Section 7
Risk Assessment

Contents of this Section

7.1 Interim Final Rule Requirement for Risk Assessments

IFR §201.6(c)(2): *The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.*

IFR §201.6(c)(2)(ii): *[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards descry*

bed in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.

7.2 Overview and Analysis of Anne Arundel County's Vulnerability to Hazards

As discussed in Section 6 of this Plan (Hazard Identification), Anne Arundel County has at least some exposure to as many as twelve natural hazards, but most of them have such low probability that there is little or no significant risk to the County from them. Section 6.4 described the process by which the County reduced the list of twelve possible hazards to the four that create the most risk to Anne Arundel County's citizens, assets and operations: These hazards include the following

- **Flood**
- **Hurricane, Tropical Storm, and Nor'easter (wind)**
- **Tornado**
- **Severe Winter Storm**

As part of the 2010 HMP update, the planning team conducted detailed research into potential vulnerabilities to natural hazards, for both County assets, as well as private structures, populations and assets. Since the first version of the Mitigation Plan was approved, the County has experienced some damage from Hurricane Isabel and other events such as the snowstorms of 2009-1010. These are generally described in this Section, and in Section 6, the Hazard Identification and Profiling. Given the very low extent of damages from natural hazards in the past, the County can be considered to have limited vulnerability to hazards, except in the most extreme events. The County has well-established and successful programs for mitigation and prevention efforts, and intends to continue these indefinitely. The County also has effective building controls that serve to limit the vulnerabilities of structures and people, so vulnerabilities going forward are expected to remain low, and hopefully will be reduced even further as mitigation projects and policy efforts are initiated and completed.

This section addresses the risk related to the four hazards listed above, and estimates future expected losses from them, in accordance with FEMA requirements. The most significant natural hazard to which Anne Arundel County is exposed is floods. Flooding in Anne Arundel County is the result of various weather events including hurricanes, thunderstorms (convectional and frontal), storm surge and winter storms. As discussed in Section 6 of this Plan, there have been 46 flood events in the County between 1950 and 2007.[1] Of the 46 flood events, 15 resulted in property damage. See Section 6 of the Plan update for additional details about past flood occurrences in Anne Arundel County.

The second most significant hazard to which Anne Arundel County is exposed to is wind from hurricanes, tropical storms and nor'easters. As discussed in Section 6 of this Plan, there have been nine tropical storms that have impacted Anne Arundel County between 1950 and 2008.[2] Several of these events made landfall as hurricanes and later downgraded to tropical storms by the time they reached the mid-Atlantic and Anne Arundel County.

The County is also at risk from tornadoes. The entire County is equally exposed to the potential effects of tornadoes. Past events in Anne Arundel County have ranged in severity from an F0 to an F3 event (Fujita

[1] National Oceanic Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC)
[2] National Hurricane Center's (NHC) Hurricane and Tropical Storm Tracker database

Scale). The County is also equally exposed to the severe winter storm hazard. The NCDC indicates that the County has experienced 68 winter storms between 1993 and 2009.

7.3 Estimate of Potential Losses (Risk Assessment)

This section describes the risks to Anne Arundel County, including its citizens, residential, government and commercial assets, and County operations. As noted above, risk is an expression of expected future monetary losses resulting from the impacts of natural hazards. Risk assessment methodologies differ based on the nature of data that is available, the hazard, and the way that the results are expressed. The sections below provide brief descriptions of the methodologies.

7.3.1 Flood Risk in Anne Arundel County

This subsection of the Plan provides estimates of future flood losses, i.e. risk. Each of the loss calculations is based on best available data, but they must be considered estimates because highly detailed engineering studies were not performed as part of this planning process. The present section is intended to provide a moderately-detailed overview of risk in the Anne Arundel County.

Flood Risk Assessment Method 1
Analysis of NFIP Repetitive Loss and Severe Repetitive Loss Data

The first risk assessment method is based on analysis of National Flood Insurance Program (NFIP) data on repetitive flood loss properties. The NFIP defines repetitive loss properties as those that have received least two NFIP insurance payments of more than $1,000 each in any rolling ten-year period. As of 2010, Anne Arundel County had 81 such properties, based on a query of the FEMA BureauNet NFIP interface. Of this total, there are 75 residential and six non-residential properties.

Table 7.3-1 summarizes the NFIP claims value and number of claims statistics for both residential and non-residential repetitive loss properties. The Table shows that approximately 7.4 percent of the repetitive loss properties in Anne Arundel County are non-residential. The Table also indicates that the majority of the paid claims, approximately 67.3 percent, are associated with residential building damages.

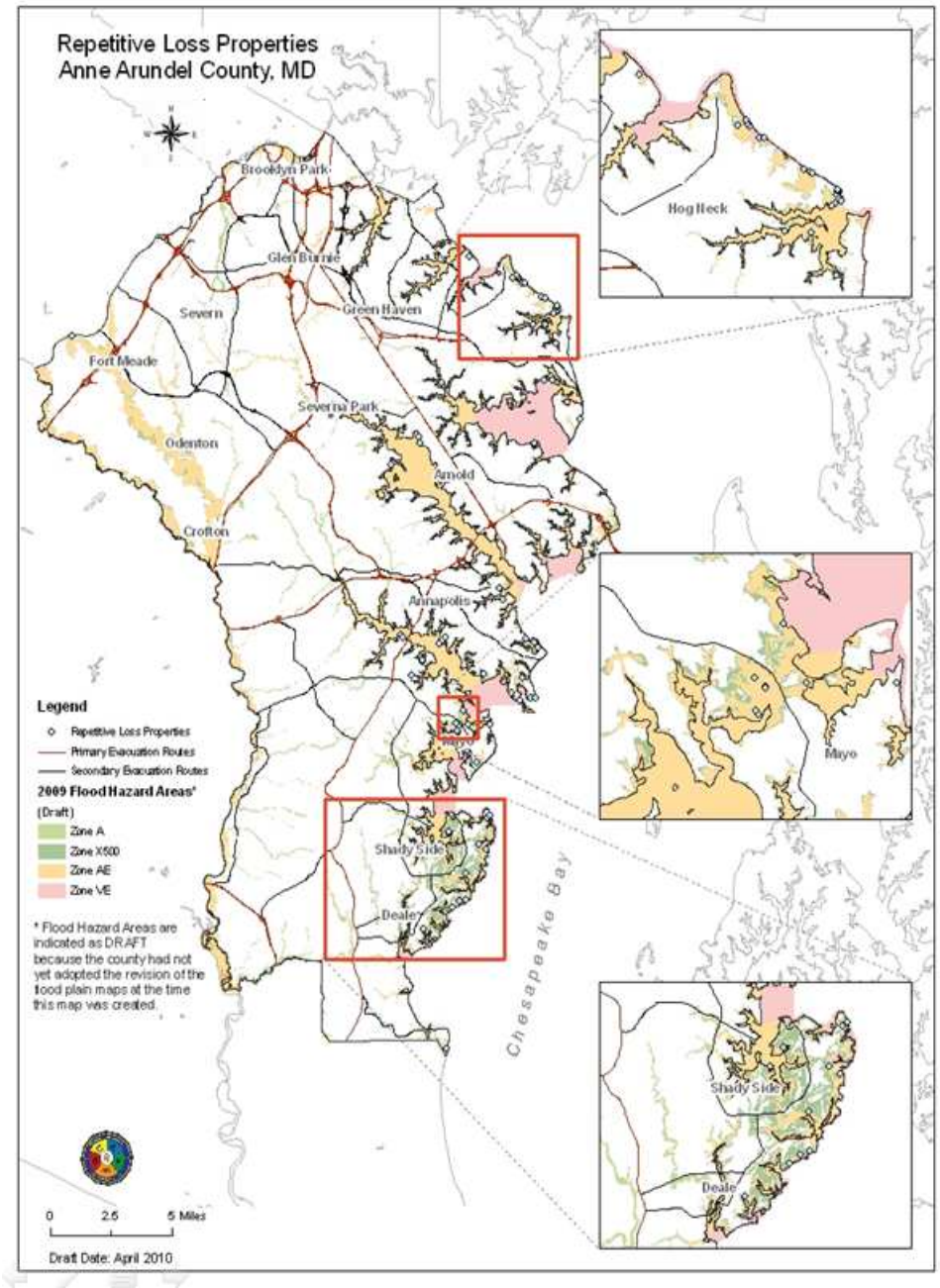
Table 7.3-1
Summary of Residential and Non-Residential NFIP Repetitive Loss Statistics, Anne Arundel County
(Source: FEMA/NFIP Query, Spring, 2010)

