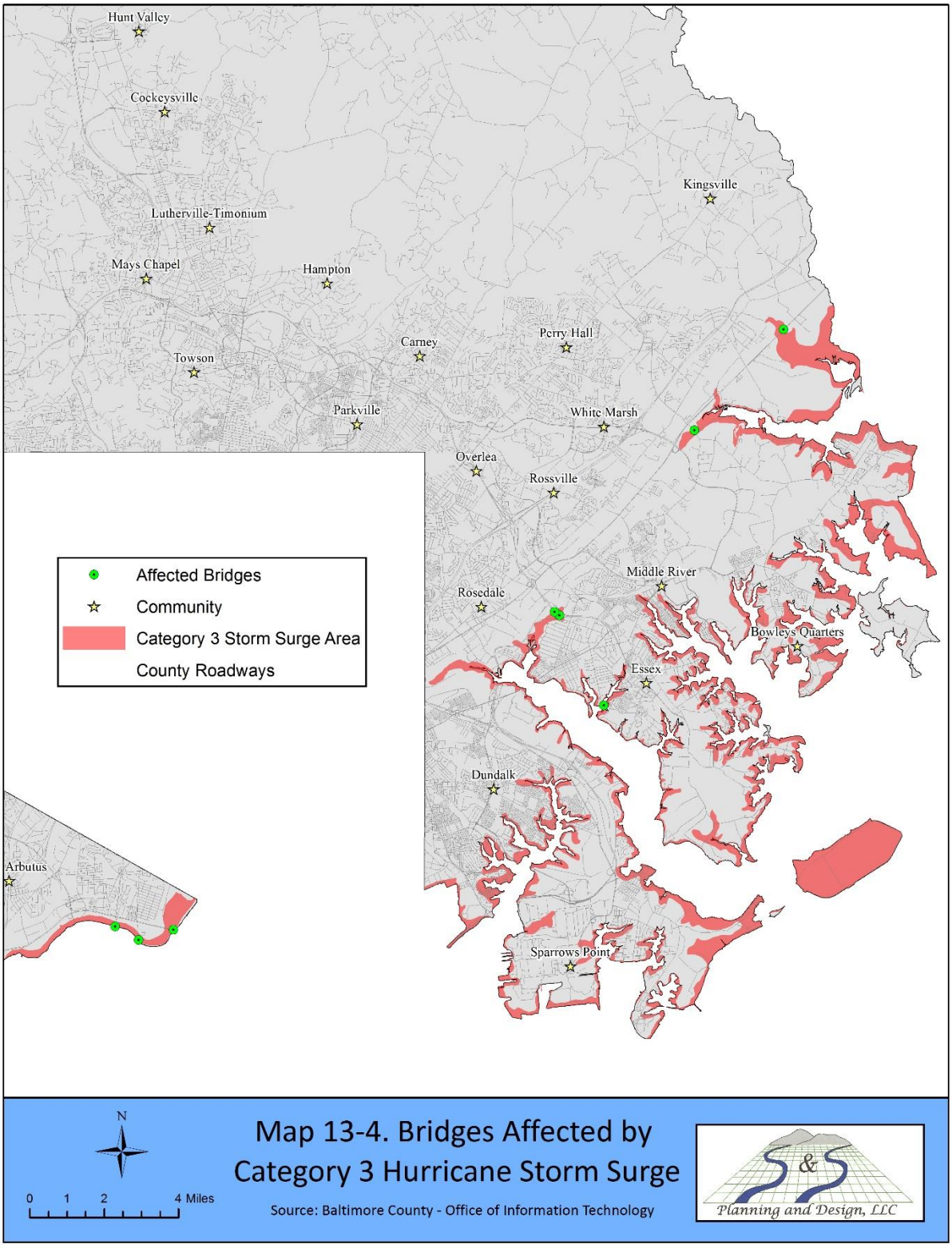
Owings Mills Growth Area

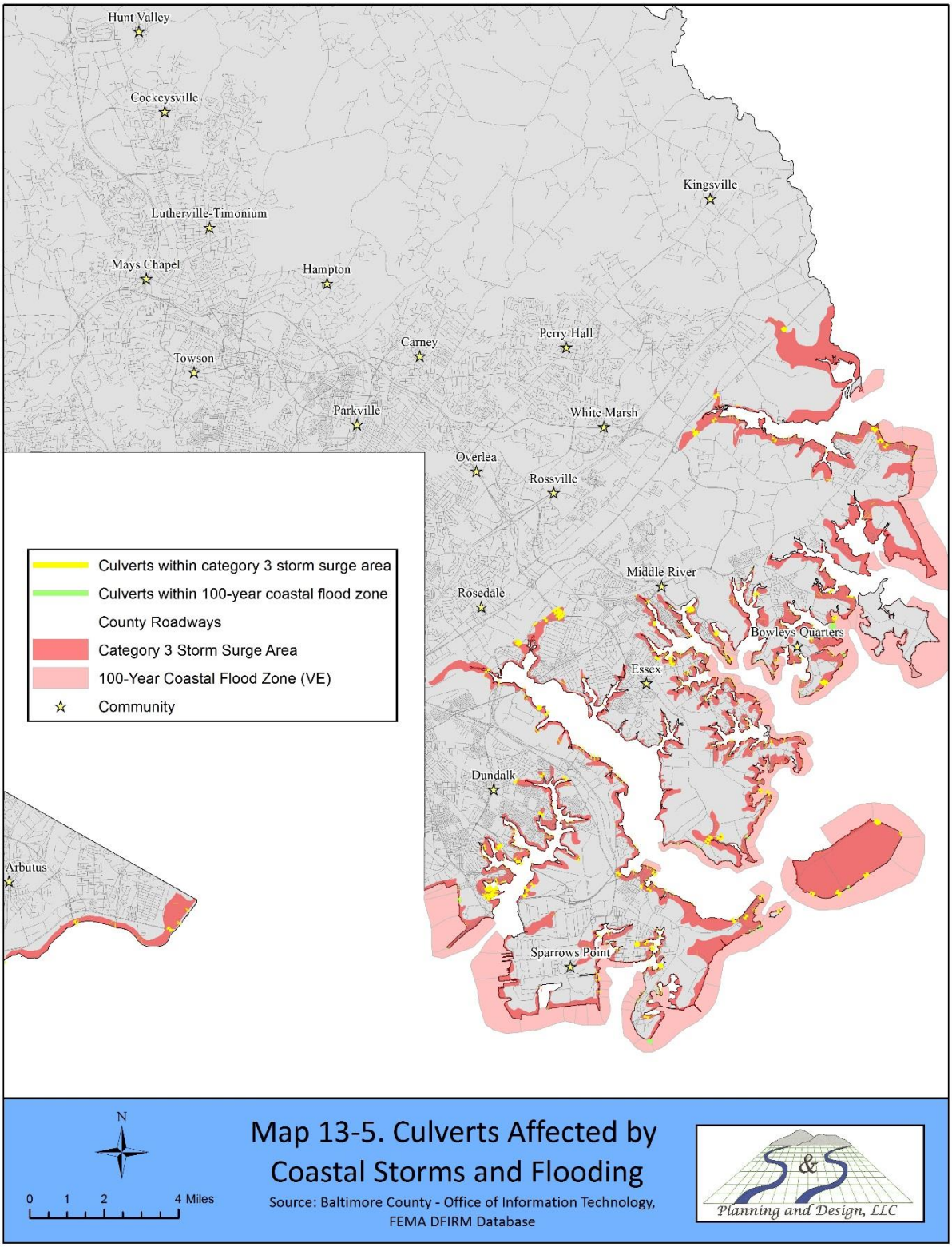
Based on both the HAZUS Level 2 Analysis and the Infrastructure Analysis, the Owings Mills area can expect to face virtually zero impacts from a 100-year coastal flood event due to its inland location.

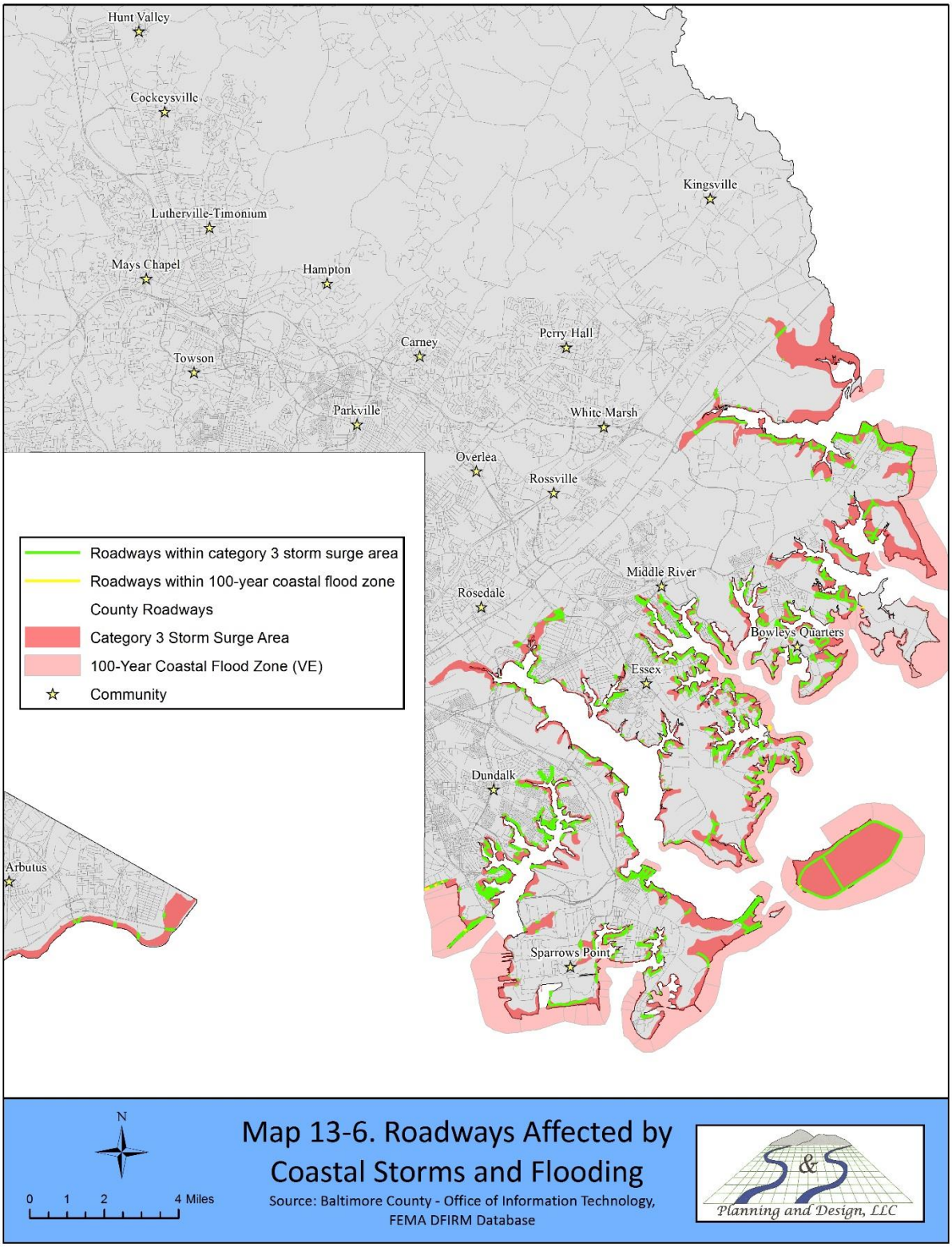
Middle River & Pulaski Highway Redevelopment Areas

The largest problem the Middle River area may face is related to the amount of roadways within the category 3 storm surge area. Combined with roadways within the 100-year coastal flood zone, Middle River has a total of 127 effected roadways. Pulaski Highway, within Middle River, also faces floodplain problems. Just over 2.5 miles of the highway is within the category 3 hurricane storm surge area.

Baltimore County's *Master Plan 2020* identifies a 920-acre district along a five-mile segment of Pulaski Highway U.S.40 in the Middle River community as a potential target area for community-scaled redevelopment.


Hunt Valley
Cockeysville
Kingsville
Lutherville-Timonium
Mays Chapel
Hampton
Carney
Perry Hall
Towson
Parkville
White Marsh
Overlea
Rossville
Middle River
Rosedale
Bowleys Quarters
Essex
Dundalk
Arbutus
Sparrows Point
Affected Bridges
Community
Category 3 Storm Surge Area
County Roadways
N
0 1 2 4 Miles
Map 13-4. Bridges Affected by Category 3 Hurricane Storm Surge
Source: Baltimore County - Office of Information Technology
S&S Planning and Design, LLC


Hunt Valley
Cockeysville
Kingsville
Lutherville-Timonium
Mays Chapel
Hampton
Perry Hall
Carney
Towson
Parkville
White Marsh
Overlea
Rossville
Culverts within category 3 storm surge area
Culverts within 100-year coastal flood zone
County Roadways
Category 3 Storm Surge Area
100-Year Coastal Flood Zone (VE)
Community
Middle River
Rosedale
Bowleys Quarters
Essex
Dundalk
Arbutus
Sparrows Point
N
0 1 2 4 Miles
Map 13-5. Culverts Affected by Coastal Storms and Flooding
Source: Baltimore County - Office of Information Technology, FEMA DFIRM Database
S&S Planning and Design, LLC


Hunt Valley
Cockeysville
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Perry Hall
Kingsville
Parkville
White Marsh
Overlea
Rossville
Middle River
Rosedale
Bowleys Quarters
Essex
Dundalk
Arbutus
Sparrows Point
Roadways within category 3 storm surge area
Roadways within 100-year coastal flood zone
County Roadways
Category 3 Storm Surge Area
100-Year Coastal Flood Zone (VE)
Community
N
0 1 2 4 Miles
Map 13-6. Roadways Affected by Coastal Storms and Flooding
Source: Baltimore County - Office of Information Technology, FEMA DFIRM Database
S&S Planning and Design, LLC

13.8 2014 MITIGATION GOALS AND ACTION ITEMS

During the 2014 Plan Update, new mitigation goals and action were added. Additionally, previous mitigation goals and action items from the 2006 Plan were reviewed, and those that were determined to be still in progress or relevant were included.

