University of Massachusetts Medical School

Hazard Mitigation Plan

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UMass Medical
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EXECUTIVE SUMMARY

To be completed once UMMS reviews plan.

1. INTRODUCTION

The University of Massachusetts Medical School (UMMS) has developed this Hazard Mitigation Plan for its campus with the purpose to:

1) Assist UMMS in identifying and reducing its risk from natural and human-caused hazards,
2) Identify actions that can be taken to prevent damage to property and loss of life, and
3) Prioritize funding for mitigation efforts.

This project was funded by a grant allocated by the Massachusetts Emergency Management Agency (MEMA) and Massachusetts Department of Conservation and Recreation (DCR) and funded by the Federal Emergency Management Agency (FEMA).

This Hazard Mitigation Plan is intended to build upon existing hazard mitigation planning efforts that have been completed at UMMS. This plan expands upon previous efforts to form a comprehensive approach to hazard mitigation planning.

Major activities involved in the development of this plan consisted of hazard identification and rankings, hazard event profiles, hazard vulnerability assessments and loss estimates, development of hazard mitigation goals and objectives, and formulation of hazard mitigation projects. Each step in this process involved extensive stakeholder engagement both on and off the campus. Campus representatives were selected from various departments and populations on campus to include a wide cross section of campus participation.

1.1 PLAN DESCRIPTION

Across the United States, natural and human-caused disasters have led to a multitude of hazards that have included increasing levels of deaths, injuries, property damage, and interruption of educational, research, business, and government services. The time, money, and efforts to recover from these disasters exhaust resources, diverting attention from important educational and research programs. With several Commonwealth of Massachusetts gubernatorial and presidential disaster declarations in recent history, UMMS recognized the impact of disasters on its community and concluded that proactive efforts needed to be taken to reduce the impact of natural and human-caused hazards.

Hazard mitigation is defined by FEMA as “any action taken to eliminate or reduce the long-term risk to human life and property from natural and technological hazards.” Hazard mitigation is crucial to UMMS because of the potential exposure to many types of natural and human hazards and disaster events, that could impact UMMS’s mission of advancing the health and well-being of the people of the Commonwealth and the world through pioneering advances in education, research and health care delivery. UMMS understands the need for improved information for decision-making in mitigation planning. Recognizing that the impacts and effects of most disaster events can be lessened by mitigation planning and preventative measures, the development of this plan was undertaken to identify cost effective mitigation measures, including reduction or avoidance, that can be taken to reduce or eliminate the long-term risk to human life and property from natural and human-caused hazards.

As part of this project, UMMS developed a methodology to evaluate the nature and extent of vulnerability to the effects of natural and human-caused hazards, and identified corresponding actions that could be taken to minimize future vulnerability to those hazards. This Hazard Mitigation Plan was prepared in compliance with Disaster Mitigation Act of 2000. By developing this plan, UMMS has experienced intangible benefits by bringing together its diverse stakeholders to engage in this process. Many of the stakeholders involved are those that may not typically work together on a routine or operational basis. The synergies and alignment realized as part of this planning

1.2 PLAN AUTHORITY AND PURPOSE

The decision to embark on this hazard mitigation planning effort was made via a collaborative effort led by the UMMS's Senior Director, Environmental Health & Safety/Radiation Safety. While this Hazard Mitigation Plan covers only the UMMS campus, four of the other five University of Massachusetts (UMass) campuses have a Multi-Campus Hazard Mitigation Plan and UMass Amherst has developed their own individual hazard mitigation plan.

In order to support UMMS's commitment to a comprehensive approach to hazard mitigation planning, the decision was made to incorporate both natural and human hazards as part of this plan. UMMS felt this decision was important to both look at the full range of potential hazards that could impact its campus as well as to optimize the planning effort since the process to assess both human and natural hazards is similar. While the approach to assess the natural hazards addressed in this Plan directly follows FEMA guidance, UMMS customized its approach to evaluating human hazards and in some cases, went beyond or in a more focused direction from the FEMA guidance for incorporating human hazards into this mitigation plan.

The purpose of the Hazard Mitigation Plan is to assist UMMS in reducing risk and help guide and coordinate mitigation activities for the campus. The mission of the UMMS Hazard Mitigation Plan is to reduce the UMMS loss of life, property, infrastructure and culture resources from disasters, and to assist UMMS in achieving its purpose of education, research and public service by enhancing disaster safety, resistance and resilience.

Planning for mitigation activities provides UMMS with a number of benefits including:

- Reduced vulnerability to future hazard events, specifically reduced loss of life, property, essential services, critical facilities and economic hardship;
- Reduced short-term and long-term recovery and reconstruction costs;
- Quicker resumption of operations, including education, research and business systems;
- Increased cooperation and communication within UMMS and local community partners through the planning process; and
- Increased potential for state and federal funding for mitigation and recovery projects.

The project was funded by FEMA and MEMA through its Hazard Mitigation Grant Program (HMGP). The HMGP is a federal program administered at the state level through MEMA. Both parties are required to review and approve the plan after adoption by UMMS in order to achieve the requirements of the program. The HGMP grant application was submitted by UMMS on to MEMA and subsequently approved.

The significance of this grant award is twofold. Once the Hazard Mitigation Plan is developed, it will help identify cost effective mitigation measures, including reduction or avoidance that can be taken to reduce or eliminate the long-term risk to life and property from hazards. In addition, it will allow UMMS to be eligible to receive certain types of non-emergency disaster assistance, including state and federal funding for mitigation and recovery projects. To be eligible to receive future funding, projects need to be pre-identified in the hazard mitigation plan, thus making it critical for the campus to have participation from a variety of campus stakeholders in the hazard mitigation planning team.

To support this important planning initiative UMMS decided to seek a consulting partner via a competitive bid process. UMMS issued a Request for Proposals (RFPs) to develop a Hazard Mitigation Plan for its campus. The RFP associated with this plan was dated August 16, 2012. Woodard & Curran was issued a contract dated January 1, 2013, which was re-contracted on January 2, 2014 after a project delay due to personnel changes at UMMS. Woodard & Curran's role was to support UMMS in meeting the requirements of the grant and to facilitate the planning process to ultimately receive approval from the grant administrators.

