Section 7
Risk Assessment

The Interim Final Rule [IFR] published in the February 26, 2002 Federal Register requires risk assessments as part of a local hazard mitigation plan. This section of the plan addresses that requirement.

Contents of this Section

7.1 Interim Final Rule Requirements 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 described 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 Background

This section of the Plan describes and quantifies UM's expected future losses from two natural hazards that have the most potential to affect the campus, flooding and high winds related to hurricanes, tropical storms and tornadoes. The first part of each hazard-specific subsection is a generalized risk assessment for the entire UM campus – this is intended to provide an overall perspective of risk to the University, not an exact quantification of expected losses. The second part of the subsections is more detailed risk assessments of a subset of critical facilities that were identified through the process described earlier in Section 6. As expected, most of these facilities are not particularly at risk from natural hazards, because the University uses appropriate land development and building controls in siting and designing its facilities. Nevertheless, there are some significant risks in particular parts of the campus, and these are described in more detail in the site-specific sections that follow.

A General Definition of Risk

Risk is a quantification of future damages; it has three components:

- Value (what it costs to repair or replace something that is damaged)
- Vulnerability (the degree to which something is damaged when exposed to a hazard)
- Probability (the likelihood that a hazard will impact a particular place)

Asset values can be determined several ways, though most often this is done through subject-matter experts or open information sources such as the RS Means or Marshall & Swift guides. Vulnerability is also usually determined through several standard methodologies and information sources, but this can be complicated when the asset being evaluated is unusual and has not been studied in terms of expected damage from hazards. Probability is simply a determination of how often something is likely to happen, and by definition include measures of severity such as flood depth or wind speed. Risk is usually projected over a fairly long period of time to account for cumulative probability. As required by FEMA and Office of Management and Budget guidance, future expected damages (risks) are discounted to present value using a 7% discount rate, for all assessments in this section.

Sources of Information about Value, Vulnerability and Probability

For the purpose of this plan, the values of various assets included in the risk assessment were obtained from open sources or estimated using commonly accepted measures. Appendix F provides detailed technical notes on the assessment process.

Section 7.3 provides an overview and analysis of the University's vulnerability to hazards. In terms of natural hazards, vulnerabilities are weaknesses (further defined below) that result in damages to people, assets or operations when they are exposed to natural hazards. For example, older buildings were not designed to meet the requirements of modern building codes, so they may be at increased threat of damage when they are exposed to earthquakes or fires. Vulnerabilities are a key component of risk, which is defined as the expected future monetary losses related to hazard impacts.

7.3 Overview and Analysis of the University of Maryland's Vulnerability to Hazards

As discussed in Section 6 of this Plan (Hazard Identification), the UM College Park campus has at least some exposure to as many as ten natural hazards, but most of them have such low probability that there is little or no potential future loss from them. Section 6 described the process by which the University reduced the list of ten possible hazards to the two that create the most risk to UM's people, assets and operations. As shown in the ranking table below, these are flooding and high winds (including tornadoes and hurricane-related winds).

Table 7-1
University of Maryland Hazard Ranking Table (repeated from Section 6)

Hazard	History	Mitigation	Vulnerability	Data	Disaster	Total
Floods	3	3	3	3	3	15
Wind (hurricanes and tornadoes)	3	3	3	2	3	14
Lightning	3	2	2	2	1	10
Earthquakes	1	2	3	2	1	9
Winter Storms	2	1	2	2	2	9
Wildfires	1	1	2	2	1	7
Hail	1	1	1	1	1	5
Extreme Temperatures	2	1	1	2	2	8
Drought	1	1	1	2	2	7
Sinkholes/Subsidence	1	1	1	1	1	5

This section addresses vulnerabilities to these two predominant risks, and provides projected future losses from them, in accordance with FEMA requirements.

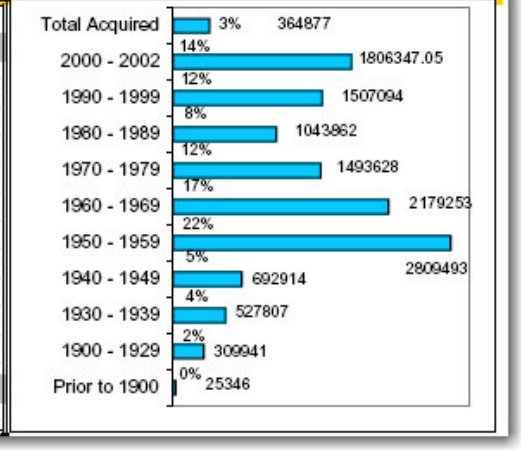
7.3.1 University of Maryland Assets

As discussed earlier in the background section of this Plan, the College Park campus of the University of Maryland is home to about 35,000 students and 3,700 staff, and a large number of physical assets of various types and ages. In many respects the University is the equivalent of a small town, with more than 250 buildings comprising more than 12 million square feet. The campus is also home to a very complex infrastructure that supports all the buildings and functions of the University. The physical assets on the campus, including the infrastructure, have a wide range of ages, some of the older ones dating back to the 1800s. The majority of these assets, however, were built from the 1960s to the 1990s. As expected, infrastructure on the campus also ranges in age quite significantly. As of 2003, the average age of facilities on the campus was 37 years. There were 12 miles of roads and 22 miles of sidewalks. Figure 7-1 below shows the gross square footages of structures on the campus, ordered by year of construction. These are 2003 statistics, so there are some minor variations between this figure and the metrics used in the risk calculation, but these have only a minor effect on the outcome.

Figure 7-1
University of Maryland, College Park Campus
Building Dates by Gross Square Footage (2003 statistic)

YEAR OF CONSTRUCTION (Main Campus)

Year of Construction	Total GSF	Percent of GSF
Prior to 1900	25,346	0.20%
1900 - 1929	309,941	2.43%
1930 - 1939	527,807	4.14%
1940 - 1949	692,914	5.43%
1950 - 1959	2,809,493	22.02%
1960 - 1969	2,179,253	17.08%
1970 - 1979	1,493,628	11.71%
1980 - 1989	1,043,862	8.18%
1990 - 1999	1,507,094	11.81%
2000 - 2002	1,806,347	14.16%
Total Acquired	364,877	2.86%
TOTAL	12,760,562	100.00%



Source: University of Maryland Facilities Management.