GOAL 1: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Public awareness and planning are crucial for safety and minimizing stress during weather events that affect the waterfront.	1. Continue to provide information on the County's web site about coastal storm risk and vulnerability.	County	High
	2. Develop an educational plan for updates on emergency preparedness, including communications, evacuation, traffic, area closures, visitor controls, damage assessment, clean up etc.	County	Medium
2. Provide technical assistance for homeowners regarding coastal storms and flooding.	Develop a technical assistance information program for homeowners to teach them how to strengthen their homes against coastal storms. The program could include providing local government building departments with copies of existing strengthening and repair information for distribution to homeowners. Other potential distribution sources include insurance companies, realtors, homeowner associations, and libraries.	County	Medium
3. Continue to build CRS credit by participating in qualifying CRS activities.	1. CRS Conduct NFIP Workshop targeting insurance and real estate agents as well as loan officers working in Baltimore County. Offer continuing education credit and request a FEMA provided instructor-Rich Sabota.	County	Medium
	2. CRS Conduct a Flood Ordinance and FEMA Mapping Workshop targeting surveyors, engineering firms, and developers that conduct business in Baltimore County.	County	Medium

GOAL 2: Eliminate or reduce human, environmental, social and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Continue to adapt to, and mitigate impacts of climate change on the environment.	Implement the recommendations of the County's Sustainability Network for County operations, energy conservation, protection of natural resources, and communities in order to reduce emissions of greenhouse gases and energy consumption.	County	Medium
2. Enforce current building standards.	Continue to perform building inspections to ensure compliance with current building standards as they relate to coastal flooding.	County	Medium

3. Identify flood prone properties for mitigation efforts.	1. Focus flood mitigation efforts in the coastal communities identified as having the greatest amount of Repetitive Loss Properties: Middle River, Sparrows Point, and Dundalk (Table 13-4).	Middle River, Sparrows Point, Dundalk	High
	2. Elevate or acquire repetitive loss and severe repetitive loss properties affected by coastal flooding when funding from State and Federal sources is available.	County	Medium
	3. Acquired properties that are adjacent should be considered for open space projects. Prime examples include RLP properties on River Drive Road (see Figure 13-2 in section 13.7.5).	County, River Drive Road	Medium
	4. Identify pre-FIRM structures located within the coastal high hazard area and determine the mitigation measures that are needed to reduce flooding.	County	Medium
	5. Obtain additional information on properties within identified high hazard areas. Ex. Lowest floor elevation.	County	Medium
	6. During the next review and/or update to the Master Plan, evaluate the Middle River and Pulaski Highway Redevelopment areas in terms of flood hazard inundation areas. Prioritize projects within the mapped redevelopment areas that are located outside of flood hazard areas.	Middle River, Pulaski Highway Areas	Medium

GOAL 3: Provide outreach to agencies and organizations within Baltimore County regarding hazard mitigation.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Utilize planning documents, reports, and analyses as targeted material for outreach and preparedness efforts.	1. Provide HAZUS coastal flood data to shelters nearby, but outside of, the projected high hazard coastal flood zone within the County.	See Map 13-3	High
	2. Provide HAZUS coastal flood data regarding shelter requirements to Emergency Preparedness for planning and preparedness purposes.	County	High
	3. Provide HAZUS coastal flood data regarding debris generation to the Bureau of Highways for planning and mitigation purposes.	County	Medium
	4. Include HAZUS coastal flood data regarding debris generation as an amendment to the County's Ten Year Solid Waste Management Plan.	County	Medium

13.9 EXISTING COASTAL STORMS AND FLOODING MITIGATION ACTIVITIES

Baltimore County's current capabilities provide a framework for future mitigation action items.

- National Flood Insurance Program (NFIP)
  - Enforce floodplain management regulations in identified flood hazard areas
  - Bill 173-93 Floodplain Management Ordinance adopted in 1993 which complies with Section 60.3 (D) of the regulations for the National Flood Insurance Program as revised on October 1, 1986
  - No new development is allowed in the 100-year riverine floodplain
  - Citizens are eligible to purchase flood insurance that is not normally available through private insurance companies
  - FEMA Flood Hazard Mapping Program
- Building Codes
  - New buildings and substantially improved structures within areas subject to tidal flooding must not have their lowest floor lower than one foot above flood protection elevation.
  - New buildings, additions, substantial improvements, and repetitive loss properties are not allowed to have basements.
  - Ground floor may be used for storage or garage, but must include flood venting.
  - Any accessory structures larger than 300 square feet should be outside the floodplain when feasible. When not feasible, structures must meet the same flood codes as the house.
- Participation in the national "Turn Around, Don't Drown" program.
- Utilization of social media (Facebook and Twitter) to disperse warnings and information prior to and during a severe weather and/or flood event.

[1] http://www.nhc.noaa.gov/climo/
[2] http://www.baltimorecountymd.gov/Agencies/emergency_prep/hurricanes.html
[3] http://www.nhc.noaa.gov/aboutsshws.php
[4] http://www.baltimorecountymd.gov/Agencies/emergency_prep/hurricanes.html
[5] http://www.nhc.noaa.gov/prepare/hazards.php
[6] http://dnr.maryland.gov/CoastSmart/pdfs/CBSE_mguide.pdf
[7] http://oceanservice.noaa.gov/facts/sealevel.html
[8] http://ian.umces.edu/pdfs/ian_report_413.pdf
[9] http://dnr.maryland.gov/CoastSmart/pdfs/CBSE_mguide.pdf
[10] http://www.baltimorecountymd.gov/Agencies/environment/watershedrestoration/shoreline.html
[11] The Baltimore Sun, 2012
[12] The Baltimore Sun, 2011
[13] The Baltimore Sun, 2011
[14] National Oceanic and Atmospheric Administration, 1972, v. 76, no. 6, p. 63
[15] National Oceanic and Atmospheric Administration, 1972, v. 76, no. 6, p.63
[16] http://md.water.usgs.gov/publications/wsp-2375/md-dc
[17] http://www.mdfloodmaps.net/pdfs/Flood_Insurance_Factsheet.pdf
[18] www.mdfloodmaps.net
[19] http://www.mdfloodmaps.net/pdfs/Floodplain_Factsheet.pdf
[20] http://msa.maryland.gov/msa/mdmanual/01glance/html/weather.html#hurricanes

CHAPTER 14: TECHNOLOGICAL AND MAN-MADE HAZARDS

14.1 INTRODUCTION

The 2014 Plan Update includes technological and man-made hazards. With the exception of Dam Failure, these hazards were not included in the 2006 Plan. During the 2013 kick-off meeting for the Plan Update these hazards were ranked by the Hazard Mitigation Planning Committee (HMPC). The results of this ranking are displayed in the accompanying table, 14-1. Each hazard, including epidemic, transportation accident, hazardous material incident, dam failure, fire and explosion, and mass power outage have been profiled in this chapter.

Table 14-1. Technological and Man-made Hazard Assessment, 2013

Hazard	Risk
Man-made	
Epidemic	Low
Technological	
Transportation Accident	High
Hazardous Material Incident	High
Dam Failure	Medium
Fire & Explosion	Medium-high
Mass Power Outage	Medium-high

In the event of a major technological or man-made hazard event, emergency responders and appropriate agencies would follow response guidelines as set forth in the County's Emergency Operations Plan (EOP). This Plan covers a broad range of topics, some of which include: mitigation, preparedness, response, and recovery operations. The EOP consists of a Basic Plan, functional annexes, and hazard-specific appendices.[1] Additionally, Baltimore County utilizes an Emergency Notification System which sends out a recorded message and/or email in the event of a disaster.

14.2 TRANSPORTATION ACCIDENT

Baltimore County consists of a highly sophisticated transportation system that includes nearby Baltimore-Washington Thurgood Marshall International Airport, Martin State Airport, local airports/helicopter pads, Amtrak passenger rail service, CONRAIL, CSX, MARC commuter trains; Interstates 95, 70, and 83; U.S. Routes 1 and 40; and numerous State routes. There is also considerable boat and barge traffic proximate to Baltimore County on the Patapsco River and the Chesapeake Bay. This section will primarily focus on accidents as they relate to roadways and railways.

Baltimore County's LEPC keeps track of transportation incidents that occur within the County. These events include roadway, railway, and air incidents. Table 14-2 and Table 14-3, below, detail the events recorded by the LEPC. This list is not exhaustive and does not include all events of this type in Baltimore County.

Table 14-2. Annual Transportation Incidents for Baltimore County, 2012

Date	Location	Type
1/6/2012	Norhurst Way	Aircraft accident
1/23/2012	Seminary and Light Rail	Train crash
4/23/2012	SB I83 north of Shawan	Tractor Trailer/Motor Vehicle Collision
5/3/2012	Shawan Rd.	Light Rail/Motor Vehicle Collision
5/4/2012	Jarrettsville Pike	Tractor Trailer/Motor Vehicle Accident

Table 14-3. Annual Transportation Incidents for Baltimore County, 2013		
Date	Location	Type
1/21/13	I-695 Outer & I-83 N	Truck rollover
4/3/2013	I 695 Between 22 and 23 inner loop	10-50 Rescue
4/27/2013	I 695 between 22-23 IL	10-50 Personal Injury
5/25/2012	I695 Innerloop at Belair Rd.	Overturned Tractor Trailer
5/28/2013	7517 Lake Dr.	Train Wreck
5/31/2013	I/L 695 Charles - York	Motor Vehicle Collision
6/1/2013	Liberty Rd. & Tiverton Rd.	Motor Vehicle Accident
6/7/2013	Hammonds Ferry & CSX RWY	Train derailment
6/7/2013	I 695 OL Bet 22-23	10-50 Property Damage
6/13/2013	695 Outer at 795	10-50 Personal Injury. Bridge beam thrown from inner to outer loop along with trailer carriage.
6/19/2012	Hanover Pike & WSeywood Dr.	Overturned Tractor Trailer
6/20/2012	I 83 MD PA Line	Jackknifed Tractor Trailer
8/8/2012	Woodstock Rd.	Train derailment
8/14/2013	Falls & Hillside Rds.	10-50 Personal Injury
########	695 & 83	Overturned truck
11/8/2012	Greenspring Ave.	Assist TOW-323
Note: ######## Indicates date not recorded by the LEPC.		

14.2.1 Roadway

The State Highway Administration (SHA) maintains numerous traffic monitoring locations throughout Maryland, including 1,240 in Baltimore County. These monitoring locations keep track of roadway traffic on 1,286 segments of roadway throughout the County. One of the most popular measures of traffic volume is Annual Average Daily Traffic (AADT). This measure represents the total volume of vehicle traffic of a highway or road for a year, divided by 365 days.

Based on 2012 AADT data for Baltimore County provided by the SHA, the top five busiest road segments within the county are:

1. Interstate 83/695 Ramp 7 to Interstate 695 Ramps (AADT: 222,500)
2. Interstate 70 to MD 122 (AADT: 212,912)
3. MD 122 to MD 26 (AADT: 202,810)
4. U.S. 1 to MD 144 (AADT: 199,082)
5. MD 372 to MD 144 (AADT: 193,762)

Maryland Highway Accident Quick Facts

- ✓ Property damage crashes comprise 66% of total crashes; fatal crashes make up less than 1% of the total.
- ✓ Total crashes show a downward trend in recent years (2008-2012).
- ✓ Most crashes occur in October (9.1%), least crashes occur in February (7.4%)
- ✓ Most crashes occur on Friday (16.3%), least crashes occur on Sunday (12.1%)
- ✓ Most crashes occur at 5 pm (7.2%), least at 3 am (1.7%)
- ✓ Male drivers are statistically more likely to get into an accident than female drivers.

*All figures represent averages from 2008 to 2012

Source: Maryland Motor Vehicle Administration

These roads comprise the Baltimore Beltway which is known for its extremely heavy traffic. Aside from these top five roads, there are many other roadways within the County that experience heavy traffic on a daily basis. Heavy traffic on any roadway increases the chance of major traffic accidents occurring simply because there are more drivers on the road. Map 14-1, at the end of this section, highlights the busiest road segments in Baltimore County based on 2012 AADT counts. Red indicates roadways with very high AADT, while green indicates roadways with very low AADT.

The Maryland Motor Vehicle Administration keeps annual records of highway transportation accidents within the state. Table 14-4 details these accidents from 2008 to 2012. Recorded accidents consist of property damage rashes, injury crashes, and fatality crashes. The most common type of transportation accident in Baltimore County is property damage, with a 5-year average of 8,486 per year, or 65.5% of the total accidents recorded in the County.

Table 14-4. Highway Transportation Accidents in Baltimore County, 2008-2012

	2008	2009	2010	2011	2012	AVG.	% of Total
Property Damage Crashes	9,427	8,890	7,941	8,202	8,148	8,486	65.5%
Injury Crashes	4,768	4,296	4,432	4,351	4,182	4,406	34.0%
Fatal Crashes	66	79	58	70	63	67	0.5%
Total Crashes	14,261	13,265	12,431	12,447	12,393	12,959	100%

Source: Maryland Motor Vehicle Administration, 2013

14.2.2 Railway

Major railway systems in Baltimore County include Amtrak passenger rail service, CONRAIL, CSX, and MARC commuter trains. Rail travel is one of the safest methods of moving both passengers and hazardous materials, but as unlikely as it is, accidents do occur. In May of 2013, a train carrying hazardous materials derailed in Rosedale.[2] While there was initial confusion at first regarding the materials carried by the train, the response from emergency officials was rapid and competent.

Incidents such as the one in Rosedale are unfortunate, but uncommon, and according to the Federal Railroad Administration (FRA), the number of derailments in Maryland has dropped from 30 in 2004 to 10 in 2012. The number of hazmat derailments over the same period declined from 21 to a single incident. In Baltimore County, there were a total of 493 recorded railway accidents from 2004 to 2013, which averages to about 51 per year. Table 14-5, below, further details these accidents.

Table 14-5. Railway Accidents in Baltimore County, 2004-2013

Category	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total For Period
TRAIN ACCIDENTS	.	.	.	.	.	.	.	.	.	.	.
Train accident injuries	2	.	3	.	.	.	.	.	.	.	5
HIGHWAY-RAIL INCIDENTS	3	8	11	4	4	3	4	4	3	2	46
Highway-rail incidents deaths	.	1	.	1	.	.	.	.	.	.	2
Highway-rail incidents injuries	2	-	1	2	-	-	1	-	1	5	12
Incidents at public crossings	2	4	5	2	2	1	3	4	2	1	26
OTHER ACCIDENTS/ INCIDENTS	34	29	33	48	42	39	64	59	47	52	447
Other incidents deaths	1	1	3	2	5	1	5	3	1	2	24

Category	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total For Period
Other incidents injuries	33	28	32	48	40	38	60	57	46	53	435
TOTAL ACCIDENTS/ INCIDENTS	37	37	44	52	46	42	68	63	50	54	493
Total fatalities	1	2	3	3	5	1	5	3	1	2	26
Total nonfatal conditions	37	28	36	50	40	38	61	57	47	58	452
Note: Total Accidents/Incidents is the sum of train accidents, highway-rail incidents, and other accidents/incidents.											