1.3 UNIVERSITY OF MASSACHUSETTS SYSTEM DESCRIPTION

UMMS is one of five campuses that comprise the University of Massachusetts (UMass). As a state supported higher education institution, UMass is an important educational/research institution and employer of the Commonwealth of Massachusetts (Commonwealth). UMass is transforming students' lives, shaping the future of the Commonwealth and addressing key state needs. The nearly 16,500 annual graduates enrich the Commonwealth, its industries, and society. The nearly 72,000 students educated each year are predominantly drawn from the region and often remain after graduation.

The UMass campuses are known for their diverse students and faculty and for their affordability in comparison with other institutions of higher education. Award-winning faculty members provide undergraduate and graduate students with research opportunities in a multitude of disciplines, with UMass scholars participating in more than $591 million in funded research in fiscal year 2013. As of Fall 2013, more than 266,000 UMass alumni live in Massachusetts, forming the foundation of the commonwealth's workforce and contributing enormously to the knowledge-based economy.

1.3.1 University of Massachusetts Medical School Overview

UMMS, also referred to as UMass Worcester, is Massachusetts' only public medical school with the main campus located in Worcester, Massachusetts (see Figure 1). UMMS has more than 1,100 graduate students in three graduate schools, they include:

- The School of Medicine,
- The Graduate School of Biomedical Sciences, and
- The Graduate School of Nursing.

UMMS provides training in medical disciplines with emphasis on practice in primary care specialties, the public sector, and in underserved areas of Massachusetts. UMMS has a number of full- and part-time faculty including:

- 331 full- and part-time faculty for basic science
- 2,522 clinical full and party time faculty
- 169 nursing faculty

Photo: University of Massachusetts Medical School, Main Building (photo from UMMS EOP 2011)

The School of Medicine is one of 14 centers in the United States to be awarded the Robert Wood Johnson Generalist Physician Initiative grant providing UMMS with $2.5 million in funding to support training in the primary care disciplines. The School of Medicine has nearly 500 MD students, more than 30 MD/PhD students, and over 3,500 alumni.

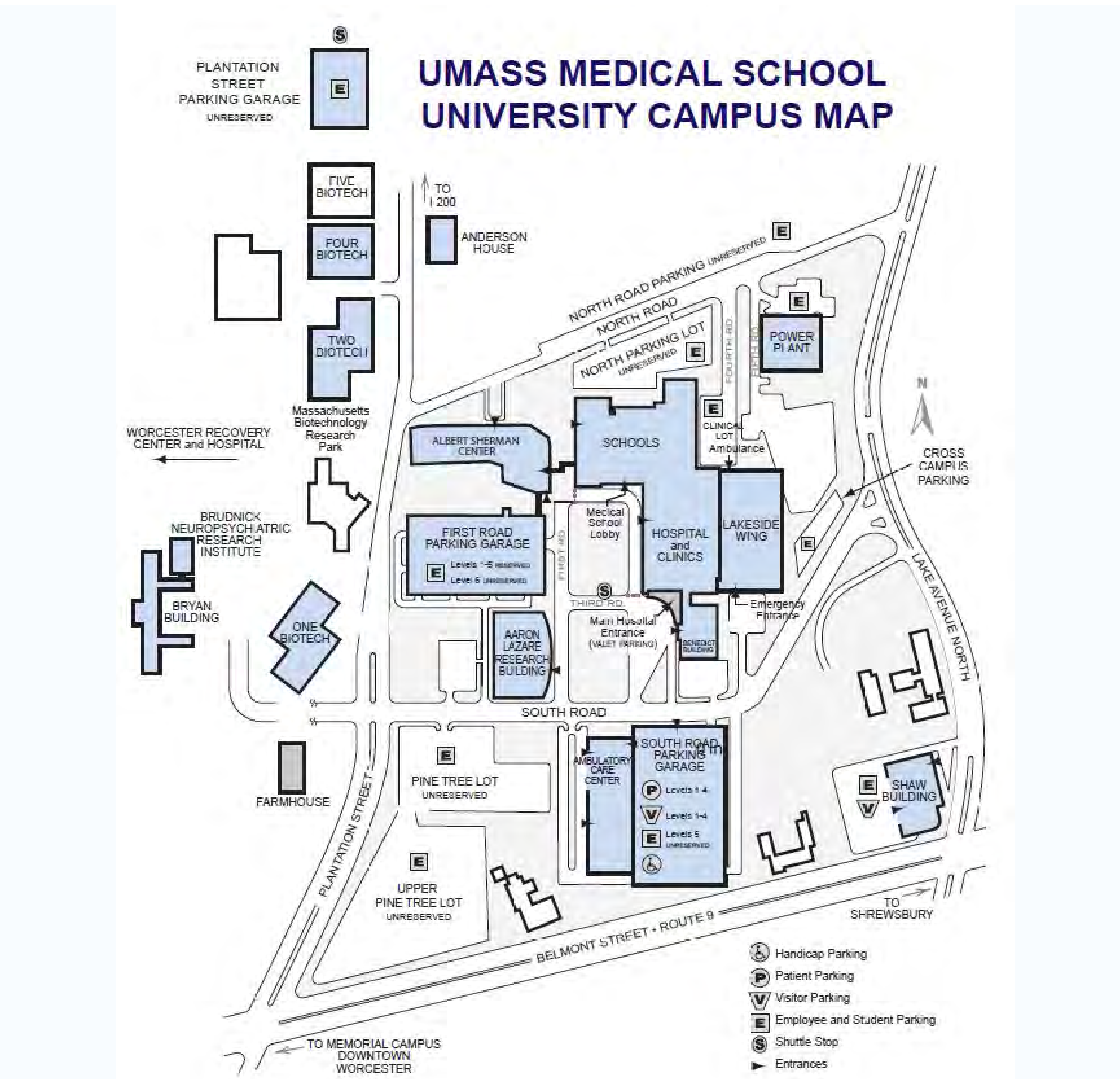
The Graduate School of Biomedical Sciences is a faculty initiated PhD program at UMMS that trains educators and scientists to conduct laboratory research on human disease issues and to serve as faculty members in institutions devoted to medical scientists. The Graduate School of Biomedical Sciences has more than 300 PhD students, over 30 MD/PhD students, 20 Clinical & Population Health Research students, nearly 10 Master of Science in Clinical Investigation students, and nearly 600 alumni.

The Graduate School of Nursing offers five nursing masters specialties (adult acute/critical care nurse practitioner, adult primary care-nurse practitioner, dual track gerontological nurse practitioner, family nurse practitioner and nurse educator) and a doctoral program in nursing. The Graduate School of Nursing has nearly 1,000 alumni, nearly 50 MS students, over 75 GEP students, nearly 30 PhD students, and over 30 DNP students.