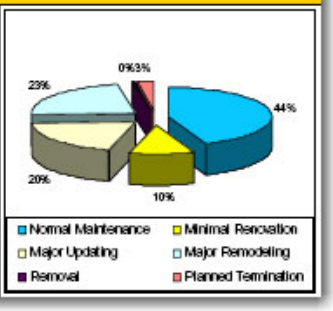
The physical assets and operations at UM are a true “system”, with many interdependent parts. Although most of these have redundancies to prevent permanent damage when hazards impact them, even short-term losses of service can have widespread and expensive impacts on people and operations.

The University periodically reviews and ranks the condition of buildings on the main campus, as shown in Figure 7-2, below.

Figure 7-2
University of Maryland College Park, Building Condition by Gross Square Footage
(2003 statistic)

BUILDING CONDITION (Main Campus)

Condition	No. of Buildings	GSF	Percent of GSF
1 - Normal Maintenance	113	5,623,767	44.07%
2 - Minimal Renovation	23	1,274,199	9.99%
3 - Major Updating	41	2,550,099	19.98%
4 - Major Remodeling	61	2,964,106	23.23%
5 - Removal	1	28,428	0.22%
6- Planned Termination	31	319,963	2.51%
TOTAL	270	12,760,562	100.00%



Source: University of Maryland Facilities Management.

In addition to these statistics, the University maintains a database of information about facilities on the campus. As shown in Table 7-2, as of 2006, the University has 262 facilities in its database, totaling slightly over 12 million gross square feet. As shown in the table below, there is a wide array of building types and functions, but the list is – not surprisingly - dominated by academic facilities, residential uses, athletic assets, and support facilities.

Table 7-2
Summary of University of Maryland (College Park) Buildings
by General and Specific Use, with Count and Gross Square Footage

General Use	Specific Use	Number	Gross SF
Academic	Academic	64	4,193,032
Academic	Communications	1	240,449
Academic	Inactive	1	1,686
Academic	Mix	1	236,229
Academic	MSquare	2	180,640
Academic	Research	11	985,817
Academic	Support	6	18,297
Administrative	Administrative	5	202,658
Auxiliary	Administrative	5	135,774
Auxiliary	Athletics	29	763,068
Auxiliary	Garage	5	1,775,741
Auxiliary	MSquare	1	53,965
Auxiliary	Residential	58	1,085,404
Auxiliary	Student Life	9	869,812
Auxiliary	Support	11	19,425
Library	Library	2	636,427
Non Academic	Admin/Public Safety	1	84,029

General Use	Specific Use	Number	Gross SF
Non Academic	Academic	2	10,655
Non Academic	Energy Plant	1	39,655
Non Academic	Fire Department	1	22,873
Non Academic	Housing	2	8,616
Non Academic	Public Safety	2	13,617
Non Academic	SCUB	4	89,584
Non Academic	Student Life	3	117,979
Non Academic	Substation	1	5,422
Non Academic	Support	33	259,743
Non Academic	Warehouse	1	34,299
Totals		**262**	**12,084,896**

Source: University of Maryland Facilities Management. Note that there are some variations in the figures for gross square footage and number of structures because of the differences in the reporting dates. This information is provided only for general information.

Utilities and Infrastructure

The UM campus is served by three regional utilities, Potomac Electric Power Company (PEPCO) Washington Gas, and the Washington Suburban Sanitary Commission. The campus also has its own power and steam generation capabilities. None of the utility infrastructure on the campus is at known risk from natural hazards.

UM has a single electric feed from PEPCO that enters the campus via the Mowatt substation on the west end of the campus. The Mowatt substation itself has no known vulnerabilities to natural hazards (see engineering appendix to this plan), but the PEPCO feed is occasionally interrupted when power lines are damaged by wind, ice or falling trees. Although this is not an insignificant problem, it occurs fairly infrequently, and UM has a good track record of adjusting to the power losses through established procedures and its own power generation capabilities. As is the case with most large electrical distribution systems, UM frequently has issues with rodents damaging electrical equipment (mostly wires and transformers), but these problems are typically localized and easily addressed. The campus also occasionally experiences power outages or interruptions because of damages to infrastructure owned and operated by PEPCO.

Natural gas is supplied to the campus by Washington Gas. UM Facilities staff indicated that gas supply infrastructure has not experienced any significant issues related to natural hazards in the past, and that there are no apparent risks from this source. Water is supplied by the Washington Suburban Sanitary Commission (WSSC). As with natural gas, there is nothing to suggest that water supplies to the campus are vulnerable to damage from natural hazards.

Generally speaking, other infrastructure on the UM campus is not especially vulnerable to the effects of natural hazards. During periods of heavy rain, roads in some very localized places on campus can accumulate water for short periods of time, but drainage is generally good, and these issues are quickly resolved. In some cases, electric and steam/condensate manholes flood for short periods of time, which occasionally requires maintenance personnel to pump out the manholes and make minor repairs to equipment such as pumps. During very cold periods when there is precipitation, some roads, walkways and

parking lots can ice over, but UM has a very good system for removing snow and ice, so there is generally very little risk from this hazard.

Selecting a Subset of UM Facilities for Detailed Assessments

During one of its early meetings, the Mitigation Core Team ranked the facilities on the UM database of 262 buildings using a variation of the FEMA "452" methodology. The 452 methodology is actually intended for evaluating terrorist threats to buildings, but the valuation part of the process is a useful tool for objectively determining the criticality of assets in a complex environment like the UM campus. The process assigns values to operations and assets based on the anticipated effects if these elements were to be lost or damaged. Appendix B includes minutes of the MCT meeting in which the process was carried out, and Appendix F has a brief description of the 452 methodology.

The results of the ranking are provided below in Table 7-3. This list was developed in order to focus the vulnerability and risk assessments on the most important facilities on the campus. Each of these facilities was assessed for vulnerabilities to flood and wind hazards, and a projection of potential future losses (the risk assessment) developed. Appendix D includes the detailed writeups about these facilities, along with basic recommendations about additional work or studies that may be required to fully assess vulnerabilities and risks.