Repetitive Loss Category	Properties	Building	Contents	Total	# Claims	Average
Residential	75	$4,624,054	$908,742	$5,532,796	174	$31,798
Non-Residential	6	$697,495	$633,246	$1,330,741	15	$88,716.07
Grand Total	**81**	**$5,321,549**	**$1,541,988**	**$6,863,537**	**189**	**$36,315**

Figure 7.3-1 shows the locations of the 81 residential and non-residential repetitive loss properties in the County. The map shows the majority of the repetitive loss properties are concentrated along the eastern border of the County, along the shoreline and tributaries of the Chesapeake Bay. Insert maps showing additional detail have been included for three areas of the County where clusters of repetitive loss properties are located.

The map also shows the location of the flood hazard areas (Zones A, AE, VE, X500). As noted on the map, flood hazard areas are indicated as "draft" because the County has not yet adopted the latest revisions to the floodplain map at the time of the Plan update.

Figure 7.3-1
Residential and Non-Residential NFIP Repetitive Loss Properties, Anne Arundel County
(Source: FEMA/NFIP Query, Spring, 2010)



Residential Repetitive Loss Properties

As mentioned above, Anne Arundel County has 75 residential repetitive loss properties in the NFIP database. Tables 7.3-2, 7.3-3 and 7.3-4 provide basic NFIP residential repetitive loss statistics, sorted in three ways: first by the number of such properties in each community, then by the total dollar value of claims to properties in the data set, then by the dollar amount of the average claim.

Table 7.3.2 indicates that the City of Pasadena has the highest number of repetitive loss properties in Anne Arundel County. As of early 2010, Pasadena had a total of 26 repetitive loss properties and is also ranked first in total dollar value of building and contents claims, total paid claims, and number of paid claims. The Table indicates that Pasadena is followed by the City of Edgewater and the City of Annapolis with 14 and 13 repetitive loss properties respectively. Note that the statistics for Annapolis are included here, even though the City is not part of the County plan update.

Table 7.3-2
Summary of Residential NFIP Repetitive Loss Statistics, Anne Arundel County;
Ordered by Number of Repetitive Loss Properties in each City
(Source: FEMA NFIP query Spring, 2010)

City Name	# RL Props	Building	Contents	Total Paid ($)	# of Claims	Average $ Claim
Pasadena	26	$1,699,541	$502,902	$2,202,443	61	$36,106
Edgewater	14	$679,120	$139,896	$819,016	30	$27,301
Annapolis	13	$931,569	$161,426	$1,092,995	33	$33,121
Shady Side	6	$299,749	$17,327	$317,076	14	$22,648
Arnold	4	$222,858	$27,589	$250,446	9	$27,827
Churchton	4	$403,300	$14,807	$418,107	9	$46,456
Severna Park	2	$203,921	$19,934	$223,855	4	$55,964
Crownsville	1	$16,364	$6,637	$23,001	3	$7,667
Deale	1	$50,166	$6,484	$56,650	2	$28,325
Gibson Island	1	$9,864	$0	$9,864	2	$4,932
North Beach	1	$49,718	$1,823	$51,541	3	$17,180
Selby on the Bay	1	$6,581	$9,918	$16,499	2	$8,250
West River	1	$51,303	$0	$51,303	2	$25,651
Grand Total	**75**	**$4,624,054**	**$908,742**	**$5,532,796**	**174**	**$31,798**

Table 7.3.3 ranks the residential repetitive loss properties in Anne Arundel County by the dollar value of the total paid claims for each City. The top three communities include Pasadena, Annapolis, and Edgewater. Pasadena is ranked highest with paid claims totaling $2,202,443.

Table 7.3-3
Summary of Residential NFIP Repetitive Loss Statistics, Anne Arundel County;
Ordered by Total Claims Paid in each Community
(Source: FEMA NFIP query Spring, 2010)

City Name	# RL Props	Building	Contents	Total Paid ($)	# of Claims	Average $ Claim
Pasadena	26	$1,699,541	$502,902	$2,202,443	61	$36,106
Annapolis	13	$931,569	$161,426	$1,092,995	33	$33,121
Edgewater	14	$679,120	$139,896	$819,016	30	$27,301
Churchton	4	$403,300	$14,807	$418,107	9	$46,456
Shady Side	6	$299,749	$17,327	$317,076	14	$22,648
Arnold	4	$222,858	$27,589	$250,446	9	$27,827
Severna Park	2	$203,921	$19,934	$223,855	4	$55,964
Deale	1	$50,166	$6,484	$56,650	2	$28,325
North Beach	1	$49,718	$1,823	$51,541	3	$17,180
West River	1	$51,303	$0	$51,303	2	$25,651
Crownsville	1	$16,364	$6,637	$23,001	3	$7,667
Selby on the Bay	1	$6,581	$9,918	$16,499	2	$8,250
Gibson Island	1	$9,864	$0	$9,864	2	$4,932
Grand Total	**75**	**$4,624,054**	**$908,742**	**$5,532,796**	**174**	**$31,798**

It should be noted that the numbers of claims or repetitive loss properties are not necessarily good indicators of risk, except on a community level. This is in part because communities with larger populations will normally have more insurance policies and more claims (holding constant the exposure to flood hazards). Table 7.3-4 shows the same data sorted by the dollar amount of the average NFIP claim. Particularly when a statistically significant number of claims are included in the data set, the dollar amount of the average claim is often a better indication of relative flood risk. The Table indicates that Severna Park has the highest average claim value ($55,964) in Anne Arundel County. Severna Park is followed by Churchton with an average claim value of $46,456.

Table 7.3-4
Summary of Residential NFIP Repetitive Loss Statistics, Anne Arundel County;
Ordered by Average of NFIP Insurance Claims in each City
(Source: FEMA NFIP query Spring, 2010)

City Name	# RL Props	Building	Contents	Total Paid ($)	# of Claims	Average $ Claim
Severna Park	2	$203,921	$19,934	$223,855	4	$55,964
Churchton	4	$403,300	$14,807	$418,107	9	$46,456
Pasadena	26	$1,699,541	$502,902	$2,202,443	61	$36,106
Annapolis	13	$931,569	$161,426	$1,092,995	33	$33,121
Deale	1	$50,166	$6,484	$56,650	2	$28,325

City Name	# RL Props	Building	Contents	Total Paid ($)	# of Claims	Average $ Claim
Arnold	4	$222,858	$27,589	$250,446	9	$27,827
Edgewater	14	$679,120	$139,896	$819,016	30	$27,301
West River	1	$51,303	$0	$51,303	2	$25,651
Shady Side	6	$299,749	$17,327	$317,076	14	$22,648
North Beach	1	$49,718	$1,823	$51,541	3	$17,180
Selby on the Bay	1	$6,581	$9,918	$16,499	2	$8,250
Crownsville	1	$16,364	$6,637	$23,001	3	$7,667
Gibson Island	1	$9,864	$0	$9,864	2	$4,932
Grand Total	**75**	**$4,624,054**	**$908,742**	**$5,532,796**	**174**	**$31,798**

The RL claims can be further broken down by focusing on individual street level data. Table 7.3-5 provides a summary of residential RL claims for individual streets within Anne Arundel County. The data displayed in the table summarizes the NFIP RL data for 54 individual streets in the county that include an RL property. The building, contents, and total claims data has been combined for streets that include two or more RL properties. Address data about individual sites is omitted for reasons of confidentiality. The data shows that Lake Drive in the City of Pasadena has the most RL properties in Anne Arundel County. Lake Drive has seven RL properties and 16 prior NFIP claims totaling $788,643.