UMMS is consistently ranked in the top ten percent of medical schools in the United States for excellence in primary care education and ranks near the top among public medical schools in the northeast United States in the amount of funding received by that National Institutes of Health. UMMS received more than $240 million in federal and private research grants and contracts in fiscal year 2013.

The UMMS extended campus includes the Brudnick Neuropsychiatric Research Institute, and labs and offices within the Massachusetts Biotechnology Research Park in Worcester; sites in Shrewsbury and Auburn; the Eunice Kennedy Shriver Center in Waltham; and the New England Newborn Screening Program and Massachusetts Biologic Laboratories in Jamaica Plain and Mattapan. These facilities are either owned or leased by UMMS.

Figure 1: UMMS Worcester Campus Map



1.3.1.1 Campus Relationship with UMass Memorial Medical Center

UMass Memorial Medical Center is the clinical partner for UMMS. Through the clinical partnership, the UMass Memorial Medical Center staff teaches UMMS students. In addition, UMass Medical Center participates in UMMS research to bring the latest diagnostic and treatment options to patients. Specific departments, referred to as Shared Services, support both UMMS and the UMass Memorial Medical Center.

UMass Memorial Medical Center is a 761-licenced bed facility on three campuses in Worcester:

- The University Campus shares a campus with UMMS and is a tertiary care referral center with 416 licensed acute-care beds specializing in bone diseases, neurology, advanced cardiovascular care, plastic surgery, dermatology, radiation therapy, cancer care. The University Campus also has a Children's Medical Center.
- The Memorial Campus is located on Belmont Street in Worcester and is an acute care facility with 345 beds. The Memorial Campus is the site of the New England Hemophilia Center, is a leading center for the treatment and care of cancer patients, and is the regional referral center for women with high-risk pregnancies.
- The Hahnemann Campus is located on Lincoln Street in Worcester and is a full-service outpatient surgery center and contains physicians' offices, laboratory facilities, x-ray facilities, a dialysis center and the Hahnemann Family Health Center.

In addition to UMass Memorial Medical Center, UMMS has teaching affiliations with:

- Saint Vincent Hospital at Worcester Medical Center
- Berkshire Medical Center in Pittsfield, Massachusetts
- Milford-Whitinsville Regional Hospital
- St. Elizabeth Hospital in Boston, Massachusetts

1.3.1.2 Campus History

UMMS was established by the Commonwealth of Massachusetts in 1962. The first students began in 1970 and started their studies in the Shaw Building, a former warehouse at the corner of Lake Avenue and Belmont Street. By 1974, the new medical science building was in use and the teaching hospital opened in 1976. In 1979, UMMS established a PhD program in the biomedical sciences, which became the Graduate School of Biomedical Sciences in 1986. The Graduate School of Nursing also opened in 1986, with the Graduate School of Nursing PhD program being initiated in 1994.

In 2001, UMMS opened a new research building and the original medical school and hospital buildings were renovated and expanded. The renovation and expansion included new meeting, educational, emergency, and surgical spaces. In 2006, Craig Mello, PhD, of UMMS, and Andrew Fire, PhD, of Stanford University, were awarded the Nobel Prize for Physiology or Medicine for their discoveries related to RNA interference.

The last decade of campus development and investment include:

- Investment in educational technology and infrastructure,
- Expansion in clinical and translational sciences including:
  - Establishment of a Clinical and Population Health PhD program (2005);
  - Creation of the Department of Quantitative Health Sciences (2009); and
  - Receipt of a National Institute of Health (NIH) Clinical and Translational Award (2010)
- Ambulatory Care Center opened in 2010,
- Albert Sherman Center opened in 2013
  - Doubled the amount of research space at the UMMS Worcester campus;
  - Supports the School of Medicine's learner-centered curriculum;
  - Home to Nobel Prize-winning research;

- o Houses the Advanced Therapeutics Cluster where knowledge from the latest biomedical discoveries is applied and new ways of treating diseases are developed and clinical trials are done to drive new therapies;
- o Includes spaces for medical education, learning communities, standardized patient program, dedicated seminar and conference space, and six floors of wet and dry laboratory space;
- o Serves as the hub for campus connecting to existing buildings.

Photo: Albert Sherman Center

1.3.1.3 City of Worcester, MA

The City of Worcester is located in the center of Massachusetts and is the second-largest city in the Commonwealth. Worcester covers a land area of 38.6 square miles and has a population of just over 181,000 according to the 2010 census. Worcester is home to nine colleges and universities, including: UMMS, Assumption College, Becker College, Worcester Polytechnic Institute, College of the Holy Cross, Clark University, Worcester State University, MCPHS University, and Tufts Cummings School of Veterinary Medicine.

Interstate 290 crosses through Worcester, with I-190 heading north from the city and I-395 heading south from the city. Bus service is provided throughout Worcester and surrounding areas by the Regional Transit Authority. Union Station, located in Worcester, serves as an inter-modal hub for rail, bus, and taxi service and also includes a parking garage and hall rentals.

The City of Worcester's Water/Sewer Operations Division is responsible for the supply, collection, and conveyance of potable water, sanitary sewage, and stormwater. The water treatment plant has a plant flow of 50 million gallons per day and the water supply system consists of ten surface water reservoirs (located in neighboring communities) with more than 590 miles of water mains. The sanitary and combined stormwater systems consists of about 750 miles of mains (150 miles of which were constructed before 1900), 28 sewage pumping stations, and a combined sewage overflow treatment facility.

Worcester's Department of Public Works & Parks owns and is responsible for the management of 28 dams. Fifteen dams are part of Worcester's water supply system and impound ponds, while the others serve cultural or recreational purposes. In 2012, four dams managed by the City of Worcester were listed in poor condition by the Auditor of the Commonwealth of Massachusetts: Patch Pond Dam, Quinsigamond Pond Dam, Green Hill Pond Dam, and Bell Pond Dam. While the four dams listed in poor condition are not in the vicinity of UMMS, several dams are located close to the UMMS main campus including:

- Bell Pond Dam
- Salisbury Pond Dam
- Bear Brook Dam
- Green Hill Pond Dam
- Green Hill Duck Pond Dam

Additional information about these dams can be found in Section 3 of this plan.

Worcester experiences precipitation approximately 35% of the days each year and averages 70 inches of snowfall and 48 inches of other precipitation annually. Climate data for the City of Worcester is included in Table 1-1.