Table 7-3
University of Maryland (College Park) Critical Facilities, Ranked by Criticality

Building Name	General Function	Key Function	Score
Chemical & Nuclear Engineering Building	Academic	Academic	10
Computer & Space Sciences Building (backup)	Academic	Communications	10
A.V. Williams Building (research, computer)	Academic	Mix	10
Energy Research Facility	Academic	Research	10
Avrum Gudelsky Veterinary Center	Academic	Research	10
Service Building (police/FM/ops)	Non Academic	Admin/Public Safety	10
Energy Plant	Non Academic	Energy Plant	10
Mowatt Lane Substation	Non Academic	Substation	10
Pocomoke Building (security operations)	Non Academic	Support	10
Environmental Service Facility	Non Academic	Support	10
Patuxent Building (telephone hub)	Auxiliary	Communications	8
Motor Transportation Facility (fuel)	Auxiliary	Support	8
Shuttle Bus Facility	Auxiliary	Support	8
College Park Fire Station	Non Academic	Fire Department	8
Marie Mount Hall	Academic	Academic	7
Biology-Psychology Building	Academic	Research	7
Biomolecular Sciences Building	Academic	Research	7
Microbiology Building	Academic	Research	7
Satellite Central Utilities Building (SCUB 1)	Non Academic	SCUB (utilities)	7
Satellite Central Utilities Building (SCUB 2)	Non Academic	SCUB (utilities)	7
Satellite Central Utilities Building (SCUB 3)	Non Academic	SCUB (utilities)	7
Satellite Central Utilities Building (SCUB 4)	Non Academic	SCUB (utilities)	7
Health Center	Non Academic	Student Life	6
Chemistry Building	Academic	Academic	5
Engineering Laboratory Building	Academic	Academic	5

Building Name	General Function	Key Function	Score
H.J. Patterson Hall	Academic	Academic	5
Institute for Physical Science & Tech	Academic	Academic	5
John S. Toll Physics Building	Academic	Academic	5
Laboratory For Physical Sciences	Academic	Academic	5
Glen L. Martin Hall	Academic	Academic	5
Jeong H. Kim Engineering Building	Academic	Research	5
Plant Sciences Building	Academic	Research	3

Facilities Known Presently at Risk

In addition to the facility ranking methodology above (which does not consider natural hazards during the ranking process), there are certain facilities and areas of the campus that UM knows are at risk from natural hazards. These include the area around the A.V. Williams building, the Security Operations Center at the Pocomoke building, and various localized sites and buildings in the area of the South Mall.

7.4 Estimate of Potential Losses (Risk Assessment)

This section describes risks to UM from natural hazards. Risks are expected future damages to students and staff, physical assets and operations from flooding, wind and lightning. There are several methods for calculating risk; the choice of methodology depends on the availability of loss and engineering information.

As noted above, risk is an expression of expected future monetary losses resulting from the impacts of natural hazards. The risk assessment process is based on several sequential steps:

1. Assign values to the assets
2. Develop damage, injury and mortality functions for the assets (quantify the vulnerabilities)
3. Determine annual probabilities and severity of natural hazard events impacting the assets
4. Calculate the annual damages from the impacts of the hazards
5. Perform a present-value calculation to bring future risks to current dollars (required by FEMA)

The risk assessment procedures used in this plan vary depending on the type, extent and reliability of data that was available. Appendix F includes detailed technical explanations of the risk assessment methodologies.

7.4.1 Insurance Records for Losses from Natural Hazards

The University is insured through the Maryland State Treasurer's Office. The State Treasurer's Office provided loss/claims records for the period 2001 through 2007. Table 7-4 summarizes the claims history. Appendix H includes a somewhat more detailed explanation of the claims. Given the size of the UM operation, the insurance loss history is not especially long (bearing in mind that this particular data set extends back only to 2001). In many instances of relatively minor damage, UM may do repairs under its own budget and forgo the insurance claim process. Although this information is not extensive, it nevertheless provides part of the overall characterization of UM's risks, especially when combined with the technical risk assessment sections below.

Table 7-4
Natural Hazard-related Insurance Claims for UM College Park Campus 2001 – 2007

Year	Amount	Damage Type	Hazard Source
2007	$31,421	Water damage to structure/contents	Wind and flooding
2006	$5,000	Power surge damaged equipment	Lightning
2006	$2,271	Water damage to structure/contents	Flooding
2006	$2,500	Power surge damaged equipment	Lightning
2005	$311,676	Water damage to structure/contents	Flooding
2005	$2,250	Water damage to structure/contents	Flooding
2004	$24,200	Roof damage	High winds
2004	$19,617	Exterior damage, non-structural	High winds
2003	$107,640	Water damage to structure/contents	Flooding/snow
2002	$2,516,402	Extensive building damage	Tornado
2002	$15,645	Structural damage, fence	Tornado
2002	$25,000	Equipment damage	Tornado
2001	$4,720	Water damage to structure/contents	Flooding