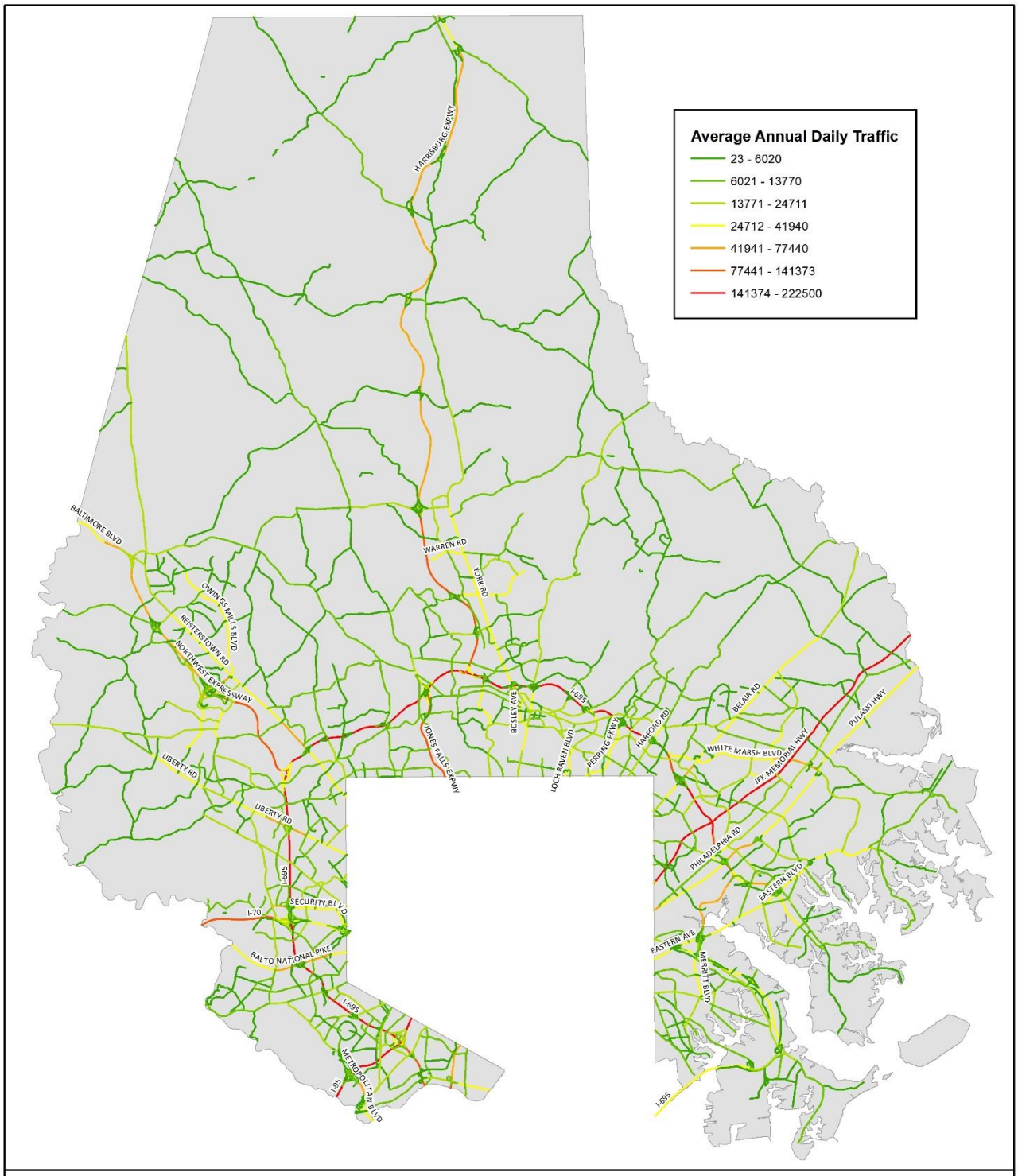
Source: Federal Railroad Administration Office of Safety Analysis

The FRA also records railway accidents by company for counties within Maryland. According to the FRA, between 2004 and 2013, there were 524 recorded accidents/incidents in Baltimore County involving railways. The greatest amount of accidents during this period were reported by Amtrak, followed by CSX, and then MARC. Table 14-6, below, further details these accidents.

Table 14-6. Railway Accidents by Railroad Company, 2004-2013

Railroad	Total Accident/ Incident Records	% Of Total	Form 57	Form 54	Form 55a
Amtrak	229	43.70	.	.	229
CSX Transportation	178	33.97	37	.	141
MARC Train Service	61	11.64	1	.	60
Norfolk Southern Corp.	23	4.39	8	.	15
Patapsco & Back Rivers RR Co.	22	4.20	.	.	22
Canton RR Co.	10	1.91	.	.	10
Baltimore Industrial RR.	1	0.19	.	.	1
	524	100.00	46	0	478
Note: Form 55a used for reporting deaths and injuries, Form 54 for train accidents, Form 57 for highway-rail crossing incident.					

Source: Federal Railroad Administration Office of Safety Analysis



Map 14-1. Average Annual Daily Traffic for Baltimore County Roadways in 2012

Source: State Highway Administration

S & S Planning and Design, LLC

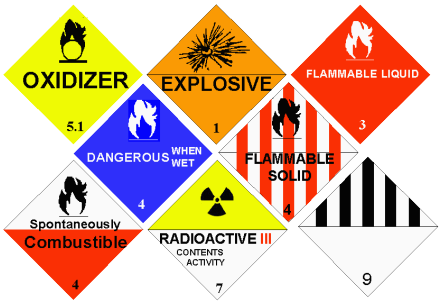
14.3 HAZARDOUS MATERIAL INCIDENT

Hazardous materials are defined as any items or agents (biological, chemical, physical) which have the potential to cause harm to humans, animals, or the environment, either by themselves or through interaction with other factors.[3]

A hazardous material incident may occur via spilling, leaking, emission of toxic vapors, or any other process that enables the material to escape its container, enter the environment, and create a potential hazard. For this hazard profile, the term 'incident' applies to hazardous material spills that require an emergency response.

The majority of hazardous materials are stored and used at fixed sites, but these materials are typically produced elsewhere and shipped to the fixed facility by rail, truck, or freight. Hazardous materials are constantly on the move in Baltimore County, and the possibility of accidental release may occur at any time. As such, vehicles carrying hazardous materials are marked with placards (Figure 14-1) specific to the materials being carried. These placards are detailed in the *2013 Emergency Response Guidebook* – a useful tool for emergency responders because it outlines containment and clean-up procedures per hazardous material.

Figure 14-1.



14.3.1 Historical Occurrences of Hazardous Material Incidents

Baltimore County's Local Emergency Planning Committee (LEPC), which comprises of community and business leaders, and local fire, police, EMS and emergency management responders, meets regularly to develop and review contingency and evacuation plans for emergencies involving hazardous materials. These may include weather disasters, industrial/transportation accidents and terrorist attacks.[4]

A portion of these meetings involves reporting hazardous material spills. Table 14-7 and 14-8, below, provide information regarding hazardous materials spills in Baltimore County from January 2012 to December 2013.

Table 14-7. Annual Hazardous Material Spill Incidents for Baltimore County, 2012

Date	Location	Type
1/4/2012	West Rd.	White powder
1/5/2012	Lake Falls	Gas Leak
1/6/2012	Waltham Woods	Investigation-mold abatement chemicals
1/9/2012	Quarry Lake Dr.	Diesel Fuel
1/9/2012	York & Stablers Church Rds.	Overturned tractor trailer-Diesel fuel
1/17/2012	Oakleigh Rd.	Leaking 275 fuel oil tank
1/19/2012	Edmondson Ave.	Chemical odor
1/20/2012	Bonnie Ridge Dr.	Gas Leak
1/20/2012	Ruxton Rd & Ellenham Ave.	Fluid in road from 10-50 Property Damage
2/11/2012	Chenoak Ave.	Hazardous Condition Detail Northeast-thermometer
2/13/2012	Towsontowne Ct.	Carbon Monoxide Leak

Date	Location	Type
2/28/2012	NB I-83 N of Mt. Carmel	Diesel Fuel
3/12/2012	Old Court Rd & Davis Ave.	Potential explosive device
3/13/2012	Litchfield Rd.	Fuel oil (in stream)
3/18/2012	Fitzwarren Pl, Apt. T1	Carbon Monoxide Call
3/21/2012	Railroad & Ebenezer Rds.	HazMat Box
3/23/2012	O/L 695 Providence Rd.	HazMat-diesel tank leaking
3/26/2012	O/L 695 between 26-27	5 gal. liquid nail
4/4/2012	Ridgebrook Rd	Bio invesigation
4/9/2012	I695 between 16-17 I	Hot asphalt diesel pump-off
4/13/2012	I695 24-25 O	Hydraulic oil on asphalt
4/13/2012	Shawan Rd - I83	Gas and trans. Fluid
4/20/2012	McCormick Rd.	Bio hazard
4/30/2012	Pitney @ Morven Rd.	Transmission fluid
5/6/2012	York Rd.	Gasoline spill
5/8/2012	Autumn Leaf Rd.	Heating oil spill in basement
5/8/2012	Hilltop Cir UMBC	Nitrogen tank leak
5/15/2012	Wade Ave.	Building with asbestos
5/18/2012	Shady Creek Way	Propane tank leaking
5/19/2012	Cobblestone Ct.	Biohazard investigation
5/28/2012	Baythorn Rd.	Carbon Monoxide
5/31/2012	Old Harris Mill & Harris Mill Rd.	Liquid fertilizer
6/11/2012	Green Summit & Hurdleford Rds.	Gasoline
6/30/2012	Still Forest Rd.	Carbon Monoxide
7/1/2012	York Rd.	Gasoline leak-vehicle tank
7/1/2012	Gaywood Rd.	Carbon Monoxide
7/7/2012	Kelly's Court	Gas leak
7/9/2012	Joppa Rd.	Diesel spill
7/13/2012	I695 between 23-24 OL	Gas/diesel spill 10-50 personal Injury
7/18/2012	St. Clari La	Glycerin
7/19/2012	Ruxview Ct.	Odor
7/19/2012	I695 IL between 22-23	Fuel spill
7/20/2012	Jarrettsille Pike	Fuel oil in basement
7/27/2012	Four Georges Ct.	Pool chemical spill, CL
8/14/2012	Susquehanna Ave.	Investigation of fluids
8/18/2012	N. Charles St.	Gasoline
8/20/2012	Dulaney Hills Ct.	Mercury spill
8/23/2012	Hollins Ferry Rd.	Contagious vehicle
8/26/2012	Cockeysville Rd. & York Rd.	Odor of fuel
9/3/2012	Ridgely Oak Rd.	Misuse of starter fluid
9/29/2012	Wholesale Club Dr.	Pump off and clean up fuel
10/18/2012	I83 Sb between 36-37	Pump off and Clean up
10/21/2012	Wentworth Ave.	Recon / Product ID - Cleanup Solvent
11/12/2012	I695 Outer at Washington Blvd	Dam and Dike stream contain ruptured saddle tank 100 Gallons
11/12/2012	Brookebury Dr.	Monitor House found Porcelain glazing being done in house
11/19/2012	83 South and 695	Pump Off
11/20/2012	Water Oak Rd.	Wash Down NH3 and Absorbent Pesticide
11/20/2012	Reisterstown Rd. & Gentlebrook Rd.	Pump Off
11/21/2012	Reisterstown Rd.	Pump Off
11/26/2012	Mt. Carmel Rd.	Large Fuel Oil Spill 5th District ES

Table 14-8. Annual Hazardous Material Spill Incidents for Baltimore County, 2013		
Date	Location	Type
1/8/13	I-695 IL between 26-27	Diesel
1/15/13	Red Run Blvd.	Inhalation Patient
1/22/13	I-695 Inner at York Rd	Intermodal HexaFlouroPropylene
1/25/13	Witherwood Ct.	Odor
1/27/13	Windsong Ct.	Propane leak
1/29/13	Hilldale Rd.	250 gal. heating fuel
1/31/13	Hathorne Ct.	Odor in house
2/5/13	Sandview Ct.	Carbon Monoxide alarm
2/6/13	Rt. 30 & Rue St. Lo Drive	Gasoline
2/7/13	Old Pimlico & Rockland Hills	Gas, oil, antifreeze
2/15/13	Clarkview Rd.	Diesel fuel spill
2/20/13	Wight Ave.	Reported Mercury
2/21/13	IL 695 Harford-Belair	Diesel saddle tank
2/22/13	I-695 between 20-21	Blood Born Pathogen clean up
2/22/13	I-83 MM 32 N	Overturned Liquid Propane tanker
2/22/13	Hambleton Ct.	Investigate unknown substance
2/24/13	Fowler Ave.	Carbon Monoxide & VOCs from PVC cement
2/25/13	Marleigh Circle	Carbon Monoxide call
2/26/13	Edenvale Rd.	Mercury
3/6/13	Cromwell Bridge Rd I-695 OP	Hydraulic fluid spill
3/20/13	I-83 North 16-17	Isopropanol containers
3/22/13	I-695 between 24-25	Diesel fuel
3/22/13	2310 Smith Avenue	Carbon Monoxide
4/3/2013	Kennilworth Dr - Parking Lot	Diesel Spill
4/7/2013	Langs Rd.	Dry Powder Extinguisher
4/11/2013	Middleborough Rd.	Propane leak
4/12/2013	Belair Rd.	Fuel Leak
4/18/2013	Liberty & Milford	Truck Fire w/100 gal gasoline
5/4/2013	Crossroads Cir & Williams Ct.	Chemical Suicide
5/20/2013	Greenspring Dr.	Carbon Monoxide
5/23/2013	I83 between 16-17 S	Fuel Spill
5/23/2013	Chelsea Bridge Wy	Carbon Monoxide
5/26/2013	Sandringham Rd.	Mercury
5/27/2013	Gunpowder and Clipper Mill Rds.	Helium/ Medical
5/27/2013	Berk Ave.	Hazmat/ Exterior Oil tank
5/28/2013	Knollcrest Rd.	Mercury
6/8/2013	I695 IL between 25-26	Gas
6/11/2013	I95 between MM64.4-64.8 N	Vehicle Fire with HazMat
6/13/2013	Blenhiem Rd.	Heating Oil Tanker rollover with rupture
6/14/2013	Windsor Mill Rd.	Identify unknown substances
6/17/2013	Hillcrest Rd.	Inhalation, Multiple Patients uncx in house. CO, Phosphine readings
6/19/2013	Padonia & Beaver Dam Rds.	Diesel Spill
6/19/2013	York Rd. & Ensor Ave.	Used oil
6/21/2013	Dorsey Ave.	Heating oil leak
7/4/2013	Hannon Ct.	Transformer, Oil
7/5/2013	Yawmeter Dr.	Heating Oil
7/8/2013	I83 North at I695 Tanker Curve	Motor Oil Tractor Trailer Oil Pan Cracked
7/13/2013	Bloombury Ave.	Chemical Odor
7/16/2013	Perry Hall Blvd.	White Powder
7/19/2013	I83 between 31-33 N	Diesel Fuel
7/24/2013	Old York & Burke Rds.	Diesel & Hydraulic
7/28/2013	Samoset Rd.	Chemical Spill
8/8/2013	I-83 South at Exit 24 Belfast Rd.	Diesel Fuel

Date	Location	Type
8/8/2013	SB I83 @ Belfast	Diesel Fuel
8/8/2013	Perry Hall Blvd.	Mothball Granules in Postal Envelope
8/9/2013	I/L 695 at Falls Rd.	Diesel Leak
8/10/2013	Teakwood Ct.	Dispatched for a Bio-Hazard
8/15/2013	Research Park Dr.	Odor/Cloud in Building
8/15/2013	Eastern Blvd.	Hazmat Sick Building
8/16/2013	Bloomsbury Ave.	HazMat Box-Chemical Truck Leaking
8/19/2013	Edmondson Ave.	Ammonia
8/23/2013	Citation Rd.	Liquid Liner
8/29/2013	I695 between 30-31 OL	Fuel Spill
8/30/2013	Joppa Rd.	Ether Merck Removal
9/12/2013	Back River Neck	White Powder
9/12/2013	Middletown Rd.	Oil on Highway
9/14/2013	Summit Ave.	Heating Oil
9/25/2013	RT 140 & 795	Leaking Saddle tank
9/26/2013	I 695 between 29-30 OL	Fuel Spill
9/27/2013	I83 between 27-31 N	Saddle Tank Leaking
10/3/2013	White Ave and York Rd.	Suspicious Package
10/9/2013	Klein Ave.	Hydrocarbon odor/spill
########	I695 between 37-38 I	Diesel Fuel Saddle Tank Leaking
########	Juniper Rd.	250 Gallon Propane leak
########	Glen Michael Ln.	Odor
########	Walker Ave.	Sulfuric Acid Spill
########	Birch Bark Ct.	Mixed Cleaners
11/4/2013	I695 between 21-22 Outer	Car fire with fuel tank release
########	North Point Blvd.	Fire Box
########	I 695 between 22-23 IL	10-50 Personal Injury
########	Pine Ridge Ln.	Spill
########	Belair Rd.	Carbon Monoxide
########	E. Joppa Rd.	Sick Patient/ Hazardous Materials
########	Philadelphia Rd.	Fuel Spill > 100 gals.
12/4/2013	Loveton Farms & Meadow Run Rds.	Leaking Freon Tank
12/6/2013	Culvert Rd.	Leaking Fuel Oil tank
12/7/2013	Taylor Ave.	Odor Investigation - Dollar Tree
########	Baronet Rd.	Rescue/W/Hazmat
########	Sunnyside Ln.	Spill
Note: ######## Indicates date not recorded by the LEPC.		