Table 1-1: Climate Data for Worcester 1950 – May 2014

	Jan	Feb	March	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Average Temperature (°F)	23.9	25.9	33.9	45.6	56.2	64.9	70.2	68.5	60.9	50.3	40.0	28.6
Average Total Precipitation (inches)	3.63	3.30	4.15	3.99	4.02	3.97	3.87	4.23	4.11	4.39	4.33	4.06
Average Snowfall[1] (inches)	17.1	15.6	11.4	2.8	0	0	0	0	0	0.2	2.6	14.4
Source: NOAA's Climate at a Glance Data for Worcester, Massachusetts (January 1950 – May 2014) *Note 1: Average Snowfall data from NOAA Climate Data for Worcester, Massachusetts (1981 – 2010)*												

1.3.1.4 Campus Location & Environment

The UMMS main campus is located on more than 60 acres in Worcester, Massachusetts, just north of Route 9, on the west side of Lake Quinsigamond, between Plantation Street and North Lake Avenue. The physical address of the main campus is 55 North Lake Avenue, in Worcester, Massachusetts. Land uses surrounding the campus include a Department of Youth Services facility, MassHighway-Disctrict #3 office, a Massachusetts National Guard Armory to the south of the main campus and University Commons and residential areas to the north of campus. Innovation Drive and Research Drive are located to the west of campus, which contain various biotechnical companies. The main campus consists of buildings that are either owned or leased that include spaces for academics, research, laboratories, offices, patient care, and ancillary support. A list of buildings owned by UMMS on the Worcester campus, and in Shrewsbury and Mattapan can be found in Table 1-2. The buildings owned by UMMS, both on campus and at these satellite locations, were the focus of this Hazard Mitigation Plan.

Table 1-2: UMMS Building Information

Building	Location	Square Feet	Building Construction Date
ACC (Ambulatory Care Center)	55 Lake Avenue, Worcester, MA	258,271	2009
ASC (Albert Sherman Center)	368 Plantation Street, Worcester, MA	540,842	2012
Power Plant	55 North Lake Avenue, Worcester, MA	88,421	1973 / 2002 / 2012
Medical School	55 North Lake Avenue, Worcester, MA	946,923	1975
Teaching Hospital	55 North Lake Avenue, Worcester, MA	707,402	1976
Lakeside Emergency Wing	55 North Lake Avenue, Worcester, MA	296,445	2003
South Garage / Public Safety	55 Lake Avenue, Worcester, MA	485,160	2004
Benedict Building	55 North Lake Avenue, Worcester, MA	78,114	1991
BNRI	303 Belmont Street, Worcester, MA	39,171	1999
CCNI	303 Belmont Street, Worcester, MA	2,884	2002
West Parking Garage	360 Plantation Street, Worcester, MA	733,432	1985
Shaw Building	419 Belmont Street, Worcester, MA	44,700	1951
South Street Building 1	333 South Street, Shrewsbury, MA	465,780	1983
South Street Building 2	333 South Street, Shrewsbury, MA	217,001	1985
Plantation (North) Garage	383 Plantation St, Worcester, MA	437,284	2013
Aaron Lazare Research	364 Plantation Street, Worcester, MA	408,160	

Building	Location	Square Feet	Building Construction Date
Building			2001
Helipad	55 North Lake Avenue, Worcester, MA	2,471	2006
Stoddard Building	217 Maple Avenue, Shrewsbury, MA	15,162	1926
Fuller Lab	218 Maple Avenue, Shrewsbury, MA	6,422	1950
Higgins Building	219 Maple Avenue, Shrewsbury, MA	4,050	1952
Chang Building	220 Maple Avenue, Shrewsbury, MA	27,695	1954
Reed Lab (Rose & Gordon)	221 Maple Avenue, Shrewsbury, MA	31,980	1965
Hoagland-Pincus Conference Center	222 Maple Avenue, Shrewsbury, MA	28,077	1967
Machine Shop	222 Maple Avenue, Shrewsbury, MA	3,267	1963
Behavioral Barn	222 Maple Avenue, Shrewsbury, MA	8,871	1968
Marine Animal Building	222 Maple Avenue, Shrewsbury, MA	1,734	1960
Mattapan II	460 Walk Hill Road, Mattapan, MA	102,654	2009
Massachusetts Biologic Filling Facility	458 Walk Hill Street, Mattapan, MA	158,572	2005
Century Drive	100 Century Drive, Worcester, MA	81,465	1991
Biotech One	365 Plantation Street, Worcester, MA	77,201	1986
Biotech Two	373 Plantation Street, Two Bio Tech Park	88,110	1986
Biotech Three	One Innovation Drive, Worcester, MA	114,038	1991
Biotech Four	377 Plantation Street, Worcester, MA	93,526	1994
Biotech Five	381 Plantation Street, Worcester, MA	92,100	1999
Biotech 3 Parking Garage	One Innovation Drive, Worcester, MA	31,030	1991

1.3.1.5 Community Involvement

UMMS is a local, regional and statewide health and academic resource and sponsors educational and service programs in health care throughout Massachusetts. UMMS's Office of Community and Government Relations (OCRG) is a liaison between UMMS. The UMMS OCRG's mission is to:

- Strengthen relationships with public officials and community stakeholders,
- Increase visibility of the medical school,
- Increase public awareness of UMMS's contributions,
- Identify and strengthen partnerships with local community and neighborhood organizations, and
- Keep the community and public officials informed about medical school developments.

The Community Engagement Committee at UMMS promotes community engagement that is focused on service and teaching. Services are provided based on response to community-identified need. Examples of Community Engagement Committee programs include:

- UMMS Summer Service Learning Assistantship,
- Students in Service at UMass Worcester,
- UMMS Learn and Serve UMass Worcester, and
- UMMS Population Health Clerkship.

UMMS supports community programs and initiatives that advance the interests of the community and UMMS with volunteerism, in-kind services, and co-hosting community events. Community programs UMMS and its partners participate in include activities designed to enhance health and science education, ensure community health, and build a diverse workforce.

UMMS exposes youth within the community to health and science careers by providing opportunities for mentoring, job shadowing, internships, laboratory opportunities, after-school science programs, academic support, and visiting-scientist programs. In addition, UMMS provides professional development training opportunities for teachers. UMMS students volunteer their time by staffing free medical clinics, homeless shelters, and middle and high school classrooms. In addition, UMMS leads and/or participates in various studies and screenings to advance medical knowledge and improve care delivery and health outcomes.