Source: Maryland State Treasurer's Office

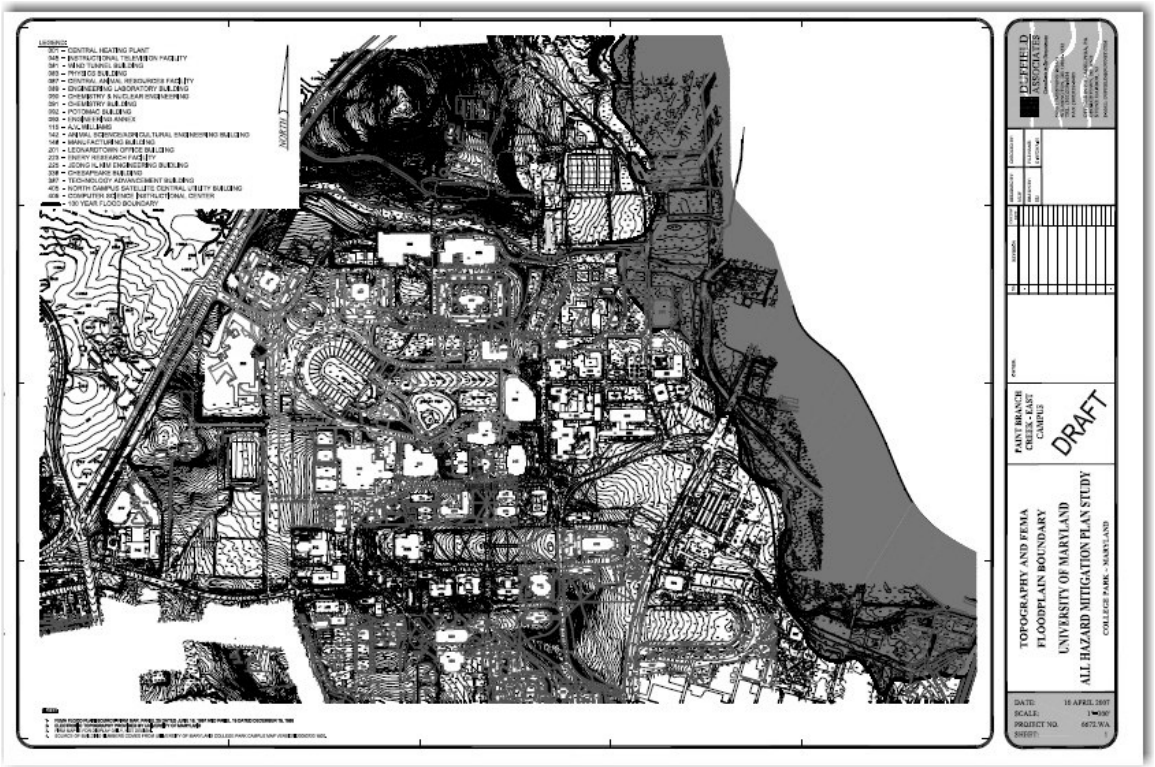
7.4.2 Flood Hazard

Generally, the flood hazard at UM is from localized overland flow, ponding, and overbank from the Paint Branch. Flood issues on the campus are generally confined to a few known areas of concern, specifically the "south mall" and the area around the corner of Campus Drive and Stadium Drive, near the A.V. Williams building, sometimes referred to as "north campus". These are discussed separately below. Note that these areas are also covered in several of the five detailed site assessments later in this section.

North Campus Flood Hazard

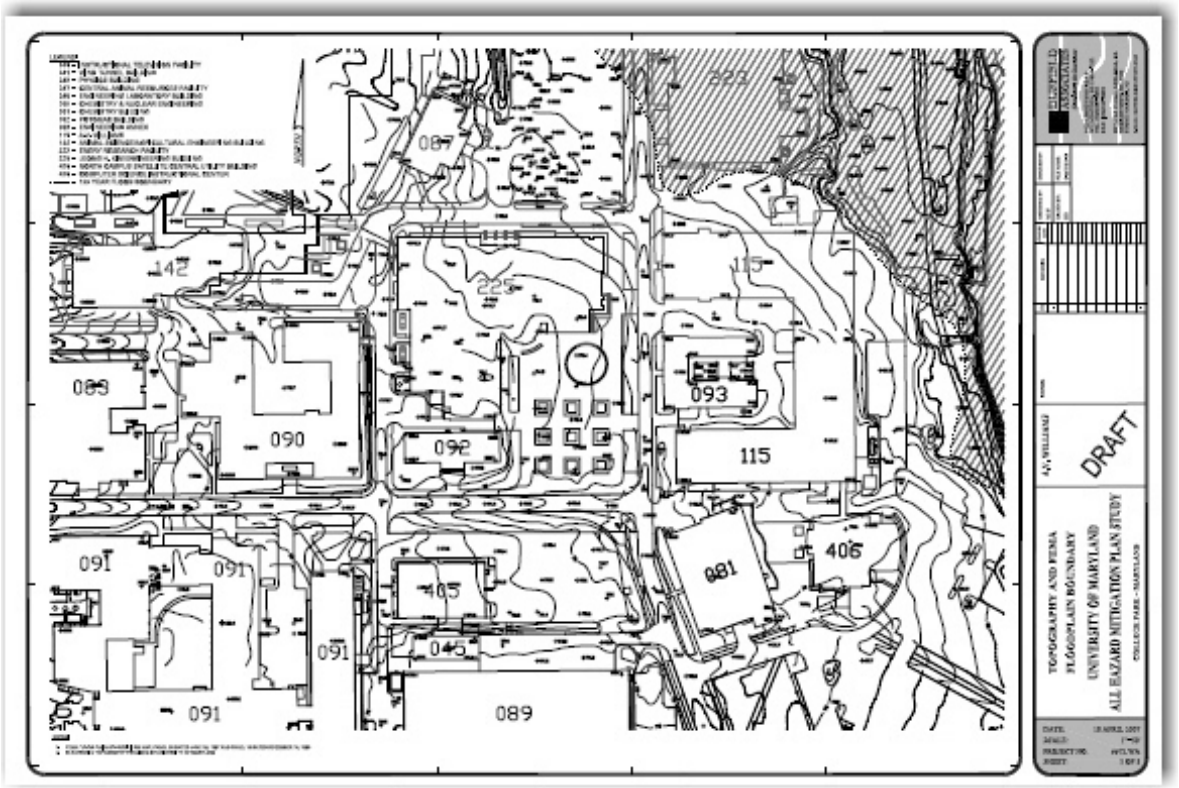
As briefly discussed in the Hazard Identification and Profiling Section, the University of Maryland site is bordered by the Paint Branch, a tributary of the Northeast Branch, which is in turn a tributary of the Anacostia River. Prince George's County (including Paint Branch) is included in a FEMA Flood Insurance Study of the area, and the Special Flood Hazard Area associated with Paint Branch is delineated on the Flood Insurance Rate Map. Figure 7-3 below provides a composite of UM topography, facilities and the FEMA-designated 100-year floodplain, which is related to Paint Branch. Appendix G includes a depiction of the Paint Branch flood hazard area and the course of Campus Creek as it crosses the campus.