Table 7.3-5
Summary of Residential NFIP RL Statistics, Anne Arundel County, ordered by Number of Properties on Each Street
(Source: FEMA NFIP query Spring, 2010)

Street Name	Properties	Building	Contents	Total	# of Claims	Average (Per Policy)
Lake Drive	7	$602,369	$186,274	$788,643	16	$49,290
Bay Street	4	$181,153	$41,844	$222,997	11	$20,272
Forest Drive	3	$191,965	$19,689	$211,654	7	$30,236
Southwest Road	3	$275,839	$62,223	$338,062	8	$42,258
East Lake Drive	2	$158,493	$45,585	$204,078	5	$40,816
Edgewater Drive	2	$63,983	$29,296	$93,279	4	$23,320
Harbor Road	2	$143,661	$36,668	$180,329	4	$45,082
Holly Drive	2	$112,332	$36,611	$148,943	4	$37,236
Kurtz Avenue	2	$45,794	$18,091	$63,885	4	$15,971
Lakeview Avenue	2	$26,262	$0	$26,262	4	$6,566
Narragansett Avenue	2	$304,696	$31,852	$336,548	8	$42,069
Thomas Drive	2	$38,352	$3,444	$41,796	5	$8,359
Ayrlie Water Road	1	$9,864	$0	$9,864	2	$4,932
Back Bay Beach Road	1	$51,303	$0	$51,303	2	$25,651
Bay Front Avenue	1	$49,718	$1,823	$51,541	3	$17,180
Bay Park Way	1	$128,297	$18,208	$146,505	2	$73,252

Street Name	Properties	Building	Contents	Total	# of Claims	Average (Per Policy)
Bay View Avenue	1	$147,004	$0	$147,004	2	$73,502
Bayside Drive	1	$3,457	$952	$4,409	3	$1,470
Baywood Lane	1	$84,163	$9,394	$93,558	2	$46,779
Carrollton Road	1	$18,781	$0	$18,781	2	$9,390
Cornfield Road	1	$10,080	$0	$10,080	2	$5,040
Cotter Drive	1	$117,435	$17,980	$135,415	2	$67,708
Dent Road	1	$76,196	$661	$76,857	3	$25,619
Dover Street	1	$3,914	$0	$3,914	2	$1,957
Farview Road	1	$19,845	$0	$19,845	2	$9,922
Ferry Point Road	1	$7,600	$0	$7,600	2	$3,800
First Avenue	1	$6,581	$9,918	$16,499	2	$8,250
Franklin Boulevard	1	$251,774	$11,573	$263,346	2	$131,673
Fullerton Road	1	$90,775	$53,863	$144,638	2	$72,319
Gina Court	1	$16,872	$0	$16,872	2	$8,436
Havre De Grace Drive	1	$27,776	$1,194	$28,970	3	$9,657
Hilltop Road	1	$41,190	$19,637	$60,827	3	$20,276
Idlewilde Road	1	$7,804	$0	$7,804	2	$3,902
Lake Avenue	1	$42,935	$13,883	$56,818	3	$18,939
Locust Road	1	$48,584	$0	$48,584	2	$24,292
Magnolia Avenue	1	$48,881	$2,378	$51,258	2	$25,629
Mahogany Trail	1	$16,364	$6,637	$23,001	3	$7,667
Mansion Drive	1	$14,260	$12,487	$26,747	2	$13,374
North Shore Parkway	1	$71,417	$2,573	$73,990	2	$36,995
Oak Road	1	$63,654	$0	$63,654	2	$31,827
Potomac Road	1	$36,863	$27,600	$64,463	2	$32,232
Riverside Drive	1	$152,736	$80,639	$233,375	2	$116,687
Riverview Road	1	$75,624	$1,726	$77,350	2	$38,675
Sands Avenue	1	$28,718	$4,832	$33,550	4	$8,387
Shore Acres Road	1	$30,893	$7,900	$38,793	2	$19,396
Shore Drive	1	$104,525	$0	$104,525	2	$52,262
Sneed Drive	1	$50,166	$6,484	$56,650	2	$28,325
South Breeze Lane	1	$15,925	$0	$15,925	2	$7,962
Sunset Road	1	$182,035	$35,104	$217,140	2	$108,570
Thomas Point Road	1	$124,729	$23,994	$148,724	2	$74,362
Turkey Point Road	1	$92,572	$0	$92,572	2	$46,286
Twin Oak Drive	1	$20,157	$0	$20,157	2	$10,078
Ventnor Road	1	$60,235	$20,533	$80,767	3	$26,922
Washington Drive	1	$27,450	$5,194	$32,644	2	$16,322
Grand Total	**75**	**$4,624,054**	**$908,742**	**$5,532,796**	**174**	**$31,798**

Non-Residential Repetitive Loss Properties

As noted earlier, as of Spring, 2010, Anne Arundel County had six non-residential RL properties in the NFIP database. Table 7.3-6 provides a summary of non-residential RL claims for municipalities within Anne Arundel County. The table identifies four municipalities that have non-residential RL properties, and includes the number of RL properties in each municipality, building and contents damages, the total number of claims, and the average claim amounts.

Table 7.3-6
Summary of Non-Residential Repetitive Flood Loss Claims in Anne Arundel County, Ordered by Number of Properties in Each City
(Source: FEMA NFIP Spring, 2010)

City Name	Properties	Building	Contents	Total	# Claims	Average
Annapolis	3	$357,259	$163,406	$520,665	6	$86,777.44
Glen Burnie	1	$35,367	$769	$36,135	2	$18,067.75
Laurel	1	$260,206	$460,510	$720,716	3	$240,238.51
Pasadena	1	$44,663	$8,562	$53,225	4	$13,306.34
Grand Total	**6**	**$697,495**	**$633,246**	**$1,330,741**	**15**	**$88,716.07**

The data indicates that Annapolis has the highest number of non-residential repetitive loss properties, total building claims value, and total number of claims. The remaining three cities each have one non-residential property. For these three properties, the City of Laurel had by far the highest building and contents claims value, total claims, and average claim value. It should again be noted that Annapolis is included in these statistics because it is within the planning area, but the City has its own mitigation plan.

Flood Risk Calculations for Residential Repetitive Loss Properties

Residential flood risk is calculated by a methodology that uses the NFIP claims history in conjunction with FEMA default present-value coefficients from the benefit-cost analysis software modules. To perform this calculation, the RL data were reviewed to determine an approximate period over which the claims occurred. This is not an exact method, because there are numerous properties in the database, and insurance policies come into force at different times, and are cancelled and reinstated periodically. These variables are not part of the query output. With the exception of a few claims in 1979, almost all of the claims in the most recent NFIP query occurred between 1985 and the present, a period of 25 years.

Anne Arundel County has a moderate history of repetitive loss flood claims, and using this historical flood data it is possible to perform a relatively simple statistical risk assessment using average annual losses and a present value coefficient calculation to project losses over a planning horizon. As shown in Table 7.3-7, there have been 174 residential RL claims in this 25-year period, for an average of approximately 7 claims per year. Based on a 100-year planning horizon and a present value coefficient of 14.27 (the coefficient for a 100-year planning horizon using the mandatory Office of Management and Budget (OMB) discount rate of 7%), the projected flood risk to these properties is calculated, and shown at the bottom of the table. It must be understood that individuals can obtain and cancel flood insurance policies, and the flood hazard depends

on many variables, including the weather, so this projection is simply an estimate of potential damages. Nevertheless, it offers a useful metric that can be used in assessing the potential cost effectiveness of mitigation actions. If the county pursues mitigation measures on a site-specific basis, it will be necessary to perform risk assessment and benefit-cost analysis on the basis of individual properties or claims histories, something that is not appropriate for a county-level mitigation plan.