The records indicate that for both 2012 and 2013, fuel spills (diesel, gasoline, motor oil, heating fuel), and carbon monoxide reports were the most commonly reported hazardous materials events. In 2012, 21 fuel related events were recorded, along with 6 reports of carbon monoxide. In 2013, 28 fuel related events were recorded, along with 7 reports of carbon monoxide.

Furthermore, based on the data, the most impacted roadways for these two years are I-695 and I-83. Between both years, 20 hazardous material incidents were reported on I-695, and 11 were reported on I-83. As stated in section 14.2.1, these roadways have a high AADT, which means they are traveled very heavily. As such, accidents involving hazardous materials are more likely to occur on these roadways due to their larger volume of traffic.

14.4 FIRE AND EXPLOSION

Fire is defined as the state, process, or instance of combustion in which fuel material is ignited and combined with oxygen, giving off heat, light, and flame. An explosion is defined as an expansion, with violent force, of materials through a chemical change or decomposition. Explosive atmospheres can be caused by flammable gases, mists, or vapors or by combustible dusts. If there is enough of a substance, mixed with air, then all it needs is a source of ignition to cause an explosion.

Each year people are injured at home or work by flammable substances accidentally catching fire or exploding. In some cases, household hazards are caused by relatively harmless chemicals, such as ammonia and bleach, being mixed together to create dangerous gases. In the workplace, activities which involve using or creating chemicals, vapors, liquids, gases, solids or dusts that can readily burn or explode is hazardous.[5]

The effects of an explosion or a fire at home or in the workplace can be devastating in terms of lives lost, injuries, significant damage to property and the environment, and to the business community. Most fires are preventable and creating fire safety procedures is an important step for any community.

The Baltimore County Fire Prevention Code promotes public health and welfare by regulating the hazards of fire and explosion. The county fire code closely parallels the Maryland Fire Prevention Code but is tailored to the specific needs of Baltimore County and its residents. The code regulates the storage, handling and use of various substances, materials and devices, including fireworks, barbeque grills, commercial cooking equipment and machinery. The Code sets standards for fire protection systems including automatic sprinkler systems, residential rural water supplies for fire suppression and smoke detectors in day care homes. It also regulates conditions related to the occupancy of various types of buildings, including proper egress and requirements for fire drills. Finally, it includes specific physical and operational requirements for new and existing occupancies based on the type of use for each occupancy.[6]

14.4.1 Fire and Explosion Incidents in Baltimore County

During 2012, there were 44 fires that resulted in 53 deaths in Maryland. In Baltimore County, the seven deaths in six fires during 2012 reflect a 30 percent decline from the 10 deaths in as many fires during that time in 2011.[7] Table 14-9 furthers details fire death occurrences in the County between 2008 and 2012. Additionally, a brief synopsis of the seven deaths and six fires reported in Baltimore County in 2012 are included below:

- Two adult women died in a kitchen fire that was attributed to combustibles too close to a heat source;
- One elderly man died of injuries sustained while burning refuse in his yard;
- An 81 year-old woman died in a fire that resulted from careless smoking in the bedroom;
- Three other fires are still being investigated for cause, including two that claimed a 59 year-old woman and a 62 year-old man in separate fires, and an 87 year-old man died from smoke inhalation suffered in a fire that started in the living room.

Table 14-9. Fire Deaths in Baltimore County, 2008-2012								
	2008	2009	2010	2011	2012	5-Year Average	% of State Total	Fire Death Rate*
Baltimore County	8	13	10	10	7	9.6	14.8%	1.2
*Death Rate: Number of civilian fire deaths per 100,000 population.								

Source: Maryland State Fire Marshal, 2013

In addition to incidents reported by the State Fire Marshall, Baltimore County's Fire Department also tracks fire incidents that occur within the County. Table 14-10, below, details structural fires recorded by the Fire Department in 2013. This list is not exhaustive and may not include all events of this type in Baltimore County.

Table 14-10. Fire Incidents in Baltimore County, 2013				
Fires in Structures by Fixed Property Use	Number of Fires	Civilian Deaths	Casualties/ Injuries	Property Damage ($)
Private Dwellings	355	2	6	10,454,007
Apartments	166	0	4	4,152,492
Hotels and Motels	2	0	0	4,002
All Other Residential	6	0	0	52,022
TOTAL RESIDENTIAL FIRES	**529**	**2**	**10**	**14,662,523**
Public Assembly	14	0	0	938,404
Schools and Colleges	6	0	0	1,001,292
Health Care/Penal	5	0	0	9,150
Stores and Offices	27	0	0	961,200
Industry/Utility	6	0	0	51,402
Storage in Structures	19	0	0	414,200
Other Structures	16	0	0	27,763
TOTAL STRUCTURE FIRES	**622**	**2**	**10**	**18,065,934**

Source: Baltimore County Fire Department, NFPA Fire Experience Survey

Finally, Baltimore County's Police Department keeps records of "hazardous devices team statistics", which covers explosions, destructive devices, incendiary devices, chemical reaction device incidents, and more. These incidents are classified by service calls, recoveries, and disposals and are included in Table 14-11, below.

Table 14-11. Explosive Device Incidents in Baltimore County, 2013	
Type of Incident	Number of Incidents
Calls for Service	
Explosions (Accidental)	0
Improvised Destructive Device Incidents	5
Incendiary Device Incidents	5
Chemical Reaction Device Incidents	6
Hoax Device Incidents	0
Bomb Threats (BATS)	16
Suspicious Item Incidents (No hazards found)	12
Military Ordnance Incidents	8
Explosives-related Searches	11
VIP/DP Detail/Special Event	5
Assist other Units/Jurisdictions/Investigation	28

Type of Incident	Number of Incidents
Instructional Presentations	20
Total	**116**
Recoveries	
Recovered Fireworks	10
Recovered Ammunition	6
Recovered Explosives	7
Recovered HAZMAT	17
Total	**40**
Disposals	
Improvised Destructive Devices (Intact)	5
Fireworks (Class 1.4)	10
Ammunition	6
Hazard Materials	17
Military Ordnance	7
Explosives	6
Total	**51**

Source: Baltimore County Police Department

14.5 MASS POWER OUTAGE

Power outages may last seconds, hours, or days depending upon the cause. The most common causes of power outages are natural causes, human error, and equipment failure. Natural causes, such as strong storms, can result in large amounts of debris generation, especially trees and branches, which may fall onto power lines. Additionally, lightning strikes, high winds, heavy rain, salt, and snow and ice can damage substations, power lines, and equipment.

Mass power outages occur over a widespread area and are often the result of a major disaster even, such as a hurricane. There may be significant risks to public health and safety depending upon the severity of the disaster event coupled with the mass power outage. These risks may prompt local emergency management to open shelters, distribute food and water, and provide other coordinated disaster responses.

Tips for Getting Along Without Power

- Along with water, flashlights with extra batteries are essential emergency supplies.
- Portable generators are invaluable during an outage, but safety precautions must be taken as generations produce carbon monoxide gas.
- Families with members who have power-dependent health needs (oxygen, dialysis, etc.) should have an emergency plan in place at all times.

Source: baltimorecountymd.gov

According to Baltimore County's Emergency Preparedness Agency, households, businesses, and institutions need an emergency plan for handling power outages for up to three days. Three days is the length of time that most emergency management agencies across the U.S. feel it is reasonable to expect citizens to get along without water or power. After three days, Baltimore County's Office of Emergency Management may provide emergency shelter to affected residents.[8]

14.5.1 Electric Service and Tracking Power Outages

Baltimore County is serviced by the Baltimore Gas and Electric Company (BGE). Presently, BGE serves roughly 362,334 residents within the County. In classifying storms, the company uses four main categories based on the total number of outages reported. These categories are detailed on Table 14-12, below. In general, smaller power outages caused by adverse weather and minor storms are most likely to occur. However, major storms and severe-impact storms, such as Hurricane Isabel in 2003, are still a possibility and have a likelihood of occurring about once every year.

Table 14-12. BGE Storm Categories by Number of Outages[9]

Storm Type	Description
Adverse Weather	A weather related event causing less than 12,000 customer outages. Normally associated with strong wings, heavy rain, or extended heat/cold waves. Customer power typically restored in one (1) day. Frequency is usually 10 to 20 per pear.
Minor Storms	A weather relayed event causing 12,000 or more customer outages. Normally associated with isolated gusty thunderstorms or very strong winds. Customer power typically restored in 1-2 days. Frequency is usually 12 to 18 per year.
Major Storms	A weather related event causing 100,000 or more customer outages. Normally associated with system wide severe thunderstorms, isolated tornadoes, and extended high wind conditions. Customer power typically restored in 2-3 days. Frequency is usually 1 to 2 per year.

Storm Type	Description
Severe-Impact Storms	A weather related event causing 200,000 or more customer outages within BGE's territory, or 25% within a region. Severe damage to the distribution system requires need for significant mutual assistance and logistical support.

BGE provides an "Outage Map" as a tool to track power outages in their service area in real-time. This tool is available online and allows the user to view power outages by region. Additionally, BGE reports the status of current power outages on their website. While the company does its best to keep track of all outages, they encourage residents to report outages whenever possible.

Additionally, during mass power outages, utility companies compile an average of interruption time. CAIDI, Customer Average Interruption Duration Index, is an index utilized by electric companies to compute the average time period of an outage. This method is capable of measuring in units of minutes or hours by calculating the sum of all customer interruption durations then dividing by the total number of customer interruptions. The outcome would be the average time length that any given customer would experience a power outage. Table 14-13, below, provides general observations regarding BGE's CAIDI and also includes its sister companies, ComEd and PECO.

Table 14-13. CAIDI Observations for BGE and Sister Companies

Measure	Observations
CAIDI Contribution by Outage CAIDI Group	Almost half of BGE's CAIDI contribution comes from outages whose CAIDI exceeds four hours, while outages longer than four hours account for less than a quarter of CAIDI at ComEd and PECO.
CAIDI Contribution by Outage Size	The CAIDI contribution from outages with larger numbers of customer interruptions is significantly higher at ComEd as compared to BGE, but only slightly higher at PECO as compared to BGE.
CAIDI Contribution by Weather Status	Storms contribute a slightly smaller fraction of CAIDI minutes at PECO as compared to BGE, while storms are a far less significant contributor to overall CAIDI at ComEd.
Distribution of CAIDI Ratios	System configuration and switching practices at ComEd and PECO contribute to their ability to achieve a lower CAIDI than BGE.
Distribution of Outage Durations	Long duration outages contribute more to CAIDI at BGE than at PECO and ComEd.
Note: Data based on a 5-year study, 2007-2011.	

Source: 2013 CAIDI Study Findings Prepared for BGE by Davies Consulting.

14.6 DAM FAILURE

Baltimore County may be affected by the failure of five high hazard dams, all of which are located within or on the border of Baltimore County. However, there is no record of a high hazard dam failure in Baltimore County. In addition to these five dams, there are fifteen significant and low risk dams located within the County. These dams are identified in Table 14-14, below.

Table 14-14. Dams Within or Bordering Baltimore County by Hazard Rating

Dam Name	Dam Type	Purpose	Max Storage Capacity (m3)	Hazard Rating
Lake Roland Dam	Gravity	Recreation	1867	High
Liberty Dam	Gravity	Water Supply, Recreation	177000	High
Loch Raven Dam	Gravity	Water Supply, Recreation	91900	High
Prettyboy Dam	Gravity	Water Supply, Recreation	90100	High
UBMC Dam	Earth	Flood Control	185	High
Bloede Dam	Concrete, Buttress	Recreation	600	Significant
GBMC Pond	Earth	Flood Control	5.4	Significant
Loveton Farms Swm Fac.	Earth	Flood Control	39	Significant
Pikesville Reservoir	Earth	Water Supply	161	Significant
Acme Paper Mill Dam	Gravity	Water Supply	8	Low
Chenoweth Farm Pond	Earth	Recreation, Wildlife, Fire/Stock, Other	52	Low
Chestnut Ridge Irrigation Pond No. 3	Earth	Irrigation, Recreation	3	Low
Daniels Dam	Concrete, Buttress	Recreation	1500	Low
Gores Mill Dam	Other	Hydroelectric Power	5	Low
Gwynn Oak Park Dam	Earth, Other	Recreation	42	Low
Gwynns Falls Dam	Gravity	Recreation	10	Low
Montrose Farm Pond	Earth	Water Supply, Irrigation	108	Low
Old Loch Raven Dam	Masonry	Recreation	300	Low
Owings Mills Commerce Center	Earth	Flood Control	5.8	Low
Simpkins Industry Dam	Gravity, Earth	Water Supply	3560	Low

With the exception of the UMBC Dam and the Lake Roland Dam, all of the high hazard dam structures that pose a risk to Baltimore County are owned and operated by the City of Baltimore. The high risk dams were constructed to provide public water supply to residents in the Baltimore Metropolitan region, as well as to provide flood control and recreational opportunities.