Figure 7-3. Composite of UM College Park Campus. Shaded portion at the right side of the graphic is the FEMA Special Flood Hazard Area, related to the Paint Branch. Note that there is a full-page version of this graphic in Appendix G.



As shown in Figure 7-4, part of the UM campus is within the designated SFHA. The shaded areas on the upper right-hand portion of the figure show the 100-year floodplain. The topography in the area is relatively flat, with drainage from the higher parts of the campus to the west (left side of the figure), toward Paint Branch. Flood risk in the northern part of the campus is a combination of potential overbank from the Paint Branch and sheet flow across impermeable surfaces (streets, parking lots, etc.) that moves toward the Paint Branch and A.V. Williams. Overbank flooding from the Paint Branch has not historically caused significant damage to UM, although several critical facilities border the stream.

Figure 7-4
Northeast part of the UM College Park campus, shading depicting the Special Flood Hazard Area (SFHA, designated 100-year floodplain). Note that there is a full-page, higher-resolution version of this graphic in Appendix E.



Source: UM Facilities Management

In addition to these documented floodplains, the campus also has various areas where floods occur during heavy rainfall, usually associated with thunderstorms, tropical depressions, or hurricanes. Most of these events are relatively minor, and are related to ponding and overland flows when storm drainage capacity is temporarily exceeded. Although it is generally well controlled by appropriately-designed infrastructure, the continued development of the campus has sometimes resulted in more impermeable surfaces, which may exacerbate localized flooding problems. Even though the affected areas normally drain in a fairly short period of time, certain critical areas – specifically the A.V. Williams building – are subject to near-flash flooding when overland flow builds up very rapidly after rainfall. In most areas of the campus ponding and overland flow creates serious but

manageable flood problems, but A.V. Williams and certain other facilities house expensive equipment and mission-critical operations. Flood risk from the Paint Branch can be characterized as low-probability/high-consequence because of the potential for the A.V. Williams facility, which clearly could be inundated by an extreme event. As discussed in the facility-specific section of this plan, A.V. Williams houses the University's primary computer systems, and its continued function is essential to the operation of UM as a whole. The Office of Information Technology has estimated that the hourly cost of interrupted service is on the order of $150,000. As described in Appendix F, this figure is used as part of the basis for the risk calculation.

There are very few flood-related road closures or interruptions on the campus, although the intersection of Campus Drive and Stadium drive does occasionally flood because of its low elevation and the previously noted overland flow from higher points on Stadium Drive. The road closures are generally short and constitute more of a nuisance than a significant risk. UM has not calculated the amount of rainfall that results in road inundation in this area, but this situation occurs on average once or twice a year.

Figure 7-5
View east down Stadium Drive, near UM's athletic practice fields. Sheet flows down Stadium Drive toward Paint Branch contribute to flood risk at and near the A.V. Williams Building and various other facilities east of this location.

Figure 7-6
The door to the mechanical room at A.V. Williams. The mechanical room is vulnerable to flooding (note the sandbags), and equipment housed in this area of the building is essential to the continuous operation of UM's computer systems.

In some larger rainfall events, campus staff have observed minor stream bank erosion and debris in the Paint Branch, although none of these effects has been significant enough to warrant any action.

Figure 7-7
View of the Paint Branch from behind the A.V. Williams building. Overbank flooding from this source is a relatively low probability event, but the potential impacts of a significant flood would be severe if the Williams building were flooded.

South Mall Flood Hazard

Another area of the campus where flooding occurs very frequently is the "South Mall", shown in Figure 7-8. The south mall is the site of numerous relatively old buildings that are used primarily as classrooms, lecture halls and administrative/office spaces. Although these buildings do not house critical infrastructure or operations, lower spaces in the buildings experience flooding several times a year, which causes physical damages and operational disruptions. Affected buildings include Tydings Hall (building 042), Taliafero Hall (043), Skinner Hall (044), Marie Mount Hall (046), Woods Hall (047) and Francis Scott Key Hall (048). A high-resolution depiction of these facilities (including topography) is provided in Appendix E of this plan.

Figure 7-8
Central part of the UM College Park campus, depicting the "South Mall" area. Note the steep topography to the south of the four buildings at the bottom of the figure. Note that there is a full-page, higher-resolution version of this graphic in Appendix E.