The Lamar Soutter Library at UMMS is Massachusetts' leading source of biomedical information via inter-library loan. The Lamar Soutter Library, the only public medical library in Massachusetts, is part of the National Library of Medicine, and is the Regional Medical Library for New England.

Representatives from higher education (including UMMS personnel), UMass Hospital, community groups, community center leaders and emergency response officials, and other community members serve on the Local Emergency Planning Committee (LEPC). The LEPC's focus is to:

- Develop response plans for hazardous material incidents in Worcester;
- Review and analyze information from local facilities that use, store, or manufacture chemicals to assess Worcester's potential to risk from accidental releases;
- Provide information to the community about chemicals in the Worcester area; and
- Test the effectiveness of the Hazardous Materials Response Plan through drills and exercises.

In addition, UMMS personnel participate in UMass Memorial Medical Center's Hospital Vulnerability Assessment (HVA) planning team. The HVA team meets to conduct an annual review on the HVA plan. Additional information about this team is available in Section 2.3.

2. PLANNING PROCESS

The Hazard Mitigation Plan planning process and stakeholders involved in this effort are discussed in Section 2.1. The planning process included stakeholder engagement that involved both on and off campus participation. Opportunities for stakeholder involvement consisted of meetings, interviews, focus groups, public meetings and informal opportunities to provide feedback made available throughout the process. The stakeholders involved included a cross section of campus representation, City of Worcester officials, and also involved representatives from the affiliated UMass Memorial Medical Center.

2.1 PLANNING TEAM

The UMMS Hazard Mitigation Planning Team associated with this project was coordinated by Charleen Sotolongo, UMMS Senior Director, and Environmental Health & Safety/Radiation Safety. Ms. Sotolongo was the primary point of contact at UMMS for this Hazard Mitigation Plan.

The first step in the planning process was to establish core departments to be actively involved in the hazard mitigation planning effort to support the Senior Director, Environmental Health & Safety/Radiation Safety, provide input into the hazard assessments and overall plan, and represent a broad cross section of the campus. It was determined that the core essential campus departments to be involved in the plan consisted of representation from Facilities, Energy Resources, Environmental Health & Safety, Public Safety, Administration & Finance, Animal Medicine, and Information Technology. Representation from these departments formed the UMMS Hazard Mitigation Planning Team.

Campus representatives and outside stakeholders involved in the development of this Multi-Hazard Mitigation Plan are listed in Table 2-1. Each of the opportunities for stakeholder engagement is discussed in Section 2.3.

Table 2-1: Stakeholders Engaged in UMMS Hazard Mitigation Plan

Person	Title	Entity	Attended xxxxx xx, 2014 Steering Committee Kick-Off Meeting	Attended March 12, 2014 Campus Kick-Off Meeting	April 9 & 10, 2014 Stakeholder Interviews	Attended May 13, 2014 Public Meeting #1	Attended May 13, 2014 Hazard Identification & Risk Assessment Meeting	Attended July 24, 2014 Campus Hazard Mitigation Goals, Hazard Profiles, Loss Estimates and Projects Meeting	Attended July 24, 2014 Community Outreach Meeting	Attended July 24, 2014 Hazard Mitigation Projects Focus Group	Attended x xxxx xx, 2014 Presentation of Draft Plan Meeting	Attended xxxxx xx, 2014Public Meeting #2
Sassan Abdollahzadeh	RSO, Radiation Safety	UMMS		X			X					
Bruce Augusti	Local Coordinator, Massachusetts Emergency Management Agency	MEMA				X						
Mark Armington	Senior Director, Facility Engineering & Construction	UMMS		X	X		X	X				
John Baker	Associate Vice Chancellor, Facilities Management	UMMS			X							
Michael Baker	Registrar, Registrar's Office	UMMS		X	X		X	X				
Joyce Barrett	Senior Administrator, MAPS & QHS Academic Departments	UMMS			X		X	X				
David Bays	Associate Director, Animal Medicine	UMMS		X	X							
Steven Blair	Assistant Director of Energy Resources, Energy Resources, Power Plant	UMMS		X	X		X					
Nina Bhabhalia	Research Associate, PGFE	UMMS			X			X				
Chris Bunn	Administration Manager, Information Technology	UMMS										
Deb Burdett	Project Coordinator, Environmental Health & Safety	UMMS		X	X		X	X				

Person	Title	Entity	Attended xxxxx xx, 2014 Steering Committee Kick-Off Meeting	Attended March 12, 2014 Campus Kick-Off Meeting	April 9 & 10, 2014 Stakeholder Interviews	Attended May 13, 2014 Public Meeting #1	Attended May 13, 2014 Hazard Identification & Risk Assessment Meeting	Attended July 24, 2014 Campus Hazard Mitigation Goals, Hazard Profiles, Loss Estimates and Projects Meeting	Attended July 24, 2014 Community Outreach Meeting	Attended July 24, 2014 Hazard Mitigation Projects Focus Group	Attended x xxxx xx, 2014 Presentation of Draft Plan Meeting	Attended xxxxx xx, 2014Public Meeting #2
Deb Campbell	Safety Director, EH&S Occupational Safety & Health	UMMS			X		X	X				
Joanna Cain	Director, OFA	UMMS/UMMC			X							
Anthony Carruthers	Dean, Graduate School of Biomedical Services	UMMS			X							
Chris Clifford	Director, Information Technology / Network Engineering	UMMS		X								
Brian Coleman	Information Security Director, Information Technology / Information Security	UMMS		X	X							
Joseph Collins	Director, Energy Resources, Power Plant	UMMS			X							
Anthony Covello	Supervisor, Auxilarary Services / EBS	UMMS		X	X		X	X				
Herb Cremer	Chairperson	Commission on Disabilities, Mass.				X						
Dan Daniska	Assistant Planner, Transportation	CMRPC				X						
Deb DeMarco	Associate Dean, GSME	UMMS			X							
Colleen Driskill	Bio-Safety Director, EH&S Biosafety	UMMS			X		X	X				