Table 7.3-7
Projected 100-Year Flood Risk in Anne Arundel County -
Residential Repetitive Loss Properties
(Source: FEMA NFIP Query Spring, 2010)

Data	Value
Period in years	25
Number of claims	174
Average claims per year	6.96
Total value of claims	$5,532,796
Average value of claims per year	$221,312
Projected risk, 100-year horizon	$3,158,122

The next table (7.3-8) shows risk projections for the two streets that appear to have the most risk in the County, based on NFIP residential RL records. These projections are done in the same manner as the calculation described above. As indicated above in Table 7.3-5, the two streets in Anne Arundel County with the most risk are Lake Drive and Bay Street, both of which are located in the City of Pasadena. Using this methodology, Lake Drive appears to show significantly more risk than Bay Street. Lake Drive shows a projected 100-year risk of $450,161 while the long-term risk (100-year horizon) for Bay Street is significantly less at just under $31,822. These risk figures are a good basis for determining the total amount that can be spent (either overall, or per typical property) on mitigation actions, although the ultimate cost effectiveness is also a function of the effectiveness and useful life of the project itself. It should be understood that these projections are for groups of properties with flood insurance. Any mitigation project or action that addresses individual properties must be analyzed on a site-specific basis.

Table 7.3-8
Projected 100-year Flood Risk, Select Streets in Anne Arundel County with Highest Number of RL Claims in the NFIP Database
(Source: FEMA NFIP, Query Spring, 2010)

Lake Drive	
Total number of paid claims	16
Average number of paid claims per year	0.64
Total value of claims	$788,643
Average value of paid claims per year	$31,546
Projected risk, 100-year horizon	$450,161
Number of claimants	7
Projected risk per policy, 100-year horizon	$64,309
Bay Street	
Total number of paid claims	11
Average number of paid claims per year	0.44
Total value of paid claims	$222,997
Average value of paid claims per year	$8,920
Projected risk, 100-year horizon	$127,288
Number of claimants	4
Projected risk per policy, 100-year horizon	$31,822

Flood Risk to Non-Residential Properties

The relatively small number and dollar amount of claims for these properties does not allow for accurate determination of annual values for flood losses. Because of this, it is also not possible to estimate losses over a longer time, such as the 100-year planning horizon that is used elsewhere in this section. If a risk projection is required in the future, it may be possible to use an approach based on survey and engineering information.

Natural Hazard Risk to Critical Facilities

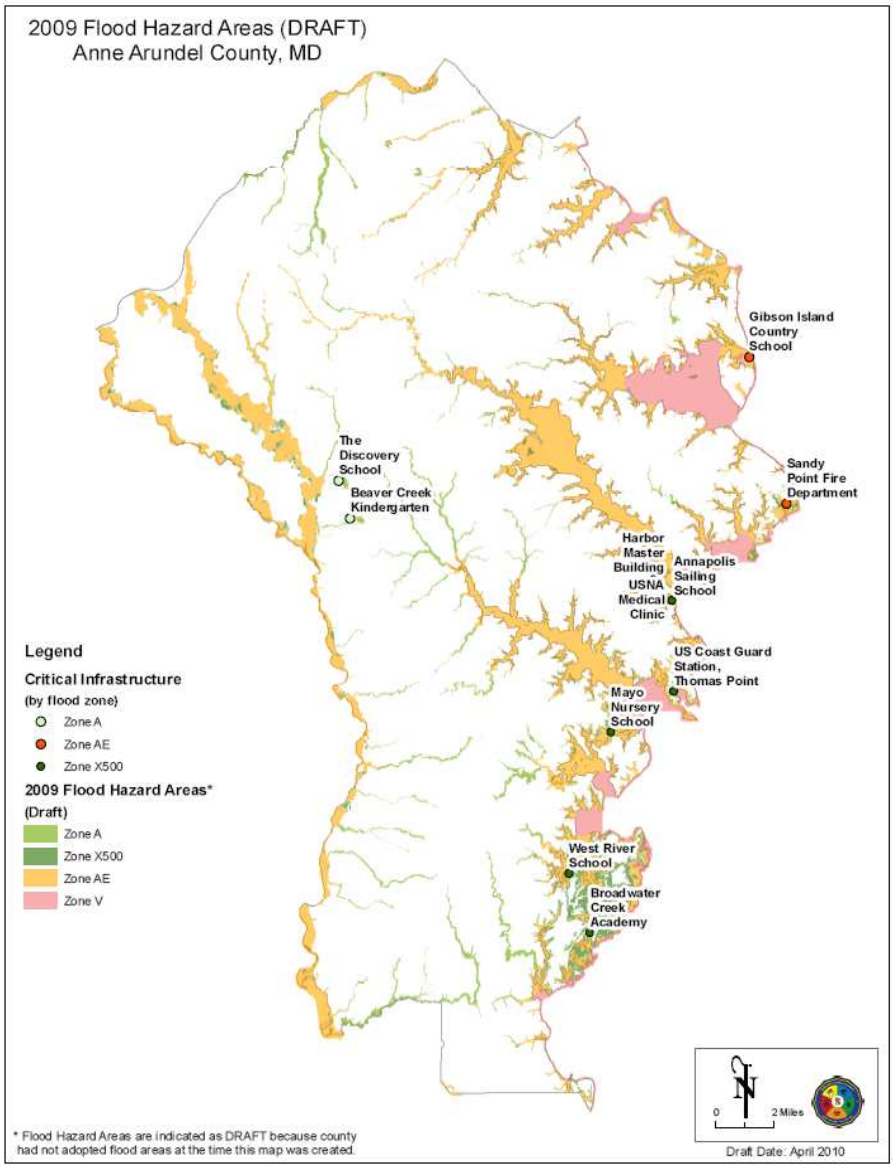
Generally speaking, critical facilities are those assets and operations that are essential to a jurisdiction maintaining functionality, especially during and after emergencies or significant natural hazard events. There is a range of facilities that can be categorized as critical, including:

- Police and fire facilities
- Emergency operations centers
- Water and wastewater treatment plants
- Shelters
- Hospitals (in particular, trauma centers)
- Communications facilities and infrastructure

- Key infrastructure, such as bridges and roads
- Lifelines, in particular utility lines (water, electricity, gas)

Figure 7.3.1-2 identifies the Anne Arundel County critical facilities that are located within flood hazard areas. The map indicates that a total of eleven facilities are located in the floodplain.

Figure 7.3-2
Anne Arundel County – Critical Facilities Located Within Flood Hazard Areas
(Source: Anne Arundel County)



The eleven critical facilities include seven schools, one fire station, one medical building, one coast guard station and a harbor master building. Although this information suggests that these facilities may be at risk, flood risk is partly a function of elevation, which is not a component of maps such as these. A more thorough risk assessment of an individual facility would require a finished floor elevation, detailed loss history, and additional engineering or hydrologic information. As part of the 2010 Plan update, members of the planning team interviewed staff and management from numerous County departments (including risk management, which deals with insurance claims), in part to determine if any County-owned or operated facilities have experienced damage from natural hazards. Except as noted in the FEMA PW table below, the County has very little history of losses related to the impacts of natural hazards.

Although the County owns and operates many facilities, there is no indication of any significant damages from natural hazards in recent memory, with the exception of those related to Hurricane Isabel. The table below shows FEMA Public Assistance Program Project Worksheet data from six recent Presidentially-declared disasters. The most severe event was Hurricane Isabel in September 2003. The data suggest that the County is not at especially high risk from even relatively significant events such as Isabel. The County received disaster declarations related to the multiple snow storms of 2009 and 2010, but the Project Worksheet data was not available by the time the HMP update was completed.

Table 7.3-9
Anne Arundel County – Declared Disaster Summary 1994 – 2009
(Source: FEMA Public Assistance)

Disaster Number	Declaration Date	Event Type	Disaster Description	PW Amount
DR-1016	3/16/1994	Ice Storm	Ice Storms of 1994	$827,001
DR-1081	1/11/1996	Heavy Snow	Blizzard of 1996 - January 11, 1996	$574,452
DR-1303	10/18/1999	Hurricane	Hurricane Floyd	$337,817
EM-1324	4/10/2000	Heavy Snow	Severe Winter Storm of 2000	$397,781
EM-3179	3/14/2003	Heavy Snow	February 14-17, 2003 "Presidents' Day Snowstorm"	$742,866
DR-1492	9/19/2003	Hurricane	Hurricane Isabel	$4,890,342
Total				**$7,770,261**

7.3.2 Hurricane Wind Risk in Anne Arundel County

This subsection describes the hurricane wind risk for Anne Arundel County. Wind is obviously a significant component of the risks presented by hurricanes, and this section of the updated Plan describes the potential future losses (risk) from this hazard. The calculations are done using the FEMA Full Data Hurricane Wind Benefit-Cost Analysis (BCA) module. Data about various asset classes were extracted from the FEMA HAZUS database version MR-4 in spring, 2010. The sections below describe the methodologies and results.