Source: UM Facilities Management

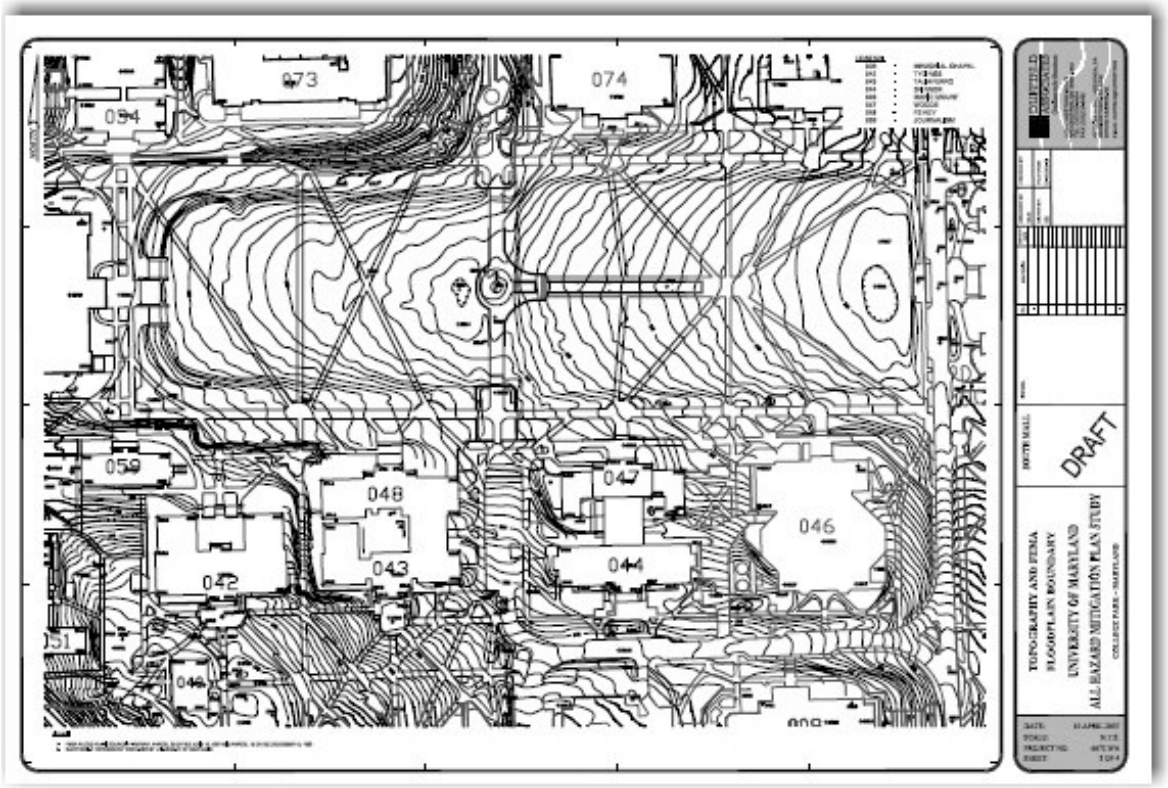


Figure 7-9
Lecture halls, classrooms and administrative offices in buildings in the South Mall area flood several times a year from overland flows due to aging and inadequate storm sewer systems.

7.4.3 Flood Risk

This subsection of the Plan provides a general estimate of flood losses campus-wide, and losses for the specific UM assets that are listed above (A.V. Williams and the South Mall). Each of the loss calculations is based on best available data, but they must be considered estimates because highly detailed engineering studies of each facility were not performed as part of this planning process. Appendix F includes more detailed explanations of the basis of these calculations. The South Mall area includes the Francis Scott Key, Taliaferro, Woods, Skinner, and Marie Mount Halls.

Table 7-5
Flood Risk for University of Maryland Assets

Asset Category	Risk	Basis of Calculation
Campus wide (general)	$57,497	Insurance records, annualized
Campus wide (general)	$821,632	Insurance records, 100-year cumulative (discounted)
Williams/north campus (annual)	$152,812	FEMA LD software, annualized
Williams/north campus	$2,180,509	FEMA LD software, 100-year cumulative (discounted)
South Mall (various sites)	$20,000	FEMA LD software, annualized
South Mall (various sites)	$285,384	FEMA LD software, 100-year cumulative (discounted)

Note that there is overlap between the general campus risk calculation and those for A.V. Williams and the South Mall, because the insurance claims on which the projection is estimated are based in part on claims for losses at those facilities. It is also important to recognize that the projected risk figure for A.V. Williams exceeds the campus-wide projection because a different methodology and assumptions were used to determine the low-probability/high-consequence scenario of a 100-year or greater flood impacting the facility. This scenario is not reflected in the claim-based calculation. The alternative methods are employed to ensure that risk is examined from multiple perspectives.

7.4.4 Hurricane Wind Hazard

This part of the risk assessment discusses wind risk to facilities, people and operations on the UM campus. The structure of this section is the same as the flood section above – first, overall wind risks to the campus are discussed and quantified, then the section addresses wind risks to a select group of critical facilities.

The first step in the risk calculation is to determine the probability of hurricanes impacting UM. The figures in these tables are estimates based on best available data. Information sources are provided in the notes below the tables, where applicable. The speed and probability data in this table is extracted from the FEMA wind database on Version 3.0 of the BCA Toolkit.

Table 7-6
Hurricane Wind Probabilities in Central Maryland

Wind Speed	Return Frequency
28	10
44	25
57	50
66	100
94	2000

This table shows the conversion from storm class to wind speed, based on ZIP code, using the FEMA wind database. For this risk assessment, a single ZIP code was used to normalize the analysis. There may be slight variations in this data based on specific locations, but the effects on the risk determination are negligible.

Table 7-7
Hurricane Storm Classes vs. Site-Specific Wind Speed

Storm Class	Wind Speed
0	60
1	74
2	96
3	111
4	131
5	155

This information is used in the FEMA Hurricane Wind BCA module, in combination with data about the building stock and UM's operating budget to calculate future wind damages (i.e. risk), as described below.

7.4.5 Hurricane Wind Risk

Campus-wide Hurricane Wind Risk

Campus-wide hurricane risk at UM was determined using the FEMA Hurricane Wind BCA Module, Version 1.1.0. This calculation is intended as a very general assessment of risk to physical assets and operations, and does not include the potential for casualties, primarily because exposed populations are generally warned far enough in advance that injuries and deaths are minimized and the future risk of injuries and fatalities negligible. The expected annual number of storms is shown in Figure 7-10. The probability calculations are performed by the FEMA software

using default calculations and a recently-developed database that provides wind speeds for hurricane categories by ZIP code.

Figure 7-10
Expected Annual Number of Hurricane-related Wind Storms at UM, College Park Campus

EXPECTED ANNUAL NUMBER OF WIND STORMS			
Storm Class	Wind Speed (mph)	Default Estimate	User Estimate
0	60-73	1.190E-02	
1	74-95	3.376E-03	
2	96-110	2.960E-04	
3	111-130	9.224E-05	
4	131-155	2.283E-05	
5	>155	7.228E-06	

Source: Updated Wind Hazard Data and Wind Damage Functions for use in
FEMA Benefit-Cost Analyses using the Hurricane Wind Full-Data Module, April 2006, Version 1.1.0.

This information is used in conjunction with basic data about the University's facilities, as shown in the table below. Appendix F includes additional discussion of the methodologies that were used to determine values of structures and contents.

Table 7-8
Basic Data Parameters used in Hurricane Wind Risk Calculation for UM

Data Parameter	Value
Gross area of buildings in square feet	13,041,803 (note 1)
Estimated value structures	$1,353,989,987
Estimated value contents	$978,135,225
Annual budget of College Park operations (2007 estimate)	$1,300,000,000

Note 1. The gross area figure is from UM Facilities Management, Spring 2007. There are slight variations in this figure in the tables in this section because of the sources from which the information is derived. The figures in the risk assessment sections are estimates, so these variations are not significant in the overall result.