Person	Title	Entity	Attended xxxxx xx, 2014 Steering Committee Kick-Off Meeting	Attended March 12, 2014 Campus Kick-Off Meeting	April 9 & 10, 2014 Stakeholder Interviews	Attended May 13, 2014 Public Meeting #1	Attended May 13, 2014 Hazard Identification & Risk Assessment Meeting	Attended July 24, 2014 Campus Hazard Mitigation Goals, Hazard Profiles, Loss Estimates and Projects Meeting	Attended July 24, 2014 Community Outreach Meeting	Attended July 24, 2014 Hazard Mitigation Projects Focus Group	Attended x xxxx xx, 2014 Presentation of Draft Plan Meeting	Attended xxxxx xx, 2014Public Meeting #2
James Fessenden	New Media Producer, Communications	UMMS		X	X		X	X				
John Finch	Deputy Director Admin. & Finance, MassBiologics	UMMS			X							
Richard Fish	Supervisor of Lab Operations, MAPS	UMMS			X		X	X				
Richard Fiske	Acting Director	LEPC				X						
Sandra Flynn	Controller, Financial Services	UMMS		X								
James Gardner	Senior Director, Facilities Management	UMMS			X		X	X				
Tom Gingras	Lieutenant	Worchester Fire Department				X						
Paulette Goeden	Assistant Vice Chancellor, Administration	UMMS		X	X							
Michael Gregory	Manager, Facilities (Off-Site Properties)	UMMS			X			X				
Judy Holewa	Administrative Director, Student Affairs	UMMS			X							
Mary House	Sr. Vice President	Woodard & Curran		X	X	X		X	X			
MaryKristin Ivanovich	Vice President	Woodard & Curran		X	X		X	X	X			
Robert Jenal	Executive Vice Chancellor,	UMMS			X							

Person	Title	Entity	Attended xxxxx xx, 2014 Steering Committee Kick-Off Meeting	Attended March 12, 2014 Campus Kick-Off Meeting	April 9 & 10, 2014 Stakeholder Interviews	Attended May 13, 2014 Public Meeting #1	Attended May 13, 2014 Hazard Identification & Risk Assessment Meeting	Attended July 24, 2014 Campus Hazard Mitigation Goals, Hazard Profiles, Loss Estimates and Projects Meeting	Attended July 24, 2014 Community Outreach Meeting	Attended July 24, 2014 Hazard Mitigation Projects Focus Group	Attended x xxxx xx, 2014 Presentation of Draft Plan Meeting	Attended xxxxx xx, 2014Public Meeting #2
	Administration & Finance											
Chris Johnson	Senior Systems Admin. Engineer, Information Technology	UMMS			X							
Patricia Keith	Admin, PGFE	UMMS					X	X				
Meghan Kellaher	Emergency Prep Spec	LEPC				X						
Will Kempskie	N/A	Saint Gobain Performance Plastics				X						
Michael Kneeland	Educational Affairs	UMMS			X			X				
Marcelino LaBella	Director, Human Resources, Labor Relations	UMMS		X	X							
Jim Leary	Vice Chancellor, Community Relations	UMMS			X							
Kenneth Lebetkin	Manager, Environmental Health & Safety	UMMS		X	X		X	X				
Marilyn Leeds	Administrative Director, GSME	UMMS			X			X				
Will Lenox	Intern, EH&S	UMMS				X	X					
Joe Lenox	EH&S	UMMS					X	X	X			
Karen Logan	Building Manager, Facilities, ASC	UMMS		X	X		X	X				
Melissa Lucas	Manager, Sustainability & Energy	UMMS			X		X					

Person	Title	Entity	Attended xxxxx xx, 2014 Steering Committee Kick-Off Meeting	Attended March 12, 2014 Campus Kick-Off Meeting	April 9 & 10, 2014 Stakeholder Interviews	Attended May 13, 2014 Public Meeting #1	Attended May 13, 2014 Hazard Identification & Risk Assessment Meeting	Attended July 24, 2014 Campus Hazard Mitigation Goals, Hazard Profiles, Loss Estimates and Projects Meeting	Attended July 24, 2014 Community Outreach Meeting	Attended July 24, 2014 Hazard Mitigation Projects Focus Group	Attended x xxxx xx, 2014 Presentation of Draft Plan Meeting	Attended xxxxx xx, 2014Public Meeting #2
John (Jack) Luippold	Chief, Public Safety	UMMS		X				X				
Mary-Elise Manuell	Title?, Emergency Medicine	UMass Memorial						X				
Edward Manzello	ACIO, Telecommunications	UMMS		X	X							
Russell Mattson	Director, Environmental Health & Safety	UMMS		X	X		X	X				
Sandy Mawdsley	Assistant Director	LEPC				X						
Chris Montiverdi?	Health	LEPC				X						
Shawn Morrissey	Director, School Services, Financial Aid	UMMS			X		X	X				
Glenn Myers	Title?, Facilities Maintenance	UMMS						X				
Denice O'Connell	Associate Director, Animal Medicine, Veterinary Services	UMMS		X	X		X					
JoAnne O'Leary	Community Relations and Economic Specialist	NSTAR				X						
Patti Onorato	Deputy COO, Commonwealth Medicine	UMMS		X	X		X	X				
Stephen Park	Title?, Facilities							X				
Krystal Pedersen	Risk Compliance, Information Security	UMMS					X	X				
David Plamondon	Title?, Information Technology	UMMS						X				

Person	Title	Entity	Attended xxxxx xx, 2014 Steering Committee Kick-Off Meeting	Attended March 12, 2014 Campus Kick-Off Meeting	April 9 & 10, 2014 Stakeholder Interviews	Attended May 13, 2014 Public Meeting #1	Attended May 13, 2014 Hazard Identification & Risk Assessment Meeting	Attended July 24, 2014 Campus Hazard Mitigation Goals, Hazard Profiles, Loss Estimates and Projects Meeting	Attended July 24, 2014 Community Outreach Meeting	Attended July 24, 2014 Hazard Mitigation Projects Focus Group	Attended x xxxx xx, 2014 Presentation of Draft Plan Meeting	Attended xxxxx xx, 2014Public Meeting #2
JoAnn Ranslow	Manager, Environmental Health & Safety	UMMS		X	X	X	X					
Allison Rapa	ARSO, Radiation Safety	UMMS			X		X	X				
Dr. Mark Restuccia	Doctor	UMMC				X						
Trish Settles	Principal Planner	CMRPC				X						
Paulette Seymour-Route	Dean, Graduate School of Nursing	UMMS			X							
Kevin Shaughnessy	Manager, Community and Customer Management	NGrid				X						
Bill Schmiedeknecht	Associate Vice Chancellor, HR	UMMS					X					
Mark Shelton	Associate Vice Chancellor, Communications	UMMS		X	X			X				
Jerald Silverman	Director, Professor, Animal Medicine	UMMS		X	X		X					
Lakshmi Sivasubramanian	ARSO, Radiation Safety	UMMS			X		X					
Gina Smith	Program Director, EMS	UMMC				X		X				
Charleen Sotolongo	Senior Director, Environmental Health & Safety / Emergency Management	UMMS		X	X	X		X	X			
Arem Still	Senior Network Engineer, Information Technology	UMMS			X							