The first step in the risk assessment process is to determine wind profiles for Anne Arundel County, using the FEMA wind hazard and damage function database (BCA Toolkit). The figures in these tables are estimates based on best available data. Information sources are provided in the notes below the table headings, where applicable. Figure 7.3.2-1 shows the wind hazard profile for the County, from the FEMA wind hazard and damage function database (BC Analysis Toolkit). Within the database, the zip code 21114 for Crofton, Maryland was entered to identify the wind speeds for each of the recurrence intervals. The Crofton zip code was selected due to its central location within the County. The recurrence interval-wind speed pairs are used in the FEMA BCA module to calculate wind risk to County Assets. The speed and probability data in the Figure below was extracted from the FEMA wind hazard database included on Version 3.0 of the BCA Toolkit.

Figure 7.3-3
Anne Arundel County Wind Hazard Profiles
(Source: FEMA wind hazard database (BCA Toolkit))

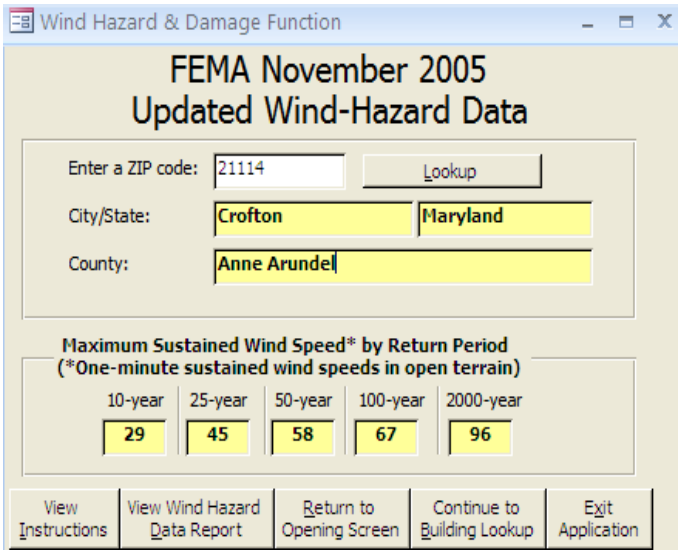


Table 7.3-10
Hurricane Wind Probabilities in Anne Arundel County
(Source: FEMA Full-Data Hurricane Wind BCA module)

WIND HAZARD DATA			
Recurrence Interval (years)	Wind Speed (mph)		
	Coast	Project Site	125 mi. Inland
10	29	29	29
25	45	45	45
50	58	58	58
100	67	67	67
2000	96	96	96

The wind risk assessments for Anne Arundel County were conducted using the FEMA Hurricane Wind BCA software and the FEMA wind database on the BCA Toolkit Version 3.0. All figures are based on a 100-year time horizon and a 7% discount rate to determine the net present value of the risk, as required by OMB Circular No. A-94. Table 7.3.2-3 shows the expected annual number of hurricane wind storms in Anne Arundel County, by storm class.

Table 7.3-11
Expected Annual Number of Wind Storms by Class, Anne Arundel County
(Source: FEMA Full-Data Hurricane Wind BCA module)

EXPECTED ANNUAL NUMBER OF WIND STORMS			
Storm Class	Wind Speed (mph)	Default Estimate	User Estimate
0	60-73	1.262E-02	
1	74-95	3.870E-03	
2	96-110	3.508E-04	
3	111-130	1.117E-04	
4	131-155	2.829E-05	
5	>155	9.246E-06	

7.3.2.2 Estimated Hurricane Wind Risk to Public and Private Assets

Damage functions for all structure types are verbatim from the FEMA software; the FEMA/HAZUS structure and roof types used in the analysis are noted in Table 7.3.2-4. Note that these assumptions are intended only to provide a general estimate of potential wind risk. Specific mitigation projects will require more detailed engineering assessments. The major roadways, transportation, communications and utilities classes were not assessed as part of this Plan because most of these are unique and require detailed engineering studies to be accurate.

Table 7.3-12
Abbreviations for HAZUS Structure Types
(Source: HAZUS)

HAZUS Structure Type	Roof Type	Abbreviation
Wood framed non-engineered gable	Gable	WMUH1 #1
Steel frame engineered commercial	Flat	SECBL #28
Masonry Industrial – RM	Flat	MLRI #25
Pre-Engineered Metal Building	Flat	SPMBL #42
Masonry non-engineered reinforced gable	Gable	MERBL #13
Concrete engineered commercial	Flat	CECBL #35
Masonry non-engineering reinforced hip	Hip	MERBL #14

As mentioned at the beginning of this subsection, a query from HAZUS version MR4 in the spring of 2010 was used as the basis for total area of structures by use category in the county. The associated HAZUS building types are estimated, and shown in the second column – the building types are used by the software to establish the correct wind damage functions.

Table 7.3-13
Anne Arundel County: Square Footage and Value for Predominant Asset Classes (in thousands)
(Source: HAZUS version MR4 Spring 2010)

Land Use Category	HAZUS Building Type	Total Square Footage
Agriculture	SPMBL #42	1,334
Commercial	SECBL #28	63,954
Education	MERBL #13	3,919
Government	CECBL #35	2,595
Industrial	MLRI #25	34,565
Religious	MERBL #14	4,013
Residential	WMUH1 #1	302,876
Total	**-------**	**413,256**

The online RS Means Quickcost Estimator was used to estimate the dollar per square foot cost for each land use category. The ZIP code 21114 for Crofton, Maryland was again used because of its central location in the County. For each asset, estimates were made about the average building square footage and a typical facility type for each land use category. Table 7.3.2-6 summarizes the assumptions and results for each land use category, with the exception of the residential category which was estimated at $125 per square foot.

Table 7.3-14
Anne Arundel County: Predominant Asset Classes
Assumptions and Results of RS Means Quickcost Estimator
(Source: RS Means Quickcost Estimator)

Land Use Category	Average Building SF	Building Type	$ per s.f. Cost	Basis Construction Type	Construction Cost
Agriculture	25,000	Warehouse (Representing Barn/storage)	$92	Tilt-up Concrete Panels/Steel Frame	$2,292,394
Commercial	35,000	Office 2-4 Story	$152	Face Brick with Concrete Block Back Up/ Wood Joist	$5,333,966
Education	50,000	Jr. High School, 2-3 story	$169	Face Brick with Concrete Block Back Up/ Steel Frame	$8,434,920
Government	30,000	Police Station	$167	Limestone with Concrete Block Backup	$5,022,803
Industrial	75,000	Factory (3 Story)	$121	Face Brick, Common Brick backup / Steel Frame	$9,091,659
Religious	5,000	Church	$204	Decorative Concrete Block / Wood Arch	$1,017,813

The output from the Quickcost Estimator includes construction low, medium, and high cost ranges. The medium construction cost was used in the present analysis. Wind risk for Anne Arundel County assets is then calculated using the FEMA Full-Data Hurricane Wind BCA module and the wind damage functions in the FEMA wind hazard database (BCA Toolkit). The assessment uses a 100-year time horizon. Data parameters used in the Wind BCA Module as part of the risk assessment are described in Table 7.3.2-7.