Hurricane wind risk for the campus was then calculated using the FEMA Hurricane Wind Full-Data BCA module and default data for wind probabilities and damage functions from the 2006 BCA Toolkit. Table 7-9 is a summary of wind risk for the overall campus, for direct physical damage to facilities and contents, and loss of operations. The cumulative risk categories are risks for a 100-year time horizon at a 7% discount rate. Using a shorter time horizon would decrease the estimated risks.

Table 7-9
Estimated Hurricane Wind Risk to all UM College Park Facilities

Data Parameter	Value
Estimated cumulative hurricane wind risk to structures	$5,636,860
Estimated annual hurricane wind risk to structures	$395,035
Estimated cumulative hurricane wind risk to contents	$3,193,678
Estimated annual hurricane wind risk to contents	$223,815
Estimated cumulative loss of public services	$912,292
Estimated annual loss of public services	$63,934
Estimated total cumulative hurricane wind risk (100-year horizon)	**$9,742,831**
Estimated hurricane wind risk, annualized	**$682,785**

7.4.6 Tornado Hazard

As noted in the hazard profile section of this plan, Maryland has a relatively low probability of tornadoes compared to many areas in the south and central U.S. According to NOAA's National Climatic Data Center (NCDC) database (query April 2007), the State has experienced 269 tornadoes since 1950, with the large majority of them F0 and F1 class. The County level is the smallest reporting area for NCDC, and Prince George's County has experienced 14 tornadoes in the same reporting period, most of which were Fujita class F1, although there have been two F2s and one F3 in the same period. In September, 2001, an F3 tornado struck the UM campus, killing two students and causing millions in structural damages.

Figure 7-11
Damage on the UM campus from the September, 2001 tornado
(photo: astro.umd.edu)

Figure 7-12 shows the locations, classes and damages in the NCDC database for the period 1950 to 2006 in Prince George's County. There were no reported tornadoes between 1950 and 1953, and none between 2001 and 2006, so the data table does not show the full date range indicated in the title. The UM tornado is the last one in the table; its location is listed as Hyattsville. This is the same table as shown in Section 6 of this plan, and is provided here for reference.

Figure 7-12
Tornado Occurrences, Fujita Classes and Damages in Prince George's County, Maryland, 1950 – 2006
(Source: NOAA National Climatic Data Center)

14 TORNADO(s) were reported in **Prince George's County, Maryland** between **01/01/1950** and **12/31/2006**.

*Click on **Location or County** to display Details.*

Mag: Magnitude
Dth: Deaths
Inj: Injuries
PrD: Property Damage
CrD: Crop Damage

Maryland

Location or County	Date	Time	Type	Mag	Dth	Inj	PrD	CrD
1 PRINCE GEORGE'S	05/26/1953	1430	Tornado	F1	0	0	3K	0
2 PRINCE GEORGE'S	07/19/1963	1800	Tornado	F1	0	0	25K	0
3 PRINCE GEORGE'S	09/12/1971	0950	Tornado	F2	0	0	250K	0
4 PRINCE GEORGE'S	08/04/1992	1310	Tornado	F1	0	0	0K	0
5 PRINCE GEORGE'S	08/04/1992	1315	Tornado	F0	0	0	25K	0
6 PRINCE GEORGE'S	11/23/1992	0200	Tornado	F1	0	0	2.5M	0
7 Cheverly	05/18/1995	1330	Tornado	F1	0	2	2.0M	0
8 Temple Hills	10/05/1995	1959	Tornado	F2	0	3	5.0M	0
9 Andrews Afb	06/24/1996	04:23 PM	Tornado	F0	0	0	200K	0
10 Upper Marlboro	06/24/1996	04:34 PM	Tornado	F1	0	0	500K	0
11 Brandywine	05/13/2000	06:45 PM	Tornado	F1	0	0	100K	0
12 Laurel	06/21/2000	09:28 PM	Tornado	F1	0	0	150K	0
13 Brandywine	05/25/2001	03:22 PM	Tornado	F1	0	0	25K	0
14 Hyattsville	09/24/2001	04:19 PM	Tornado	F3	2	55	100.0M	0
				TOTALS:	2	60	110.778M	0

Although, as noted, tornado probability in the planning area is relatively low, there is clearly some risk from this hazard, in part because of the potential for tornadoes to occur in the future, and in part because various facilities on the campus have some vulnerabilities to high winds, as described in the sections below.

7.4.7 Tornado Risk

Tornado risk for the UM campus was calculated using the FEMA Tornado BC Analysis software, as described in Appendix F of this plan. Note that the FEMA tornado assessment software considers *only* injuries and casualties related to tornadoes, not direct physical damages to structures or contents. There is no reliable methodology for assessing potential tornado damage to physical assets, except to perform highly detailed engineering studies, something that was outside the scope and requirements of this plan. Clearly, there is potential for damage to buildings and infrastructure if they are impacted by tornado winds, but the

injuries and death calculations are used as a proxy for relative damages in this plan. Three risk calculations were completed for this hazard:

- All facilities on the campus, using building size and occupancy data from UM
- The 32 highest-value facilities, as determined by the MCT
- Key facilities with known flood or wind risks (see previous discussion)

It is worth noting that although tornado recurrence probability in any specific area (particularly small ones) is extremely low, the density of both the built environment and population significantly influences risk because of the variability of casualties and damages to physical assets. College campuses, including the University of Maryland, are typically high-density environments, and thus have an increased tornado risk (again, not related to probability). UM has five shelter facilities, including Cole Field House, the Armory building, Richie Coliseum, Comcast Center, and Stamp Student Union. The University has not identified shelter areas in specific buildings other than these facilities, and has included a mitigation action item to begin to address this issue.

Campus-wide Tornado Wind Risk

Table 7-10 shows the estimated future damages (risk) for the UM campus as a whole. Note that the FEMA software used for this calculation counts only the values of injuries and deaths, not direct damages to buildings and contents.