Person	Title	Entity	Attended xxxxx xx, 2014 Steering Committee Kick-Off Meeting	Attended March 12, 2014 Campus Kick-Off Meeting	April 9 & 10, 2014 Stakeholder Interviews	Attended May 13, 2014 Public Meeting #1	Attended May 13, 2014 Hazard Identification & Risk Assessment Meeting	Attended July 24, 2014 Campus Hazard Mitigation Goals, Hazard Profiles, Loss Estimates and Projects Meeting	Attended July 24, 2014 Community Outreach Meeting	Attended July 24, 2014 Hazard Mitigation Projects Focus Group	Attended x xxxx xx, 2014 Presentation of Draft Plan Meeting	Attended xxxxx xx, 2014Public Meeting #2
Brian Szymanski	Senior Director, Financial Services	UMMS			X							
Bill Tsaknopoulos	Director, Parking & Transportation	UMMS		X	X		X	X				
Nancy Vasil	Associate Vice Chancellor, Administration & Finance	UMMS										
Sam Varghese	Director, IACUC/IBC, Office of Research	UMMS			X		X					
Diego Vazquez	Assistant Vice Provost, Research Funding Services, Office of Research	UMMS			X			X				
Greg Wolf	Chief Information Officer, Information Technology	UMMS										
Karen Zirpola (Miller)	Administrator, School Services	UMMS			X		X	X				
Arthur Zorge	N/A	Saint Gobain Abrasives				X						

2.2 EXISTING DATA AND REPORTS USED FOR PLAN DEVELOPMENT

The goal of this hazard mitigation planning effort was to build upon and enhance previous hazard mitigation planning and related activities conducted at UMMS. At the start of the project, a data request was issued to UMMS for existing documentation related to hazard and vulnerability risk assessments, emergency preparedness efforts, and campus assets. The following presents a list of the information received and additional data sources that were utilized during the planning process.

- UMMS/UMMHC Joint Strategic Plan, August 2014
- UMass Medical School Emergency Operations Plan (January 2011)
- UMass Medical School / UMass Memorial Health Academic Health Sciences Center Strategic Plan (FY 2009 – 2014)
- University of Massachusetts Worcester Annual Security Report (2012, published in 2013)
- UMass Medical School 2014 Capital Plan (August 2013)
- The University of Massachusetts 2013 Report on Annual Indicators: University Performance Measurement System (July 2013)
- UMass Performance: Accountable and on the Move (March 1014)
- University of Massachusetts Medical School. Emergency Operations Plan, 2011
- Animal Health Emergency, Standard Operating Procedure
- Animal Rights Activity, Standard Operating Procedure
- Safety Manual – Emergency Procedure for a Laboratory Accident
- Safety Manual – Hazardous Waste Minimization
- UMass Memorial Health Care Contingency Plan – Biotech 3
- UMass Memorial Health Care Contingency Plan – University of Massachusetts Medical School
- Clery Reports (Various Years)
- University of Massachusetts Emergency Operations Plan, January 2011
- University of Massachusetts Medical School Fire Safety Plan
- UMass Memorial Medical Center Hazard Vulnerability Analysis
- University of Massachusetts Medical School Spill Prevention, Control and Countermeasure Plan
- Commonwealth of Massachusetts – State Hazard Mitigation Plan, 2013
- Central Massachusetts Region-Wide Pre-Disaster Mitigation Plan, 2012
- City of Worcester Emergency Management Website: http://www.worcesterma.gov/emergency-communications/emergency-management
- National Oceanic and Atmospheric Administration (NOAA) Comparative Climatic Data For the United States Through 2012
- City of Worcester Climate Action Plan, 2006
- On the Water Front: News and Information about Your Water and Sewer Utilities, Volume 19, Number 1, Spring 2014
- Massachusetts Drought Management Plan, May 2013
- Massachusetts Local Financial Impact Review: Massachusetts Dam Safety Law, 2011

External plans and programs reviewed as part of the hazard mitigation planning effort are included in Section 6.6. Appendix A includes a bibliography of the documents that were provided by UMMS.

2.3 STAKEHOLDER ENGAGEMENT

There were several opportunities for stakeholder engagement that included the above referenced response to data request, campus stakeholder meetings, one-on-one interviews, focus groups and public meetings. Each opportunity for stakeholder engagement and individuals involved have been documented in the sections that follow.

2.3.1 Campus Kick-Off Meeting

On March 12, 2014, a campus kick off meeting was held at UMMS to initiate stakeholder engagement activities. The individuals who attended are listed in Table 2-1. The meeting agenda, sign-in sheet and Power Point presentation are provided in Appendix B. The topics reviewed during this meeting are outlined in Table 2-2.

Table 2-2: Topics Reviewed During Campus Kick-Off Meeting

Topic	Details
Project Overview	Reviewed the goals of the project, background of the grant funding, and benefits to be achieved by UMMS.
Hazard Mitigation Planning	Introduced the concept of hazard mitigation planning including the planning phases, types of hazards to be included, and recent hazard events that have impacted Massachusetts and the New England region.
Approval Process and Requirements	Reviewed the requirements and expectations of FEMA/MEMA in order to achieve plan approval. Topics included the importance for documentation, stakeholder engagement, and focus on the importance of the process. FEMA's evaluation criteria was provided as a handout.
Components of Hazard Mitigation Planning	Reviewed the planning process, hazard identification and risk assessment, mitigation strategy, and plan review, evaluation, and implementation.
Team Roles and Responsibilities	Roles and responsibilities consisted of participation in meetings, providing relevant documentation, identification and assessment of hazards, support outreach activities, review and comment on the draft Plan and support Plan implementation.
Project Schedule	The project schedule was reviewed with interim and final deadlines. Approval by MEMA/FEMA is necessary by xxxxx xx, 2015 to meet the obligations of the grant.
Project Website	Gave an overview of the project website including future content to be included.