Table 7.3-15
Data Parameters Entered into BC Module for each Asset Class

Data Field	Values per Category
Rental Cost of Temporary Building Space	▪ Government: $1 per SF/Month ▪ Agriculture: $1 per SF/Month ▪ Education: $1 per SF/Month ▪ Commercial: $1 per SF/Month ▪ Industrial: $2 per SF/Month ▪ Religious: $1 per SF/Month ▪ Residential: $1 per SF/Month
One Time Displacement cost	▪ Government: Equal to Building SF ▪ Agriculture: Equal to Building SF ▪ Education: Twice the building SF ▪ Commercial: Equal to Building SF ▪ Industrial: Twice the building SF ▪ Religious: Equal to Building SF ▪ Residential: Equal to Building SF

Data Field	Values per Category
Annual Budget	▪ Education: $150 per SF ▪ Government: $200 per SF ▪ Remaining Categories: $0
Estimated Net Income of Commercial Business	▪ Commercial: $100 per SF ▪ Industrial: $200 per SF ▪ Agriculture: $25 per SF ▪ Remaining Categories: $0

The data parameters described above are then used in the FEMA Hurricane Wind BCA module to calculate hurricane wind risk for Anne Arundel County. Tables 7.3.2-8 and 7.3.2-9 summarize the results of the analysis. The last column *100-year Wind Risk* indicates the estimated cumulative wind damages over a 100-year planning horizon, using the mandated 7% discount rate for net present value.

In Table 7.3.2-8, the data is sorted by 100-year risk. This table shows the wind risk by building category and the total wind risk for Anne Arundel County assets from hurricanes. Although these figures seem relatively high, it should be noted that this hazard (hurricane wind) affects all the assets in Anne Arundel County about equally, whereas flooding generally affects only those assets or operations that are close to flood sources. The last column *100-year Wind Risk* indicates the cumulative expected wind damages over a 100-year planning horizon, using the mandated 7% discount rate for net present value. This table shows that the residential category has the highest 100-year risk. Table 7.3.2-9 sorts the data by risk per square foot. When sorted by risk per square foot, the government and commercial categories move to the top of the list.

Table 7.3-16
Estimated Hurricane Wind Risk to Anne Arundel County Assets, ordered by 100-year Risk
(Sources: HAZUS Query, Fall 2007, FEMA Hurricane Wind BCA Module)

Land Use Category	HAZUS Structure Type	Total SF	Risk per SF	Annual Building Damages	Annual Content Damages	Annual Displacement Costs	Business Income Lost	Annual Public Services Lost	Total Annual Damages	100-yr Risk
Agriculture	SPMBL #42	1,334	$0.40	$20,689	$5,802	$10,514	$0	$264	$37,269	$531,801
Commercial	SECBL #28	63,954	$1.58	$3,106,798	$2,365,784	$1,237,361	$327,515	$34,370	$7,071,828	$100,909,701
Education	MERBL #13	3,919	$1.70	$143,723	$104,795	$173,139	$42,585	$1,779	$466,021	$6,649,777
Government	CECBL #35	2,595	$0.71	$53,180	$37,723	$29,387	$0	$9,420	$129,711	$1,850,849
Industrial	MLRI #25	34,565	$1.88	$1,913,483	$1,562,473	$688,889	$0	$381,089	$4,545,934	$64,867,197
Religious	MERBL #14	4,013	$0.51	$75,865	$39,610	$26,376	$0	$975	$142,826	$2,038,046
Residential	WMUH1 #1	302,876	$0.81	$7,954,295	$5,327,938	$3,445,590	$374,409	$95,148	$17,197,380	$245,398,087
Total	**-----**	**413,256**		**$13,268,034**	**$9,444,126**	**$5,611,256**	**$744,509**	**$523,045**	**$29,590,970**	**$422,245,458**

Table 7.3-17
Estimated Hurricane Wind Risk to Anne Arundel County Assets, ordered by Risk per Square Foot
(Sources: HAZUS Query, Spring 2010, FEMA Hurricane Wind BCA Module)

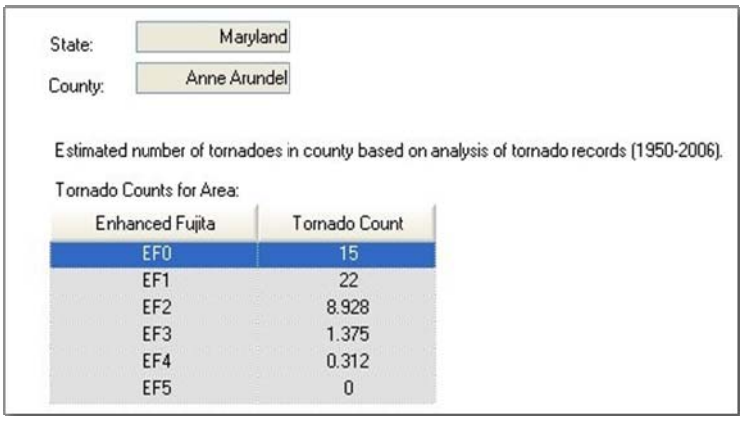
Land Use Category	HAZUS Structure Type	Total SF	Risk per SF	Annual Building Damages	Annual Content Damages	Annual Displacement Costs	Business Income Lost	Annual Public Services Lost	Total Annual Damages	100-yr Risk
Agriculture	SPMBL #42	1,334,000	$0.40	$20,689	$5,802	$10,514	$0	$264	$37,269	$531,801
Religious	MERBL #14	4,013,000	$0.51	$194,946	$148,449	$77,642	$20,551	$2,157	$443,745	$6,331,905
Government	CECBL #35	2,595,000	$0.71	$95,168	$69,391	$114,646	$28,198	$1,178	$308,580	$4,403,208
Residential	WMUH1 #1	302,876,000	$0.81	$6,206,959	$4,402,871	$3,429,898	$0	$1,099,493	$15,139,221	$216,022,238
Commercial	SECBL #28	63,954	$1.58	$3,540,428	$2,890,971	$1,274,619	$0	$705,111	$8,411,129	$120,020,735
Religious	MERBL #14	3,919,000	$1.70	$74,088	$38,682	$25,758	$0	$952	$139,481	$1,990,308
Industrial	MLRI #25	34,565,000	$1.88	$907,765	$608,038	$393,220	$42,728	$10,859	$1,962,610	$28,005,470
Total	**-----**	**413,256**		**13,268,034**	**$9,444,126**	**$5,611,256**	**$744,509**	**$523,045**	**$29,590,970**	**$422,245,458**

In this case, the risk per square foot metric may be the most effective way to prioritize decisions about where to focus additional resources and efforts, both in terms of further risk studies and in developing site-specific mitigation measures to reduce the risk.

7.3.3 Tornado Risk in Anne Arundel County

Although tornado risk is small in Anne Arundel County relative to other parts of the nation, there is nevertheless enough exposure to the hazard to make it worthwhile to perform a simple risk assessment to characterize potential future losses. The calculation is done using FEMA's Benefit-Cost Analysis Tool (BCAT), Version 4.5.5. Figure Tornado Benefit-Cost Analysis, and some relatively simple methods to estimate the total exposure of assets in the County. The first figure shows the expected number of tornadoes in the County, based on an analysis of tornado records from 1950 to 2006.

Figure 7.3-4
Number of Tornadoes in Sample Area for Anne Arundel County
(Source: FEMA BCAT software, version 4.5.5)


State: Maryland
County: Anne Arundel

Estimated number of tornadoes in county based on analysis of tornado records (1950-2006).

Tornado Counts for Area:

Enhanced Fujita	Tornado Count
EF0	15
EF1	22
EF2	8.928
EF3	1.375
EF4	0.312
EF5	0

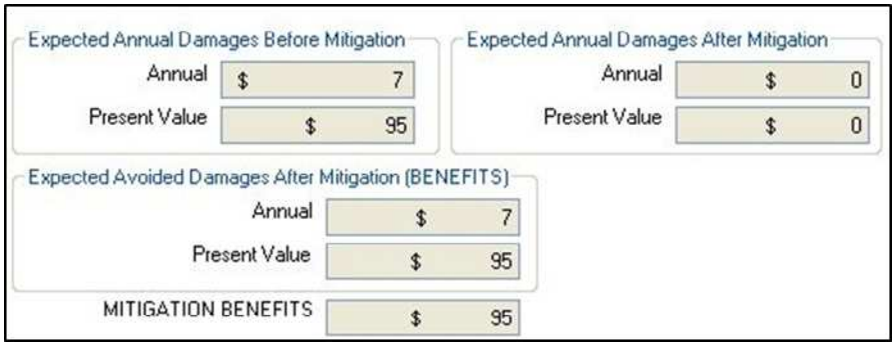
The FEMA tornado BCA analysis methodology and software are based on avoided injuries and fatalities. As a result, it is not necessary to separate public assets from private ones in order to estimate potential future losses (risk) – the calculation is based on the population at risk, rather than the square footage or value of buildings or functions.