Table 7-10
Estimated Tornado Wind Risk to all UM College Park Facilities

Data Parameter	Value
Estimated annual tornado wind risk (injuries)	$70,359
Estimated cumulative tornado wind risk (injuries)	$1,004,017
Estimated annual tornado wind risk (fatalities)	$374,268
Estimated cumulative tornado wind risk (fatalities)	$5,340,809
Estimated annual tornado risk (injuries and fatalities)	$444,627
Estimated cumulative tornado risk (injuries and fatalities)	$6,344,826

The table below shows estimated tornado risk for the 32 most critical facilities on the UM campus, as determined by the MCT. As noted, tornado risk is calculated using the FEMA Tornado BCA software. See notes in Appendix F.

Table 7-11
Summary of Tornado Wind Risk for 32 Most Critical UM Facilities

	Tornado Risk	
Building Name	**Annual**	**100-year horizon**
Chemical & Nuclear Engineering Building	$2,292	$32,702
Computer & Space Sciences Building (backup)	$6,632	$94,632
A.V. Williams Building (research, computer)	$6,803	$97,084
Energy Research Facility	$1,683	$24,016

	Tornado Risk	
Building Name	**Annual**	**100-year horizon**
Avrum Gudelsky Veterinary Center	$1,074	$15,329
Service Building (police/FM/ops)	$215	$3,066
Energy Plant	$143	$2,044
Mowatt Lane Substation	$0	$0
Pocomoke Building (security operations)	$358	$5,110
Environmental Service Facility	$215	$3,066
Patuxent Building (telephone hub)	$859	$12,263
Motor Transportation Facility (fuel)	$143	$2,044
Shuttle Bus Facility	$143	$2,044
College Park Fire Station	$107	$1,533
Marie Mount Hall	$3,151	$44,965
Biology-Psychology Building	$6,889	$98,311
Biomolecular Sciences Building	$1,081	$15,431
Microbiology Building	$2,428	$34,644
Satellite Central Utilities Building (SCUB 1)	$36	$511
Satellite Central Utilities Building (SCUB 2)	$36	$511
Satellite Central Utilities Building (SCUB 3)	$36	$511
Satellite Central Utilities Building (SCUB 4)	$36	$511
Health Center	$1,540	$21,972
Chemistry Building	$10,742	$153,291
Engineering Laboratory Building	$2,292	$32,702
H.J. Patterson Hall	$3,223	$45,987
Institute for Physical Science & Tech	$788	$11,241
John S. Toll Physics Building	$6,374	$90,953
Laboratory For Physical Sciences	$1,432	$20,439
Glenn L. Glen L. Martin Hall	$4,368	$62,338
Jeong H. Kim Engineering Building	$4,454	$63,565
Plant Sciences Building	$5,013	$71,536
Risk Totals	$74,587	$1,064,350

Table 7-12 shows the 100-year risk for the 32 UM critical facilities, for both tornado and hurricane winds.

Table 7-12
Summary of Tornado and Hurricane Wind Risk for 32 Most Critical UM Facilities

Building Name	Tornado Risk	Hurricane Wind Risk
Chemical & Nuclear Engineering Building	$32,702	$276,763
Computer & Space Sciences Building (backup)	$94,632	$786,472
A.V. Williams Building (research, computer)	$97,084	$772,669
Energy Research Facility	$24,016	$200,045
Avrum Gudelsky Veterinary Center	$15,329	$276,158
Service Building (police/FM/ops)	$3,066	$274,846
Energy Plant	$2,044	$129,706
Mowatt Lane Substation	$0	$17,735
Pocomoke Building (security operations)	$5,110	$88,921

Building Name	Tornado Risk	Hurricane Wind Risk
Environmental Service Facility	$3,066	$27,357
Patuxent Building (telephone hub)	$12,263	$78,500
Motor Transportation Facility (fuel)	$2,044	$27,678
Shuttle Bus Facility	$2,044	$21,519
College Park Fire Station	$1,533	$74,814
Marie Mount Hall	$44,965	$374,610
Biology-Psychology Building	$98,311	$818,497
Biomolecular Sciences Building	$15,431	$122,706
Microbiology Building	$34,644	$288,770
Satellite Central Utilities Building (SCUB 1)	$511	$21,682
Satellite Central Utilities Building (SCUB 2)	$511	$39,250
Satellite Central Utilities Building (SCUB 3)	$511	$43,306
Satellite Central Utilities Building (SCUB 4)	$511	$43,335
Health Center	$21,972	$187,102
Chemistry Building	$153,291	$1,370610
Engineering Laboratory Building	$32,702	$275,317
H.J. Patterson Hall	$45,987	$389,139
Institute for Physical Science & Technology	$11,241	$93,330
John S. Toll Physics Building	$90,953	$759,305
Laboratory For Physical Sciences	$20,439	$217,511
Glen L. Martin Hall	$62,338	$519,869
Jeong H. Kim Engineering Building	$63,565	$529,537
Plant Sciences Building	$71,536	$595,769
Risk Totals (100-year horizon, discounted at 7%)	**$1,064,350**	**$9,742,831**

7.5 Summary of Flood and Wind Risk Assessments

Table 7-13 summarizes the estimates of future losses from floods and wind for the overall campus, as well as for several key sites that have known risks. As expected, a few specific areas of the campus account for a considerable amount of the risk. In the case of flooding, the A.V. Williams facility is at risk because of the criticality of the operation it houses; for the South Mall area, the risk is created by the highly recurrent nature of the hazard, which impacts one or more buildings once or twice every year. Risk to the Pocomoke Building is related to both the vulnerabilities of the facility and its critical function housing the Security Operations Center (SOC).

Table 7-13
Risk Summary for UM Campus

Hazard	Annual Risk	100-year Risk
Flood (campus-wide)	$57,497	$821,632
Tornado (campus-wide)	$444,627	$6,344,826
Hurricane Wind (campus-wide)	$682,785	$9,742,831
Flood; (A.V. Williams)	$152,812	$2,180,509
Flood; (South Mall)	$20,000	$285,384
Tornado; Pocomoke/SOC	$358	$5,110
Hurricane Wind; Pocomoke/SOC	$3,446	$49,175