14.6.1 Contributing Factors to Dam Failure Risk

There are several factors that can contribute to dam failures. Initiating events can be classified as external or internal. External events include floods, upstream dam failure, and earthquakes. Internal events include chemical/physical changes in soil or concrete properties, latent construction defects or long-term deterioration.

At low levels all of these events would not normally lead to dam failure. However, at high inflow rates a rapid rise in pool level could lead to overtopping. These and other dam-foundation-

spillway-reservoir system responses can lead to the outcome of the sudden release of the reservoir contents. The magnitudes of the resulting life loss and property or environmental damage would depend on various exposure factors.[10]

Flood

The occurrence of a Probable Maximum Flood (PMF), which is the most severe storm that can theoretically occur, is one scenario that could cause dam failure. This failure would result in a peak dam breach flow. In certain instances, a condition of uplift could occur at the heel of a dam which would not necessarily create a situation where overturning would occur.

Upstream Dam Failure

The failure of an upstream dam can, in some cases, put downstream dams at risk for failure depending on the amount of flood wave from the upstream dam and the downstream reservoir's capacity to store that wave. This factor is relevant in Baltimore County, because Prettyboy Dam is upstream from Loch Raven dam. A failure of Prettyboy Dam would cause major impacts on downstream flood levels as it approaches Loch Raven Reservoir.

Dam Safety in Baltimore County

- ✓ The State of Maryland has been assuring the safety of dams since 1934 through a permit and inspection program. The laws governing dam safety are administered by MDE's Dam Safety Division.
- ✓ Baltimore City participates the National Dam Safety Program as a source for grant assistance to improve dam safety, and to provide funds for research and training.
- ✓ Model Emergency Action Plans (EAP) are in place for all High Hazard and Significant Hazard dams. These are available on MDE's Dam Safety website.

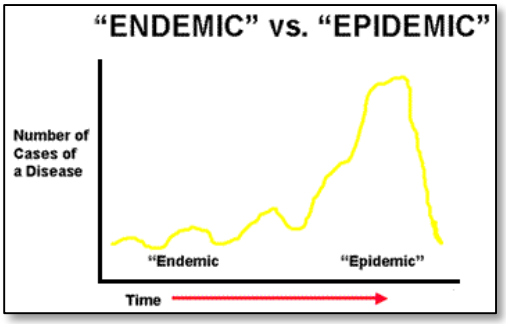
Earthquake

A severe earthquake, which is not a high risk in Baltimore County, could result in structural deformation or liquefaction. This can lead to the outcome of the sudden release of reservoir contents.

14.7 EPIDEMIC

The amount of a particular disease that is usually present in a community is referred to as the baseline or endemic level of the disease. This term refers to the constant presence and/or usual prevalence of a disease or infectious agent in a population within a geographic area, such as Baltimore County.

Figure 14-2.



Source: health.mo.gov

Sometimes the amount of disease in a community rises above the expected level; this is known as an epidemic. Epidemics are characterized by an increase, often sudden, in the number of cases of a disease above what is normally expected in that population in that area. While some diseases are so rare in a given population that a single case warrants an epidemiologic investigation (e.g., rabies, plague, polio), other diseases occur more commonly so that only deviations from the norm warrant investigation.[11] Figure 14-2 provides a visual representation of the difference between endemic and epidemic.

According to the Center for Disease Control (CDC), epidemics may commonly result from:

- A recent increase in amount or virulence of the agent;
- The recent introduction of the agent into a setting where it has not been before;
- An enhanced mode of transmission so that more susceptible persons are exposed;
- A change in the susceptibility of the host response to the agent, and/or;
- Factors that increase host exposure or involve introduction through new portals of entry.

In the event of a mass-casualty incident that involved significant health hazards, the Health Officer, as appropriate, would carry out the following activities:

- Initiate epidemic control measures, such as quarantines and mass immunization;
- Identify contaminated and exposed individuals, and provide guidance for the treatment and care of these individuals;
- Assist in the identification of areas to which access should be restricted.

Source: Baltimore County Emergency Operations Plan, 2011

Epidemics may also take the form of large scale incidents of food or water contamination, infestations of disease bearing insects or rodents, or extended periods without adequate water or sewer service. An epidemic may also be a secondary effect from other disasters such as flooding, tornadoes, hurricanes, or hazmat incidents.

Maryland's Department of Health and Mental Hygiene (DHMH) maintains counts for 86 diseases as reported by health care providers and laboratories. The surveillance and reporting of these diseases is the responsibility of local health departments, which investigate and complete reports both electronically and manually as per DHMH regulations. Table 14-15, below, represents total infectious diseases reported within Baltimore County by the DHMH for the year 2012. The most reported diseases for this year include: chlamydia, animal bites, gonorrhea, lyme disease, and salmonellosis.

Baltimore County's Department of Health recognizes that sexually transmitted infections (STIs), lyme disease, and animal related diseases have a high endemic level within the County, and as such, provides informational resources online regarding these diseases. Additional information regarding HIV/AIDS, perinatal infections, west nile virus, water safety, and general public health preparedness is also readily available online.

Table 14-15. Infectious Diseases with Reported Cases in Baltimore County, 2012

Disease	Maryland	Baltimore County	% of Total in Maryland
Amebiasis	21	2	9.52%
Anaplasmosis	5	2	40.00%
Animal Bites	10,399	1,613	15.51%
Campylobacteriosis	629	85	13.51%
Chlamydia	29,534	3,025	10.24%
Coccidioidomycosis	7	1	14.29%
Creutzfeldt-Jakob Disease	7	2	28.57%
Cryptosporidiosis	86	6	6.98%
Cyclosporiasis	4	2	50.00%
Dengue Fever	10	1	10.00%
Encephalitis - non-Arboviral	21	2	9.52%
Giardiasis	239	22	9.21%
Gonorrhea	5,686	595	10.46%
H. influenzae - Invasive Disease	87	17	19.54%
Hepatitis A (Acute-Symptomatic)	28	1	3.57%
Hepatitis B (Acute-Symptomatic)	52	17	32.69%
Hepatitis C (Acute-Symptomatic)	39	2	5.13%
Kawasaki Syndrome	3	1	33.33%
Legionellosis	123	22	17.89%
Listeriosis	16	3	18.75%
Lyme Disease	1,650	171	10.36%
Malaria	112	14	12.50%
Meningitis, Aseptic	514	94	18.29%
Meningococcal Invasive	4	1	25.00%
Mycobacteriosis, Other than TB & Leprosy	504	76	15.08%
Pertussis	369	49	13.28%
Pneumonia - Hospitalized Healthcare Worker	17	1	5.88%
Q Fever	1	1	100.00%
Rabies - Animal	325	19	5.85%
Salmonellosis - Other than Typhoid Fever	951	119	12.51%
Shiga toxin producing E. coli (STEC)	75	11	14.67%
Shigellosis	222	30	13.51%
Strep Group A - Invasive Disease	128	27	21.09%
Strep Group B - Invasive Disease	511	93	18.20%
Strep pneumoniae - Invasive Disease	426	60	14.08%
Syphilis - Congenital	12	3	25.00%

Disease	Maryland	Baltimore County	% of Total in Maryland
Syphilis - Primary and Secondary	431	29	6.73%
Tuberculosis	224	29	12.95%
Tularemia	2	1	50.00%
Typhoid Fever - Acute	7	2	28.57%
Vibriosis (Non-Cholera)	53	4	7.55%
West Nile Virus Symptomatic Infections	47	7	14.89%
Yersiniosis	13	1	7.69%

14.8 2014 MITIGATION GOALS AND ACTION ITEMS

14.8.1 Transportation Accident

GOAL 1: Eliminate or reduce human, environmental, social, and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Strong enforcement of traffic laws in high hazard areas.	1. Increase traffic enforcement along transportation corridors that have a high Annual Average Daily Traffic (AADT) count. These areas are more prone to transportation accidents due to the large volume of vehicles on the road.	See Map 14-1	Medium
	2. In reviewing data specific to transportation roadway accidents, areas between exits 22 and 23 of I-695 have a higher occurrence of accidents. Explore and determine mitigation options for this section of roadway.	I-695	Medium
2. Gather additional data relating to railway accidents in Baltimore County.	1. Conduct/obtain additional data on railway accidents specific to Amtrak, which has the highest recorded accidents resulting in death and/or injury within the 10 year period detailed on Table 14-6.	County	Medium

14.8.2 Hazardous Materials Incident

GOAL 1: Eliminate or reduce human, environmental, social, and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Determine the amount and types of hazardous materials being transported and stored throughout Baltimore County.	1. Conduct a Hazardous Materials Study to identify all hazardous materials that are either stored or traveling through the County. This study should also seek to identify critical facilities and commercial centers with large populations that are within 1000 feet of street centerlines.	County	Medium
	2. Using the Hazardous Materials Survey results, develop a plan to mitigate any identified risks.	County	Medium
2. Enhance the capabilities of emergency service providers.	1. Based on data for transportation accidents, tailor training and exercise programs to include fuel related incidents.	County	Medium

GOAL 2: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about man-made and technical hazard risks, preparedness and mitigation.	1. Distribute information concerning hazmat transportation to highly developed areas that are located nearby and/or along heavily traveled roadways. Refer to Map 14-1 for heavily traveled roadways (shown in red).	See Map 14-1	Medium

14.8.3 Fire and Explosion

GOAL 1: Eliminate or reduce human, environmental, social, and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Increase the number of structures that are more resistant to fire and explosion.	1. Ensure compliance with all life safety codes through diligent inspections. Attempt to inspect all commercial uses annually.	County	Medium
	2. Consider incentives to encourage retrofitting of existing buildings to meet current Baltimore County Building Code requirements.	County	Medium
2. Acquire information regarding potential fire and explosion threats.	1. Conduct inventory of sites or facilities that may be prone or vulnerable to explosions.	County	Medium
	2. Conduct inventory of buildings that do not meet current Building Code standards.	County	Medium

GOAL 2: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about man-made and technical hazard risks, preparedness and mitigation.	1. Enhance fire safety awareness information and make such information more available to local homeowners and businesses via the County website.	County	Medium
2. Enhance the capabilities of emergency service providers.	1. Encourage the training of Fire Department personnel through fire and explosion disaster drills and response planning.	County	Medium

14.8.4 Mass Power Outage

GOAL 1: Eliminate or reduce human, environmental, social, and economic loss from natural and technological hazards.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Provide fuel for emergency response vehicles during a long-term power outage.	1. Determine the number and locations of fuel service stations with generator power, as well as the number of emergency vehicles that need fuel.	County	Medium
	2. Identify the fueling locations that do not have generators, but are "generator ready". Then, identify the size and type of generators that are required for fueling.	County	Medium
2. Provide for the life safety of vulnerable populations during a long-term power outage.	1. Assess the number of vulnerable persons that may need assistance such as shelter, medication, medical equipment, and food and water.	County	Medium
	2. Conduct outreach to vulnerable populations during the power outage event.	County	Medium
	3. Consider developing a Vulnerable Populations Plan. This document would seek to identify vulnerable population within Baltimore County and provide a useful aid to emergency responders by filling resource gaps and increasing preparedness before a mass power outage.	County	High

14.8.5 Dam Failure

GOAL 1: Support mitigation measures that show potential for environmental enhancement and cost-effectiveness.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Develop a Green Infrastructure Plan that would redevelop inundation areas as open spaces, thus creating amenities and services to benefit the overall community.	1. Analyze land in the inundation areas to assess its suitability for conservation or recreational uses.	County	Medium

GOAL 2: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about man-made and technical hazard risks, preparedness and mitigation.	1. Develop a targeted outreach program to increase awareness of dam safety and emergency response procedures for residents and businesses located in dam inundation areas.	County	Medium
	2. Update and Maintain notification listing found in Emergency Action Plans (EAPs). Review information and provide to stakeholders.	County	Medium

14.8.6 Epidemic

GOAL 1: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.			
OBJECTIVE	**ACTION ITEM(S)**	**COMMUNITY**	**RANKING (HIGH, MEDIUM, OR LOW)**
1. Educate the public about man-made and technical hazard risks, preparedness and mitigation.	1. Continue to provide information on the County website regarding infectious diseases.	County	Medium
	2. Coordinate with local hospitals, clinics, and medical groups to disseminate information about the effects and transmission of diseases causing epidemic	County	Medium
	3. Promote epidemic hazard mitigation strategies within the County's business communities.	County	Medium
2. Enhance the capabilities of emergency service providers.	1. Conduct annual epidemic emergency operation's center drills to ensure efficiency of County staff and coordination of resources and information.	County	Medium

[1] Baltimore County Emergency Operations Plan, October 2011
[2] The Baltimore Sun, 2013
[3] Baltimore County 2011 Emergency Operations Plan – Appendix 4
[4] http://www.baltimorecountymd.gov/Agencies/emergency_prep/lepc.html
[5] http://www.hse.gov.uk/fireandexplosion/about.htm
[6] http://www.baltimorecountymd.gov/Agencies/fire/firemarshal/firecode.html
[7] https://www.mdsp.org/LinkClick.aspx?fileticket=TE2cRmpYga4%3d&tabid=580&mid=1538
[8] http://www.baltimorecountymd.gov/Agencies/emergency_prep/waterpoweroutage.html
[9] http://emergency.baltimorecity.gov/Portals/Emergency/documents/Power%20Outages%20presentation.pdf
[10] http://www.engineering.usu.edu/uwrl/www/faculty/DSB/Risk.html
[11] http://www.cdc.gov/osels/scientific_edu/ss1978/lesson1/section11.html

CHAPTER 15: HAZARD MITIGATION STRATEGIES

15.1 INTRODUCTION

As stated in *Chapter 3: Overall Hazard Mitigation Goals, Objectives, and Action Items*, the purpose of hazard mitigation strategies is to reduce or eliminate long-term risk to people and property from hazards and their effects using mitigation measures that promote environmental and fiscally responsible objectives and strategies.

During the 2014 Plan Update process, hazard-specific goals, objectives, and action items from the 2006 Plan were reviewed and updated as necessary by the 2013 Hazard Mitigation Planning Committee (HMPC). This review process also included adding new hazard-specific goals, objectives, and action items for the Plan Update.

Mitigation strategies include goals, objectives, action items, and mitigation projects. Goals provide a general guideline as to what Baltimore County hopes to achieve within the next planning cycle, 2014-2019. Objectives are not as broad as goals or defined as action items, but serve to provide a measureable connection between goals and action items. Action items consist of real-world steps that can be taken to fulfill the mitigation goals set by the County. Mitigation projects, which are derived from high priority action items (refer to section 15.1.1) are the final step to making action items come to life. These mitigation projects are included in section 15.2, following Table 15-1, which summarizes the results of the STAPLEE cost-benefit analysis performed by the HMPC during the Final Meeting.