The FEMA BCA module requires analysts to specify building dimensions in order to determine the probability of a tornado impacting a site. Although (as noted), it is not important to differentiate between residential and public/commercial assets in the present analysis, the total size of the residential "footprint" in the County is used to calibrate the analysis. The U.S. Census-estimated population of the County is also used in the risk calculation.

To calculate tornado risk, the analysis uses the 2008 U.S. census count of 204,199 residential structures in Anne Arundel County, and assumes that each structure comprises approximately 2,000 square feet. Using this estimated square footage for each structure, the total square footage for the County is 408,398,000. The square root of this figure is then used in the software to calculate the probability of tornado impacting residential structures (this is a valid proxy for the total risk because individual structures are uniformly exposed to the risk in the County).

The software then uses inputs related to building occupancy by time of day to calculate the expected loss of life and number of injuries for tornado classes F0 to F5. Figure 7.3.3-1 shows the expected annual benefits (risk), and benefits over a 100-year planning horizon. The figures in this table represent the expected annual losses due to tornadoes for a single residential structure in the County. The very low $7 figure simply expresses the fact that this area of the U.S. is not prone to tornadoes. The cell labeled "Present Value" shows the expected losses over a 100-year planning horizon – the figure is discounted using the mandatory 7% discount rate.

Figure 7.3-5
Tornado Risk in Anne Arundel County
(Source: FEMA Tornado Benefit-Cost Analysis module)



In order to assess the overall risk to residential properties in the County, these figures are simply multiplied by the number of housing units in the County (204,199) to yield annual expected losses of $1,429,393, and losses over a 100-year planning horizon of $19,398,905, again, discounted to present value. It should be recognized that although expected losses on a structure basis are very small, the cumulative amount of risk in the County (as above) may be sufficient to suggest County-wide mitigation measures would be cost-effective, though probably not sufficient to justify large or expensive projects.

7.3.4 Severe Winter Storm Risk in Anne Arundel County

This subsection describes the severe winter storm risk in Anne Arundel County. The National Oceanic Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC) and FEMA Public Assistance (Project Worksheet) records were used to identify past events and the impacts on life and property in the County. The NCDC database lists 68 winter storm/snow/ice events from 1993 to 2009 for Anne Arundel County. The database does not indicate why the recorded events do not extend back to 1950. However, the amount of data that is presently on the site is sufficient for a basic risk assessment for Anne Arundel County. Table 7.3.4-1 shows the basic data required for the assessment.

Table 7.3-18
Data Parameters for Anne Arundel County Winter Storm Risk Assessment;
Data from the NOAA/NCDC Database (1993-2009)
(Source: FEMA – Project Worksheet records, NOAA/NCDC)

Data	Value
Winter storm events	68
Average annual number of winter storm events	4.25
Total reported damages	$8,730,000
Annual damages	$545,625
Total damages – Public Assets (PW records)	$2,542,101
Annual damages – Public Assets	$158,881
Reported deaths	4
Annual deaths	.25
Value of single death (FEMA, approximately 1998 value)	$3,000,000
Estimated annual cost of deaths from winter storms	$750,000
Reported injuries	16
Annual injuries	1
Value of single injury (FEMA, approximately 1998 value)	$20,000
Estimated annual cost of injuries from winter storms	$20,000

After determining the annual figures for damages, deaths and injuries for the County, the risk assessment comprises a simple projection of future expected damages based on a standard present value coefficient of 14.27. This represents a 100-year time horizon and a 7% discount rate (the latter required by OMB). Review of the winter storm events in the NCDC indicate that the majority of the infrastructure damages (estimates from project worksheets) have not been included the total estimated property damage. Therefore these figures have been combined to calculate the winter storm risk presented below in Table 7.3.4-2.

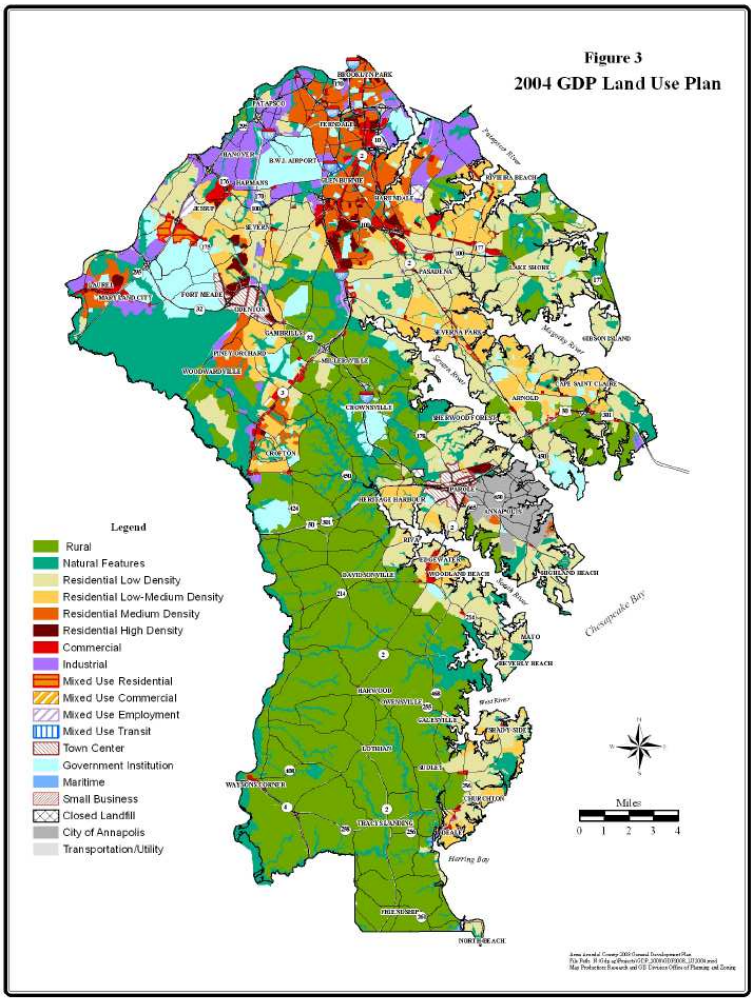
Table 7.3-19
Estimate of Risk (100-year horizon) to Anne Arundel County from Winter Storms
(Source: NOAA/NCDC)

Data	Value
Annual damages to Anne Arundel County	$704,506
Projected 100-year risk from direct winter storm damages	$10,053,300
Estimated Annual cost of deaths	$750,000
Projected 100-year risk from winter storm-related deaths	$10,702,500
Estimated annual cost of injuries	$20,000
Projected 100-year risk from winter storm-related injuries	$285,400
Estimated total risk from winter storms (100-year horizon)	**$21,041,200**

7.4 Future Development Trends in Anne Arundel County

To identify future development trends in Anne Arundel County, the *2009 General Development Plan (GDP)* was reviewed as part of the Plan Update. The report provides a comprehensive overview of residential and commercial development in the County. Figure 7.4.1 displays the 2004 land use map for Anne Arundel County. This represents the current land use zoning map for the County. See Section 3.3.6 for additional information on development trends.

Figure 7.4-1
Anne Arundel County 2004 Land Use Map
(Source: 2009 General Development Plan – Background Report on Land Use)



Residential Development

In 2008 the Anne Arundel County completed a land use analysis to estimate the remaining development capacity for the County. Figure 7.4-2 identifies the remaining residential development available within Anne Arundel County.