15.1.1 Action Item Ranking Exercise

Each identified hazard and associated hazard specific chapter within the Plan contains goals, objectives, and action items. In order to prioritize these action items, an action item ranking exercise was conducted during the final HMPC meeting on February 19, 2014. HMPC members were asked to rank each hazard-specific action item on a simple scale of high, medium, or low priority. Then, by combining individual ratings of high, medium, or low for each action item, a composite score for each action item was created. Action items with a composite score of "high" were deemed to be of highest priority and will receive mitigation projects. In total, thirteen action items were deemed to be high priority by the HMPC, including:

- 4 action items from *Chapter 4: Flood;*
- 4 action items from *Chapter 13: Coastal Storm and Flooding;*
- 2 action items from *Chapter 12: Winter Weather;*
- 1 action item from *Chapter 7: Thunderstorm;*
- 1 action item from *Chapter 14: Man-made and Technical Hazard relating to Mass Power Outages;*
- 1 action item from *Chapter 6: Tornado.*

15.1.2 Cost-Benefit Analysis

A cost-benefit analysis was then performed on these thirteen high priority action items. The cost-benefit criteria utilized by the HMPC is known as the STAPLEE criteria. This criteria is recommended by FEMA as it addresses all the major factors when weighing the costs to the benefits of implementing one action item over another. Each aspect of the STAPLEE criteria is described in Figure 15-1.

Figure 15-1. The STAPLEE Criteria Defined

Social: Mitigation actions are acceptable to the community if they do not adversely affect a particular segment of the population, do not cause relocation of lower income people, and if they are compatible with the communities social and cultural values.

Technical: Mitigation actions are technically most effective if they provide long-term reduction of losses and have minimal secondary adverse impacts.

Administrative: Mitigation actions are easier to implement if the jurisdiction has the necessary staffing and funding.

Political: Mitigation actions can truly be successful if all stakeholders have been offered an opportunity to participate in the planning process and if there is public support of the action.

Legal: It is critical that the jurisdiction or implementing agency have the legal authority to implement and enforce a mitigation action.

Economical: Budget constraints can significantly deter the implementation of mitigations actions. Hence, it is important to evaluate whether an action is cost-effective, as determined by a cost-benefit review, and possible to fund.

Environmental: Sustainable mitigation actions that do not have an adverse effect on the environment, that comply with Federal, State, and local environmental regulations, and that are consistent with the community's environmental goals, have mitigation benefits while being environmentally sound.

The analysis rated items on a scale of -1 to 2, with negative values representing a cost, and positive values representing a benefit. For each action item, the analysis considered social, technical, administrative, political, legal, economic, and environmental aspects. This rating system allowed the HMPC to prioritize their high-rated action items. The lowest possible priority score an item could receive is -7, and the highest possible score is 14. In total:

- 9 actions items were rated with a priority score of 14;
- 1 action item was rated with a priority score of 7;
- 1 action item was rated with a priority score of 3;
- 2 action items were rated with a priority score of 2.

Full results of this analysis are contained in Table 15-1, on the following page.

Table 15-1. Results of the STAPLEE Cost-Benefit Analysis									
Actions		Criteria							Priority
		Social	Technical	Administrative	Political	Legal	Economic	Environmental	
Flood									
1. Continue to provide information on the County's web site about flood risk and vulnerability.	Cost	-	-	-	-	-	-	-	14
	Benefit	2	2	2	2	2	2	2	
2. Provide HAZUS flood data regarding shelter requirements to Emergency Preparedness for planning and mitigation purposes.	Cost	-	-	-	-	-	-	-	14
	Benefit	2	2	2	2	2	2	2	
3. Conduct stream corridor assessments to determine the status of bridges, culverts, pipes, failing channelization, debris blockages, and other issues that may increase the severity of flood events.	Cost	-	0	0	-	0	-	-	7
	Benefit	2	-	-	2	-	1	2	
4. Focus flood mitigation efforts in the communities identified as having the greatest amount of Repetitive Loss Properties: Middle River, Sparrows Point, Dundalk, Cockeysville, and Pikesville (Table 4-3).	Cost	-	-1	0	-	0	-1	-	2
	Benefit	1	-	-	1	-	-	2	
Coastal Storm and Flooding									
1. Continue to provide information on the County's web site about coastal storm risk and vulnerability.	Cost	-	-	-	-	-	-	-	14
	Benefit	2	2	2	2	2	2	2	
2. Provide HAZUS coastal flood data to shelters nearby, but outside of, the projected high hazard coastal flood zone within the County.	Cost	-	-	-	-	-	-	-	14
	Benefit	2	2	2	2	2	2	2	
3. Provide HAZUS coastal flood data regarding shelter requirements to Emergency Preparedness for planning and preparedness purposes.	Cost	-	-	-	-	-	-	-	14
	Benefit	2	2	2	2	2	2	2	

4. Focus flood mitigation efforts in the coastal communities identified as having the greatest amount of Repetitive Loss Properties: Middle River, Sparrows Point, and Dundalk (Table 14-4).	Cost	-	-1	0	-	0	-1	-	2
	Benefit	1	-	-	1	-	-	2	
Winter Weather									
1. Continue to provide, and possibly increase, warming center locations within Baltimore County.	Cost	-	-	-	-	-	-	-	14
	Benefit	2	2	2	2	2	2	2	
2. Continue to maintain the Baltimore County Snow Emergency Plan.	Cost	-	-	-	-	-	-	-	14
	Benefit	2	2	2	2	2	2	2	
Thunderstorm									
1. Provide staff training in the form of a damage assessment course so that emergency personnel are up-to-date on the latest techniques for assessing thunderstorm related damage, as well as any other major natural disaster. This course, and those like it, would be beneficial to new staff members, and provide a refresher for current staff.	Cost	-	-	-	-	-	-	-	14
	Benefit	2	2	2	2	2	2	2	
Mass Power Outage									
1. Consider developing a Vulnerable Populations Plan. This document would seek to identify vulnerable population within Baltimore County and provide a useful aid to emergency responders by filling resource gaps and increasing preparedness before a mass power outage.	Cost	-	0	0	-	-1	0	0	3
	Benefit	2	-	-	2	-	-	-	
Tornado									
1. Provide staff training in the form of a damage assessment course so that emergency personnel are up-to-date on the latest techniques for assessing tornado damage, as well as any other major natural disaster. This course, and those like it, would be beneficial to new staff members, and provide a refresher for current staff.	Cost	-	-	-	-	-	-	-	14
	Benefit	2	2	2	2	2	2	2	

15.2 MITIGATION PROJECTS

The following mitigation actions and associated projects are organized by project type and then further refined by hazard. Types of projects include: Public Outreach, Training, Data Distribution, Flood Mitigation, Studies, Continuation of Services, and Snow Emergency Plan Maintenance. Each hazard-specific action item also includes associated goals and objectives. Additionally, those actions pertaining to flooding that may be undertaken and documented for the National Flood Insurance Program (NFIP) – Community Rating System are denoted with the following: CRS. All projects are presented with the responsible organization(s) for implementing the action, the estimated cost of each action, potential sources of funding, and a timeline for implementation.

15.2.1 Public Outreach

FLOOD & COASTAL STORM FLOODING

Goal: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.

Objective: Educate the public about natural hazards risks, preparedness, and mitigation.

HMPC Priority Action Item #1 (Flood): Continue to provide information on the County's web site about flood risk and vulnerability.

HMPC Priority Action Item #2 (Coastal Storm and Flooding): Continue to provide information on the County's web site about coastal storm risk and vulnerability.

Discussion

At present, Baltimore County's Office of Homeland Security and Emergency Management maintains an informational webpage called "Flash Floods and Other Flooding". The webpage primarily focuses on flash flooding, but also briefly discusses coastal, riverine, and urban flooding. Information is geared towards residents living within flood-prone areas and largely consists of important precautions to take before, during, and after a flood event. This webpage was last revised in April of 2012. Baltimore County's Fire Department also maintains a webpage regarding flood information. This page, titled "Coping with Floodwaters," provides a brief description of flash flooding and highlights the National Weather Service campaign known as "Turn Around, Don't Drown". This webpage was last revised in May of 2013.

A webpage dedicated to coastal storms and flooding, called "Hurricanes and Tropical Storms", is maintained by Baltimore County's Office of Homeland Security and Emergency Management. The webpage provides an overview of the three most common tropical cyclone events: tropical depression, tropical storm, and hurricane. Information is primarily focused on coastal flooding as a byproduct of tropical cyclone events. The webpage includes personal and community preparedness tips as well as important precautions to take during and after a coastal storm/flooding event. Additionally, brief discussions of storm surge, storm tide, and the Saffir-Simpson hurricane scale are included. This webpage was last revised in May of 2012.

In general, these webpages should be consistently revised so as to provide Baltimore County residents with the most up-to-date information regarding flood and coastal storm risk and vulnerability. Updates can occur as new information becomes available, but a cyclical update schedule should be adopted and performed by appropriate departmental staff to ensure timely updates. More specific updates are described in the projects below.

CRS Project 1 – Add a section regarding flood insurance to both the "Flash Floods and Other Flooding" and "Hurricanes and Tropical Storms" webpages.

Public Outreach Project 1

Responsible Organization(s): Office of Homeland Security and Emergency Management

Estimated Cost: Staff time

Potential Funding Sources: No funding required

Implementation Timeline: Consider revisions every 2 years

Flood insurance is briefly mentioned within the text of both webpages, but useful tools and sources of flood insurance information for residents are never discussed. The following links, along with a brief description of each website, can be added to both the "Flashfloods and Other Flooding" and "Hurricanes and Tropical Storms" webpages:

- FEMA Map Service Center (http://msc.fema.gov) – Alternatively, or in conjunction with, link to the Department of Public Works "Flood Plain, Metropolitan District and Mapping" webpage, which currently includes a link to the FEMA Map Service Center.
- DFIRM Outreach (http://www.mdfloodmaps.com)
- Floodsmart.gov (http://www.floodsmart.gov)
- The National Flood Insurance Program (http://www.fema.gov/national-flood-insurance-program)

Public Outreach Project 2

Responsible Organization(s): Office of Homeland Security and Emergency Management

Estimated Cost: Staff time

Potential Funding Sources: No funding required

Implementation Timeline: To be updated in a manner that provides sufficient notice prior to the event.

CRS Project 2 – Utilize these webpages to publicize outreach activities, such as workshops and public meetings.

Given the subject matter of these webpages, they would provide a solid platform for promoting activities such as upcoming flood insurance workshops, or public meetings regarding FEMA map updates.

Option A: Each webpage, either at the top or bottom, could contain an eye-catching text box which includes any upcoming meetings or workshops with topics related to flood and/or coastal storm risk and vulnerability. An example of this proposed text box is shown below.

Upcoming Event(s)

"Preparing for Changes in Flood Insurance" Workshop - This workshop will focus on strategies communities can use to effectively plan, in the short and long term, for changes to the National Flood Insurance Program. The workshop will include sessions dedicated to education on the current workings and status of NFIP changes; policy and legal implications for communities preparing for flood insurance reform; and mortgage and banking perspectives on how NFIP reform will affect lending practices. The workshop will also provide community leaders with opportunities to discuss the effects these changes will have on their communities. Local and national examples will be explored that present best practices for planning resilient communities that use strategies to reduce insurance burdens.

Date: August 22, 2014
Time: 9:00 AM to 4:00 PM
Location: Simpson Building, Room 3.

Option B: Alternatively, each webpage could have a dedicated section at the bottom of the page labeled "Upcoming Events." This section could include dates and times of workshops and meetings as they occur, or it could list all scheduled events several weeks or months out. An example is included below.

Upcoming Events

The following events related to flooding and coastal storms are scheduled for Baltimore County residents in the near future:

May 10, 2014 – NFIP Workshop for Realtors, 9:00 AM to 2:00 PM
June 17, 2014 – Public Meeting, 6:00 PM

15.2.2 Training

THUNDERSTORM & TORNADO

Goal: Promote hazard mitigation as the cornerstone of emergency management in Baltimore County.

Objective: Continued education for emergency responders and personnel.

HMPC Priority Action Item #1 (Thunderstorm): Provide staff training in the form of a damage assessment course so that emergency personnel are up-to-date on the latest techniques for assessing thunderstorm related damage, as well as any other major natural disaster. This course, and those like it, would be beneficial to new staff members, and provide a refresher for current staff.

HMPC Priority Action Item #2 (Tornado): Provide staff training in the form of a damage assessment course so that emergency personnel are up-to-date on the latest techniques for assessing tornado damage, as well as any other major natural disaster. This course, and those like it, would be beneficial to new staff members, and provide a refresher for current staff.

Discussion

According to Baltimore County's Emergency Operations Plan 2011, the county agencies and departments listed below are responsible for providing staff to perform damage assessments after a hazard event. Appropriate staff members from these agencies and departments would take priority over staff from agencies and departments not on the list.

- Office of Homeland Security and Emergency Management (coordinates and supervises all aspects of damage assessment);
- Fire Department;
- Department of Permits, Approvals, and Inspections;
- Department of Public Works;
- Public Schools (Recovery Team);
- Department of Recreation and Parks;
- Baltimore County Food and Agricultural Council.

Project 1 – Schedule a damage assessment "refresher" course for appropriate staff members of responsible agencies and departments as defined in the Emergency Operations Plan 2011.

Option A: The refresher course should be modeled after FEMA's "IS-559: Local Damage Assessment" course and then may be adjusted as appropriate to meet Baltimore County's specific needs. This course is available online at http://training.fema.gov and may be

Training Project 1

Responsible Organization(s): Office of Homeland Security and Emergency Management

Estimated Cost: Staff time

Potential Funding Sources: No funding required

Implementation Timeline: After initial training session, consider additional sessions whenever damage assessment guidelines and/or techniques change.

requested through the Maryland Environmental Management Agency (MEMA) for local delivery.

A refresher course modeled after the FEMA training course would need to include, at a minimum, the following over-arching topics:

- Introduction to Local Damage Assessment – explain basic concepts related to damage assessment;
- Hazard Analysis – describe how risk and vulnerability assessment information is used for damage assessment planning;
- Planning the Damage Assessment Program – explain the process for planning the damage assessment program;
- Training and Exercises – Describe how training and exercises are used to enhance the damage assessment program;
- Operations – describe basic operations of local damage assessment, and;
- Data Collection and Analysis - describe damage assessment after-action activities.

In order to personalize the training at the county-level, Baltimore County may want to address the following topics: hazard information with photographs of past damages following disaster events, samples of past Baltimore County damage assessment data sheets, and highlights from past successes and failures encountered during the damage assessment process.

Option B: As an alternative to Option A, the refresher course could simply utilize the interactive web-based course provided by FEMA at http://training.fema.gov. This could be a requirement for all new hires within appropriate departments (listed above) to be completed during their training. In addition to the web-based course, a final exam is also available online (Note: the final exam requires the user to provide their FEMA Student Identification Number or their Social Security Number at the end of the exam).

This option would be easier and quicker to setup than Option A, but would lack any information tailored to Baltimore County specifically.

Project 2 – Building upon staff training for damage assessments, consider the acquisition of, and staff training in the use of, tools such as GPS-enabled cameras, which could greatly aid in the damage assessment process.

Training Project 2

Responsible Organization(s): Office of Homeland Security and Emergency Management

Estimated Cost: $1,900 to 4,400 per unit, depending on model purchased. Training at a cost of $3,000 per session.

Potential Funding Sources: Homeland Security Grant Program

Implementation Timeline: Dependent upon availability of funds, shipping times, and training times

The Ricoh G700SE-M GPS-Enabled Tactical Camera, made available through various vendors, such as Geo Tactical Solutions, Geospatial Experts, and SDG Systems, is an example of how a GPS-enabled camera would help simplify the damage assessment process. The camera is specifically recommended for emergency and disaster response, and boasts the following features:

- On-board GPS module and electronic compass

- Descriptive image memos
- SAASM compatible (avoid GPS jamming and spoofing)
- Works with laser range finders for geotagging distant 'objects'
- GIS integration - export data to ArcGIS, FalconView, GeoSuite, Google Earth, Palantir, etc.
- GPS track-logs (records travel routes)
- Multiple GPS formats (LAT/LONG, MGRS, Decimal Degrees, UTM, State Plane, and more)
- Ultra-rugged (water, dust, drop, shock, weather, and chemical resistant)
- Extended optics allow for detailed observation and photo-capture up to 2,000 meters
- PVS-14 night vision compatibility
- Streamlined photo mapping and reporting (with GeoJot+ or FoxView)

As an example, during a damage assessment after a severe thunderstorm event which caused severe flash flooding, the camera could be utilized to not only take pictures of flood elevations and associated damages, but also to geo-tag objects within the picture itself, such as high water marks or debris blockages.

For this particular line of GPS-cameras, certain vendors do include training at an additional cost. On average, the cost for training is around $3,000 and includes on-site instruction which covers software, basic camera operations, field camera operations, and technical support functions.

15.2.3 Data Distribution

FLOOD & COASTAL STORM FLOODING

Goal: Provide outreach to agencies and organizations within Baltimore County regarding hazard mitigation for plan integration opportunities.

Objective: Utilize planning documents, reports, and analyses as targeted material for outreach and preparedness efforts.

HMPC Priority Action Item #1 (Flood): Provide HAZUS flood data regarding shelter requirements to Emergency Preparedness for planning and mitigation purposes.

HMPC Priority Action Item #2 (Coastal Storm and Flooding): Provide HAZUS coastal flood data regarding shelter requirements to Emergency Preparedness for planning and preparedness purposes.

HMPC Priority Action Item #3 (Coastal Storm and Flooding): Provide HAZUS coastal flood data to shelters nearby, but outside of, the projected high hazard coastal flood zone within the County.

Discussion

The HAZUS Level II Analysis performed for *Chapter 4: Flood* and *Chapter 13: Coastal Storm and Flooding* estimated the number of households that are expected to be displaced from their homes due to a 100-year flood (riverine or coastal) event and the associated potential evacuation. The analysis also estimated those displaced people that will require accommodations in temporary public shelters. For riverine flooding (Chapter 4), the model estimated that 4,009 households would be displaced due to the flood and, of these, 8,835 people would seek temporary refuge in public shelters.

For coastal flooding caused by a tropical cyclone event (Chapter 13), the model estimated that 611 households would be displaced due to the flood and, of these, 1,069 people would seek temporary refuge in a public shelter.

Short-term shelter needs for both *Chapter 4: Flood* and *Chapter 13: Coastal Storm and Flooding* are depicted by census block on Map 4-3 and Map 13-3, respectively.

Baltimore County's *Emergency Operations Plan 2011* currently provides guidance for mass sheltering in the event of a natural disaster. Responsible agencies for shelter coordination in the event of a disaster include: Department of Social Services (lead agency), American Red Cross, Public Schools, Department of Aging, Health Department, and the Office of Homeland Security and Emergency Management.

Data Distribution Project 1

Responsible Organization(s): Office of Homeland Security and Emergency Management

Estimated Cost: Staff time

Potential Funding Sources: Regular employee pay

Implementation Timeline: 1 month

Project 1 – Ensure that designated mass care shelters and reception centers within the County receive the HAZUS Level 2 Analysis results contained in this Plan as they relate to short-term shelter needs.

The most efficient method of disseminating this information to mass care shelters would be to create a separate handout of the HAZUS Level 2 Analysis results for shelter needs as they relate to flood and coastal storms, and then email said handout to the responsible parties at each shelter. Shelters may handle the data as they see fit, but it would be useful to provide guidance within the email on how to utilize the analysis results. For example, the data contained within the HAZUS Analysis results for Flood are probably most useful for shelters in determining how many people to expect in the event of a 100-year riverine flood event. This knowledge allows shelters to have a better idea of how to prepare prior to a disaster event.

Project 2 – Integrate the HAZUS Level 2 Analysis shelter results as an attachment to the Mass Care Annex (M) of the Emergency Operations Plan 2011.

The HAZUS Level 2 Analysis results for sheltering during a flood or coastal storm event may be added as an attachment to the Mass Care Annex (M) of the Plan, following the guidelines dictated on pages BP-II through BP-III of the Emergency Operations Plan 2011, which state: "Any required changes needed throughout the year are incorporated into associated procedures and checklists. These changes will then be included in the next change to this Plan."

Data Distribution Project 2

Responsible Organization(s): Fire Department, Office of Homeland Security and Emergency Management

Estimated Cost: Staff time

Potential Funding Sources: Regular employee pay

Implementation Timeline: Dependent upon EOP update cycle

Data Distribution Project 3

Responsible Organization(s): Fire Department, Office of Homeland Security and Emergency Management

Estimated Cost: Staff time

Potential Funding Sources: Regular employee pay

Implementation Timeline: 3-6 months

Project 3 – Utilize the GAP Lifecycle, designed by FEMA, to complete a review of current capabilities (incorporating HAZUS shelter requirements) to determine resource gaps that may exist within the following categories as they relate to short-term shelter needs: planning, organization, equipment, training, and exercises.

According to FEMA, GAP was designed to follow a systematic and cyclical lifecycle that repeats on an annual basis. The GAP lifecycle is composed of six distinct phases through which a program achieves its mission and meets its goal and objectives.

These six phases include:

1. **Select Disaster Scenario** – Selection and development of a disaster scenario through which the state's response capabilities will be analyzed.

2. **Estimate Response Requirements** – Generation of estimated resource and response capability requirements that would be needed in the aftermath of the modeled or simulated disaster.

3. **Measure Baseline Preparedness** – Inventory of the emergency management response capabilities and resources available within a state.

4. **Define the Gaps** – Measurement of any anticipated response shortfalls made by comparing actual baseline preparedness to estimated response requirements.

5. **Develop and Implement Strategies** – Efforts made to address or eliminate potential response shortfalls.

6. **Evaluate and Apply Lessons Learned** – Ongoing improvement of GAP through the application of best practices and lessons learned.

The HAZUS Level 2 Analysis for Baltimore County provides a backbone for the GAP Lifecycle as it has already satisfied the requirements of phases one, two, and three. The disaster scenario discussed in Phase 1 is fulfilled by the 100-year riverine and the 100-year coastal flood HAZUS Level 2 Analyses. Phase 2 is fulfilled because HAZUS generates the estimated resource and response capability requirements of several factors, including short-term shelter requirements. Phase 3 is partially fulfilled due to the fact that the HAZUS analysis takes into consideration critical facilities within the County, including police stations, fire station, hospitals, EOCs, schools, and shelters. However, while these critical facilities are identified, the response capabilities of each facility are not included in the analysis and would need to be determined.

15.2.4 Flood Mitigation

FLOOD & COASTAL STORM FLOODING

Goal: Eliminate or reduce human, environmental, social, and economic loss from natural and technological/man-made hazards.

Objective: Identify flood prone properties for mitigation efforts.

HMPC Priority Action Item #1 (Flood): Focus flood mitigation efforts in the communities identified as having the greatest amount of Repetitive Loss Properties: Middle River, Sparrows Point, Cockeysville, Dundalk, and Pikesville.

HMPC Priority Action Item #2 (Coastal Storm and Flooding): Focus flood mitigation efforts in the coastal communities identified as having the greatest amount of Repetitive Loss Properties: Middle River, Sparrows Point, and Dundalk.

Discussion

As of July 31, 2013, Baltimore County has 121 repetitive loss properties; two of which are severe repetitive loss properties. Of these properties, 71 are within coastal communities (Middle River, Sparrows Point, and Dundalk), which represents nearly 60% of the repetitive loss properties in the County. The top five communities with the greatest amount of repetitive loss properties within the County are listed in Table 15-2, below. Additionally, Table 15-3 contains a list of all the repetitive loss properties within Baltimore County.

Table 15-2. Communities with the Greatest Amount of RLP in the County

Community	# of Properties	% of total RLP (out of 121)
Middle River	33	27%
Sparrows Point	22	18%
Cockeysville	19	16%
Dundalk	13	11%
Pikesville	6	5%
Total:	**93**	**77%**

Table 15-3. Repetitive Loss Properties within Middle River, Sparrows Point, Cockeysville, Dundalk, and Pikesville			
Street Name	Community	Street Name	Community
(2) Alt Rd	Cockeysville	(2) Galloway Rd	Middle River
(6) Beaver Run Ln	Cockeysville	Glenwood Rd	Middle River
Boxwood Ln	Cockeysville	Greenbank Rd	Middle River
Ivy Hill Rd	Cockeysville	Kingston Rd	Middle River
Off Of Cockeysville Rd	Cockeysville	(2) Middle River Ave	Middle River
Veneer Ln C	Cockeysville	Nannette Ln	Middle River
Williamson Ln	Cockeysville	New Section Rd	Middle River
(6) York Rd	Cockeysville	Oakdene Rd	Middle River
Bullneck Rd	Dundalk	Red Rose Farm Rd	Middle River
Cornwall Rd	Dundalk	Schaadts Rd	Middle River
Cove Rd	Dundalk	Shore Rd	Middle River
Dundalk Ave	Dundalk	Transverse Ave	Middle River
Fairgreen Rd	Dundalk	(2) Wilson Point Rd	Middle River
Mcshane Way	Dundalk	Anita Rd	Pikesville
Northview Rd	Dundalk	Milford Mill Rd	Pikesville
(2) Sandy Plains Rd	Dundalk	Old Court Rd	Pikesville
Searles Rd	Dundalk	Scotts Level Rd	Pikesville
Thruway	Dundalk	Sudvale Rd	Pikesville
Watersedge Rd	Dundalk	SW Corner Falls & Old Court	Pikesville
Willow Spring Rd	Dundalk	4th St	Sparrows Point
(3) Bay Dr	Middle River	8th St	Sparrows Point
Beach Dr	Middle River	(2) 9th St	Sparrows Point
Beach Rd	Middle River	Chesapeake Ave	Sparrows Point
(2) Beech Dr	Middle River	Cuckold Point Rd	Sparrows Point
Briar Pt Rd	Middle River	Ella Ave	Sparrows Point
(2) Burke Rd	Middle River	Grace Rd	Sparrows Point
Chestnut Rd	Middle River	(2) Hinton Ave	Sparrows Point
(2) Clarks Point Rd	Middle River	(11) River Drive Rd	Sparrows Point
(2) Cold Spring Rd	Middle River	River Drive Rd*	Sparrows Point
(2) Frog Mortar Rd	Middle River		
Note: (#) Indicates number of RLP on street. * Indicates a Severe Repetitive Loss Property			

CRS Project 1 – Conduct an assessment of all the repetitive loss properties identified within Table 15-2 and obtain structural characteristics in order to determine the best flood protection measure(s).

Characteristics to consider including:

- First Floor Elevation;
- Flood Depths;
- Foundation Type;
- Age of Structure;
- Historical Nature of Property;
- Presence of Stormwater System;

Flood Mitigation Project 1

Responsible Organization(s): Budget and Finance, Office of Information Technology, Department of Homeland Security and Emergency Management

Estimated Cost: Approx. $20,000

Potential Funding Sources: Pre-disaster Mitigation Assistance Funds, Hazard Mitigation Grant Program Technical Assistance, Flood Mitigation Assistance Program Technical Assistance Funds

Implementation Timeline: 3 years

- Adjacent Land Uses

Potential Mitigation Measures:

- Acquisition, elevation, or relocation for structures that are repetitively flooded or have high flood depths;
- Dry flood-proofing for buildings on sound slab foundations that are subject to less than two feet of flooding.

Flood Mitigation Project 2

Responsible Organization(s): Budget and Finance, Office of Information Technology, Department of Homeland Security and Emergency Management

Estimated Cost: Approx. $20,000

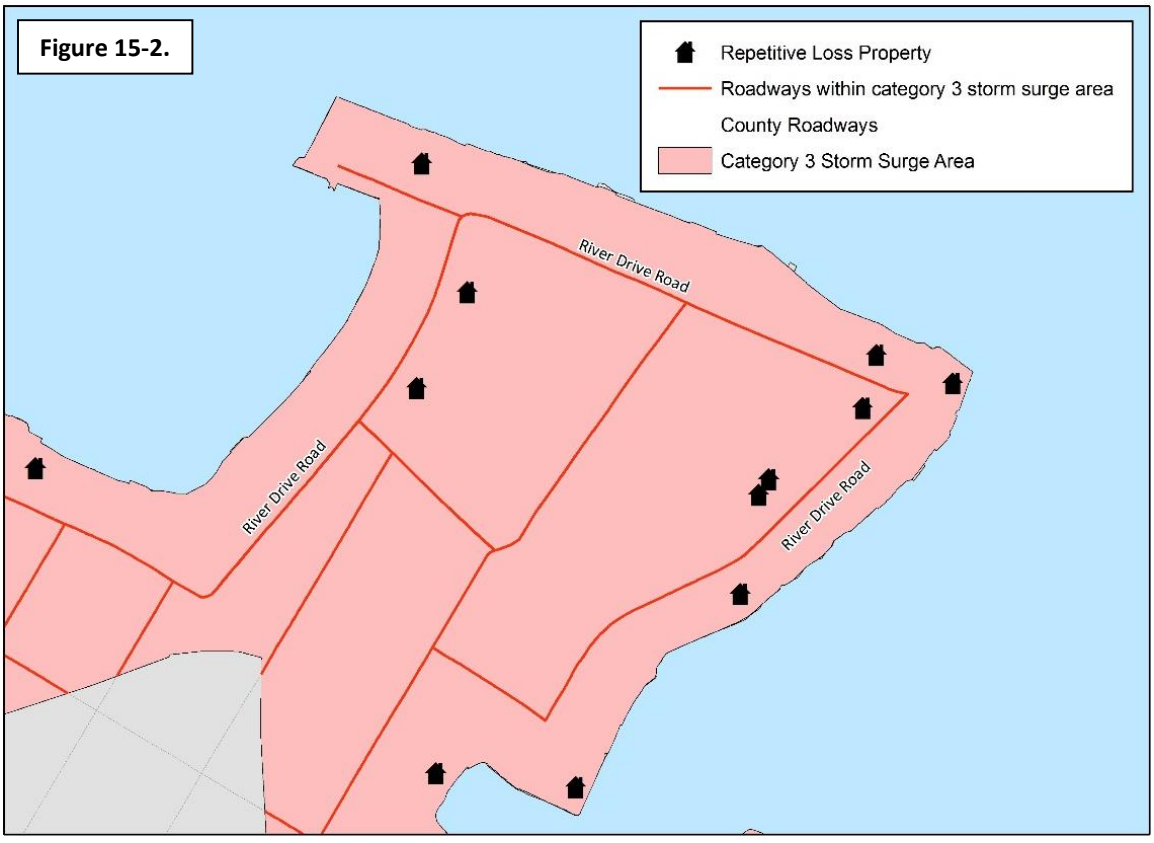
Potential Funding Sources: Pre-disaster Mitigation Assistance Funds, Hazard Mitigation Grant Program Technical Assistance, Flood Mitigation Assistance Program Technical Assistance Funds

Implementation Timeline: 3 years

CRS Project 2 – Conduct a detailed structural assessment of the twelve (12) repetitive loss properties on River Drive Road, identified in Figure 15-2, in order to determine appropriate mitigation measures to reduce damages caused by flooding and keep the character of the structure intact.