Table 7.4-1
Residential Development Capacity
(Source: 2009 General Development Plan – Background Report on Land Use)

Zoning Category	Potential Residential Units Available from			Total Units
	Vacant Lots	Antiquated Lots	Redevelopment	
RA	1,690	7	620	2,317
RLD	600	30	170	800
R1	2,370	100	1,720	4,190
R2	4,250	550	2,490	7,290
R5	4,230	780	4,730	9,740
R10	1,080	0	0	1,080
R15	1,440	2	0	1,442
Additional Potential Units	N/A	1,110	N/A	1,110
Totals	**15,660**	**2,579**	**9,730**	**27,979**

The 2009 GDP indicates the County has capacity for approximately 28,000 additional residential units under the current zoning. Most of this additional capacity exists in the low to medium density residential zones (R2 and R5, and to a lesser degree R1). In addition, most of the available capacity can be attributed to vacant lots, although there is a significant amount of redevelopment capacity in the residential zones, particularly in the R5 zone. Much of the development capacity in the R5 zone is located in Brooklyn Park, Glen Burnie, Pasadena, and Arnold, while much of the capacity in the R2 zone is located in Severn and Pasadena.[3] The GDP report estimates that as of 2008 there were approximately 9,000 residential units considered for future development.

The GDP also projects both population and housing units in five year increments between 2005 and 2035 for Anne Arundel County. Figure 7.4-1 below estimates population and housing statistics for the County between 2005 and 2035.

Table 7.4-2
Residential Development Capacity
(Source: 2009 General Development Plan – Background Report on Land Use)

Category	2010	2015	2020	2025	2030	2035
Population	532,539	545,964	556,105	564,925	572,828	579,137
Housing Units	202,359	210,960	218,039	224,148	229,513	234,391

Commercial Development

Review of the County's GDP, Small Area Plans, Town Center Plans, and other functional plans indicate that new growth will be targeted to five identified principal growth areas. All are located in the northern and western parts of the County with the exception of the Parole Town Center. Although a portion of the targeted

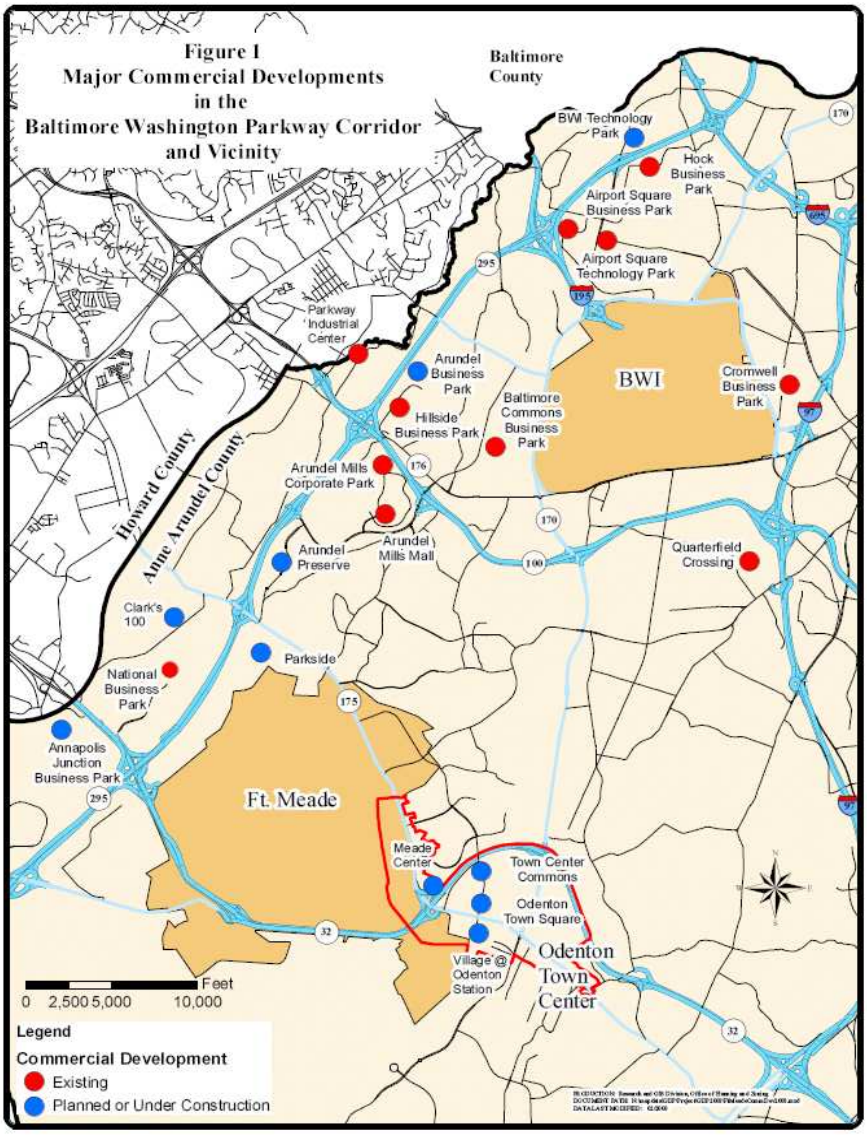
[3] 2009 Anne Arundel County General Development Plan (GDP) – Background Report on Land Use

growth focuses on residential housing (such as mixed development at Odenton Town Center), the majority of the growth is related to commercial and industrial development. The five targeted growth areas are listed below.

- **Odenton Town Center** – Significant economic efforts by the County directed toward attracting development in this area particularly due to the anticipated transfer of employees to nearby Fort Meade under the Federal Base Realignment and Closure (BRAC) initiative.
- **BWI Airport Vicinity** – Primarily Industrial or Office Technology Park uses
- Fort Meade Vicinity and the Baltimore Washington (BW) Parkway Corridor – 4,500 new households projected due to new defense positions and expansion of the National Security Agency (NSA)
- **Parole Town Center** – Most significant project in this area is the Annapolis Towne Centre at Parole. Mixed use redevelopment project that will include 675,000 square feet of retail space, 92,000 square feet of office space, and 900 residential units.
- **Commercial revitalization districts** – A total of 16 county-designated commercial revitalization areas generally located in the northern and western parts of the County.

Figure 7.4-2 identifies the location of existing and proposed major businesses and technology parks in Anne Arundel County. Over the past two decades growth has particularly occurred along the Nursery Road corridor in Linthicum and west of the Baltimore-Washington International (BWI) airport in Hanover. Additional commercial sites include the Hock Business Park, Airport Square Technology Park, Cromwell Business Park, and Baltimore Commons Business Park. Some of the significant projects under construction include the BWI Technology Park that will include nearly 600,000 SF of retail, flex and office space when completed, and the Preston Gateway Corporate Park in Hanover to include over one million SF of industrial space. Many of these office parks are occupied by defense-related contractors and support services that desire to locate near BWI Airport.

Figure 7.4-2
Major Commercial Developments in the Baltimore-Washington Corridor and Vicinity
(Source: 2009 General Development Plan- Background Report on Economic Development and Revitalization)



7.5 Summary of Risk Assessment

Table 7.5-1 shows the results of the risk assessments for floods, hurricane wind and tornadoes for Anne Arundel County.

Table 7.5-1
Summary of Anne Arundel County Flood, Hurricane Wind and Tornado Risks by Asset and Hazard Type (100-year horizon)

Asset	Hazard	Risk (100-year horizon)
Residential repetitive loss properties	Floods	$3,158,122
All land use classes	Hurricane wind (physical damage)	$422,245,458
Residential properties	Tornado wind (life safety)	$19,398,905
Infrastructure and residential properties	Severe Winter Storm	$21,041,200

As noted elsewhere, these figures must be considered with some caution because of the underlying data and assumptions that were used in the analyses. Although these summary data compare risk by the same planning horizon, it is important to recognize that, generally speaking, mitigation efforts are highly localized. Although the table shows County-wide risk, many of the hazards are difficult or impossible to mitigate on a large scale. For this reason, it is important to read and consider the detailed results in the sections above.