River Drive Road in Sparrows Point contains the largest number of repetitive loss properties in Baltimore County and includes one severe repetitive loss property. Additionally, all twelve of these properties are within the Category 3 Storm Surge Area identified in *Chapter 13: Coastal Storm and Flooding.*

Figure 15-2.



CRS Project 3 – Educate property owners about flood insurance and recommended property protection measures for their structures, including costs, and funding.

Flood Mitigation Project 3

Responsible Organization(s): Department of Homeland Security and Emergency Management

Estimated Cost: Mailing costs and staff time

Potential Funding Sources: Regular employee pay

Implementation Timeline: 3 months

As of July 31, 2013 only 62 repetitive loss properties in Baltimore County had flood insurance, out of a total of 121 properties. This means that 59 properties were without flood insurance as of that same date.

Targeted mailings should be used to inform residents about their status within the 100-year floodplain, as well as the benefits of purchasing flood insurance, particularly for repetitive loss properties. These mailings should direct homeowners to informational material located on the County website, as well as the Flood Risk Application located at www.mdfloodmaps.com.
Currently, multiple departmental webpages on the Baltimore County website provide information and links to sources of information regarding flood insurance, including:

- Department of Public Works – "Flood Plain, Metropolitan District and Mapping"
- Department of Homeland Security and Emergency Management – "Flash Floods and Other Floods"
- Department of Health – "Flood Safety, Before and After"

15.2.5 Studies

FLOOD

Goal: Eliminate or reduce human, environmental, social and economic loss from natural and technological/man-made hazards.

Objective: Identify potential contributing factors to flood risk within the floodplain.

HMPC Priority Action Item: Conduct stream corridor assessments to determine the status of bridges, culverts, pipes, failing channelization, debris blockages, and other issues that may increase the severity of flood events.

Discussion

A Stream Corridor Assessment (SCA) seeks to identify circumstances within a stream channel that may be degrading stream function and potentially increasing the severity of a flood event. A typical stream assessment involves an in-stream walkthrough by a trained professional and may look at such factors as the condition of bridges, culverts, and pipes, failing channelization, debris blockages, or any other abnormality that may be detrimental to stream function.

An example of a stream corridor assessment performed by the Maryland Department of the Environment in 2006 for the Prettyboy Reservoir Watershed in Baltimore County can also be found online: http://www.dnr.state.md.us/irc/docs/00013837.pdf

A detailed guide regarding the methodology of conducting a standard stream corridor assessment can be found online via the Maryland Department of Natural Resources (www.dnr.state.md.us). Modifications may be necessary when conducting a stream corridor assessment with regard to how stream conditions affect flooding. An example of a modified SCA is the *Tiber-Hudson and Plumtree Branch Stream Corridor Assessment* which was completed for Howard County in 2012. This assessment is available online at www.howardcountymd.gov.

CRS Project 1: Prioritize those streams and stream sections which are to receive a stream corridor assessment.

Studies Project 1

Responsible Organization(s): Environmental Protection and Sustainability – Watershed Management and Monitoring, Department of Public Works

Estimated Cost: Staff time, total cost dependent upon total linear feet of stream assessed

Potential Funding Sources: Regular employee pay

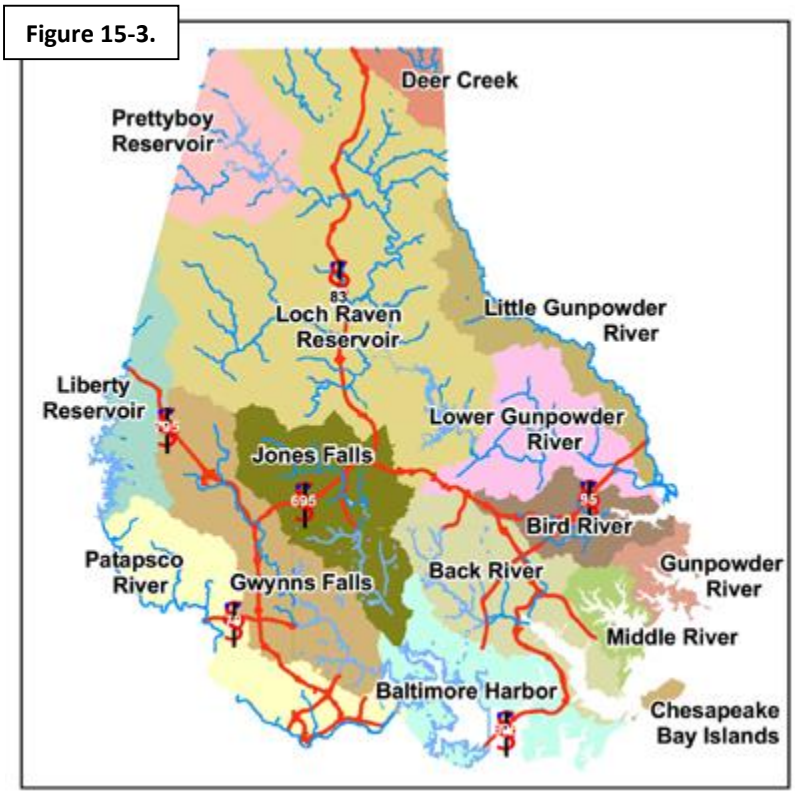
Implementation Timeline: 3 months

To accomplish this task, it would be useful to first divide streams by their major watershed. Baltimore County has 14 major watersheds, which are shown on Figure 15-3. Then, determine major streams within each watershed and see which ones flow through areas of high population density and development. Streams within these types of areas, regardless of their size, or more likely to cause significant damages if and when they flood because of their proximity to greater

populations, and because human development tends to alter how stream systems naturally work, which can lend itself to more catastrophic flooding.

It may aid in the prioritization process to also consider historical occurrences of riverine flooding throughout the County. Repeat flooding of the same area may indicate issues within nearby stream channels. Also, examining the location of repetitive loss properties and identifying clusters or multiple properties along the same stream may indicate a stream that should be considered high priority. For example, seven repetitive loss properties were identified along Beaver Dam Run in Cockeysville. These properties are very likely within the 100-year riverine floodplain, but a stream corridor assessment may help identify issues within the stream channel that could be addressed in order to lessen the severity of future flood events.

Figure 15-3.



MASS POWER OUTAGE

Goal: Eliminate or reduce human, environmental, social, and economic loss from natural and technological/man-made hazards.

Objective: Provide for the life safety of vulnerable populations during a long-term power outage.

HMPC Priority Action Item: Consider developing a Vulnerable Populations Plan. This document would seek to identify vulnerable population within Baltimore County and provide a useful aid to emergency responders by filling resource gaps and increasing preparedness before a mass power outage.

Project 2: Develop a Vulnerable Populations Plan which would seek to spatially identify vulnerable and special needs populations within Baltimore County. The plan would serve as a tool for emergency responders and health care providers to prepare and respond to a mass power outage event by identifying and filling resource gaps that may exist specific to vulnerable populations.

Studies Project 2

Responsible Organization(s): Department of Health, Office of Information Technology

Estimated Cost: $30,000 to $50,000

Potential Funding Sources: Homeland Security Grant Program

Implementation Timeline: 1 year

The National Response Framework defines vulnerable, or special needs, populations as follows:

> "Populations whose members may have additional needs before, during and after an incident in functional areas, including but not limited to: maintaining independence, communication, transportation, supervision, and medical care. Individuals in need of additional response assistance may include those who have disabilities; who live in institutionalized settings; who are elderly; who are children; who are from diverse cultures; who have limited English proficiency or are non-English speaking; or who are transportation disadvantaged."

The plan development process of a Vulnerable Populations Plan consists of four main components:

- Data Collection
  - Creation of a Vulnerable Population Planning Committee;
  - Identification of Key Stakeholders;
  - Identification of Sources of Vulnerable Population Data;
  - Request Data from Local Agencies and Organizations.
- Development of Vulnerable Population Database
  - Various data obtained should be reviewed and compiled to create a centralized database which will enable planners to query data for analysis and integrate into GIS software for mapping applications.
- Creation of GIS Mapping Product(s) Identifying Vulnerable Populations

  - Utilization of GIS software to analyze spatially referenced data in order to display the association between the locations of vulnerable populations, community resources, and the potential hazard(s).
  - This mapping product could be used during future emergency incident response and operations. Response planning personnel may use this mapping product, and an overlay of hazard impact area(s) could be incorporated, thereby providing critical information to first responders and officials to promote better decision making specific to vulnerable populations.
- Development of Plan Document
  - The plan document will include data analysis and results; scenario-based planning using hazard identification and risk assessment results; preparedness, response, and recovery information and resource gaps specific to special needs population; recommendations and suggested Best Practices including public outreach efforts.

15.2.6 Continuation of Services

WINTER WEATHER

Goal: Eliminate or reduce human, environmental, social and economic loss from natural and technological/man-made hazards.

Objective: Provide those residents in need with shelter during cold weather.

HMPC Priority Action Item: Continue to provide, and possibly increase, warming center locations within Baltimore County.

Discussion

According to the Baltimore County Department of Health, there are several warming centers available throughout the County for people to seek relief from cold temperatures. The Baltimore County Public Library has 17 branches that are open from November to March where residents may warm up and senior centers within Baltimore County are also open to the general public for shelter from the cold, regardless of age. In addition to the aforementioned, there are other places residents may go to warm up within the County:

- Community Centers
- Churches
- Malls
- Movie Theaters
- Museums
- Neighbor's homes with heat
- Restaurants

Baltimore County has four facilities that provide emergency shelter for people who would otherwise be homeless. These shelters are:

- Eastside Family Shelter (men, women, children) - Rosedale
- Hannah More Shelter (for women and children) - Reisterstown
- Night of Peace Overnight Shelter - Woodlawn
- Westside Men's Shelter - Catonsville

Finally, from the months of November through March, the County also has a temporary, freezing weather shelter at the North Point Government Center, which is activated on nights when temperatures reach 32 degrees or lower and there are no available beds in the other homeless shelters.

Project 1 – Utilizing a GIS mapping program, map the locations of current warming shelters within the County and make available on the County website.

Continuation of Services Project 1

Responsible Organization(s): Department of Health, Office of Information Technology

Estimated Cost: Staff time

Potential Funding Sources: Regular employee pay

Implementation Timeline: 1 month to complete mapping; to be updated when necessary

Mapping current warming centers and placing the product online will provide useful information to residents who may need to utilize a warming shelter during cold months. This product would be best placed on the Department of Health's website, "Warming Centers in Baltimore County", as information related to warming centers already exists here. It may also be useful to make the warming center's layer available within "My Neighborhood," the County's online mapping/data service.

The mapping product could number each warming center and then provide an attached explanation for each center that would contain important information regarding the center, such as address, hours of operation, etc.

Continuation of Services Project 2

Responsible Organization(s): Department of Health, Office of Information Technology

Estimated Cost: Staff time

Potential Funding Sources: Regular employee pay

Implementation Timeline: 1 to 3 months

Project 2 – After initial mapping of warming centers, determine potential ideal locations for new warming centers by comparing the location of current centers with population densities in Baltimore County.

Should Baltimore County decide to increase warming center locations, the examination of population density throughout the County, in comparison to current warming center locations, will allow for a more educated determination of potential new locations.

Generally, areas with a higher population density will require either more warming centers, or bigger centers that can accommodate more people. Due to the risk of frostbite from extended exposure to extremely cold temperatures, it is important that the majority of warming centers are within short walking distance or, weather permitting, driving distance from population centers.

Important factors to consider when determining suitable warming center locations:

- Distance from community;
- Proximity to existing warming centers;
- Number of residents the center is expected to serve;
- Data from existing centers regarding annual center usage (if kept);
- Potential hours of operation.

15.2.7 Snow Emergency Plan Maintenance

WINTER WEATHER

Goal: Reduce vulnerabilities to future natural hazards; guide and facilitate post-storm recovery.

Objective: Enforce current winter weather policy and procedure.

Action Item: Continue to maintain the Baltimore County Snow Emergency Plan.

Discussion

When Baltimore County's Snow Emergency Plan is in effect:

1. Vehicles traveling on the roads must be equipped with snow or all-weather radial tires or chains, and;
2. No parking is permitted on designated snow emergency routes.

During this time, Baltimore County's Winter Storm Operations, known as "Snowfighter" on the County website, monitors all activity regarding the winter storm event and provides real-time updates to the public. Winter Storm Operations recommends residents heed the following during a snow emergency:

- Never shovel or plow snow into the street;
- Do not call the County to have your road shoveled;
- County snowplow drivers do not intentionally block driveways or vehicles;
- Park all vehicles in a driveway or other off-street parking, if possible;
- Prevent flooding after snow and ice melt by cleating drains, and;
- Take proper steps for dealing with intense cold.

Project 1 – Provide a personal/vehicle "recovery" service for those residents trapped on roadways during a snow emergency/winter storm event

Snow Emergency Plan Maintenance Project 1

Responsible Organization(s): Department of Public Works, Office of Homeland Security and Emergency Management, State Highway Administration

Estimated Cost: Staff time

Potential Funding Sources: Regular employee pay

Implementation Timeline: Ongoing

In the event that a motorist would choose to travel during a snow emergency without taking proper precautions, it may be necessary to recover said motorist, along with their vehicle, should they become trapped on a roadway. Other potentially affected parties include truck drivers who may have wrecked or simply find themselves unable to continue driving in hazardous conditions.

Assuming the motorist is unharmed and only unable to drive because of road conditions, it would be reasonable to provide a separate hotline for this service, rather than rely on emergency service

numbers, such as 911. In conjunction, Baltimore County could consider partnering with the State Highway Administration by having employees, in properly equipped vehicles, constantly monitoring major roadways for trapped/broken down motorists.