2.3.2 Stakeholder Interviews

On April 9 & 10, 2014 stakeholder interviews were completed to discuss hazards that have or could impact the campus, potential vulnerabilities to those hazards and assets that could be impacted. Potential hazard mitigation projects were also discussed. The interviews were completed on campus and each lasted from a half hour to an hour and a half in duration. Most interviews were completed in a group setting with specific groups of department representatives, however some one on one interviews were also conducted. The interview matrix is provided in Table 2-3.

Table 2-3: UMMS Stakeholder Interview Matrix

	Department/Person	Department/Person
April 9, 2014		
	Facilities Management / John Baker	Facilities Engineering & Construction / Mark Armington
	Energy Resources (Power Plant) / Joe	Energy Resources (Power Plant) / Steve Blair

	Department/Person	Department/Person
	Collins	
	Facilities (Off-Site Properties) / Keri Kirrane	Facilities (Off-Site Properties) / Mark Markarian
	Facilities (Off-Site Properties) / Paul Stasaitsi	Facilities (Off-Site Properties) / Mike Gregory
	Facilities Maintenance / Jim Gardner	Facilities Maintenance / Steve Park
	Albert Sherman Center / Karen Logan	Sustainability & Energy / Melissa Lucas
	Admin & Finance / Bob Jenal	Administration / Paulette Goeden
	Communications / Mark Shelton	Communications / Jim Fessenden
	Animal Medicine / Gerry Silverman	Animal Medicine, Veterinary Services / Denise O'Connell
	Animal Medicine / David Bays	Radiation Safety / Sassan Abollahzadeh
	Radiation Safety / Allison Rapa	Radiation Safety / Lakshmi Sivasubramanian
	EH&S, RS / Deb Burdett	EH&S / Russ Mattson
	EH&S / JoAnn Ranslow	EH&S Biosafety / Colleen Driskill
	EH&S Occupational Safety & Health / Deb Campbell	EH&S / Ken Lebetkin
	Registrar's Office / Michael Baker	School Services, Financial Aid / Shawn Morrissey
	School Services / Karen Zirpola (Miller)	Student Affairs / Judy Holewa
	GSBS / Anthony Carruthers	Provost & Exec. Deputy Chancellor / Lisa Beittel
	Graduate School of Nursing / Paulette Seymour-Route	Medical School / Tim Boardman
April 10, 2014		
	EMS / Gina Smith	Disaster Medicine / Mary-Elise Manuel
	Emergency Medicine / Andrew Milsten	Labor Relations / Marc Labella
	Financial Services / Sandra Flynn	Financial Services / Brian Szymanski
	CWM / Patti Onorato	Information Technology / Chris Bunn
	Information Technology / Chris Johnson	Information Technology, Network Engineering / Chris Clifford
	Information Technology, Information Security / Brian Coleman	Telecommunications / Ed Manzello
	Transportation / Bill Tsaknopoulos	Auxiliary Services / Tony Covello
	Research Funding Services / Diego Vazquez	Office of Research / Sam Varghese
	Public Safety / Jack Luippold	GSME / Deb DeMarco
	GSME / Marilyn Leeds	Faculty Talent Management / Joanna Cain
	Community Relations / Jim Leary	Facilities Management / John Baker
	MassBiologics / John Finch	MassBiologics / Frank Fazio
	MassBiologics / Mark Leney	Medical School / Caleb Dresser
	MAPS / Joyce Barrett	PGFE / Patricia Keith
	MAPS / Richard Fish	PGFE / Nina Bhabhalia

Interviews were conducted in an open format by one or two interviewers. An interview questionnaire (Appendix C) was prepared and distributed in advance, however this was only intended to give the interviewees a flavor for the types of topics to be addressed as opposed to a list of questions that would be strictly adhered to during the interview. The approach was to have the interviewees focus on the areas in which they had the most experience and information to share and not to be restrictive in the discussion. After the interviews, a series of themes were identified by the interviewees and are presented in Table 2-4 by topic:

Table 2-4: UMMS Interview Topics & Themes

Topic	Themes
Campus Operations	Use and handling of select agents. The campus has the only BL3 cell laboratory in the northeast.
	High dependency on technology for campus operations.
	Campus does not close due to weather and essential personnel must be present.
	Events held on campus that brings large quantities of people.
Utilities/Campus Assets	Any hazard that might shut down the University is of high concern.
	Potential impacts to animal research from power loss.
	Water failure vulnerabilities/redundancy and potential impacts to the power plant and fire suppression capabilities.
Campus Setting and Surrounding Areas	Bottlenecks for entrance and evacuation of campus at campus parking garage; specifically the considerable amount of time it can take to exit campus during weather or special events. Dependency on the City of Worcester to support campus evacuations.
	Ability to shut down the campus and limit access with existing security resources.
	Proximity to the UMass Memorial Medical Center.
	The need to interface with the hospital for hazard events and resiliency and to have stronger lines of communication. Inter-departmental communications are also important and could be stronger.
	In general, there is an "open" feel on campus allowing accessibility to many campus areas. Many areas are not controlled by a swipe card system and in general individuals are not challenged when entering campus or campus facilities.

The themes in Table 2-4 were important considerations that factored into the hazard identification and risk assessment process. Aside from these common themes, interviewees gave perspectives on hazards that had or could impact the campus and previous damages or campus impacts that had been experienced from hazard events. A brief summary of the specific previous hazard events mentioned by interviewees includes:

- Winter storm events and associated campus disruptions have represented the largest past impacts of natural hazard events,
- Extreme heat event impacting MassBiologics HVAC systems
- Thunderstorm related power outages,
- Tornadoes in the Worcester area,
- High wind events,
- Past bomb threat,
- Minor vandalism, theft and business fraud instances,
- Incidents of stalking,
- Frequent cyberthreats,
- Guns on campus, and
- Past power outages and infrastructure failures.

The list is not meant to be all inclusive of past events experienced on campus and only represents events mentioned during the interviews. More specific hazard information is presented in Section 3.

2.3.3 Hospital Vulnerability Assessment (HVA) Plan Review Committee Meeting

On April 10, 2014, the HVA Plan Review Committee met to discuss updates to UMass Memorial Medical Center's HVA. This committee is comprised of employees from UMass Memorial Medical Center, UMMS, and the UMass Police Department. In 2014, two members of the UMMS Environmental, Health, and Safety Department were involved in the HVA annual review. This committee meets annually, or more often if the HVA is activated, to review UMass Memorial Medical Center's HVA and determine if the probability, risk, and preparedness level rank for natural events, technological events, and human hazard events that could occur at UMass Memorial Medical Center should change from the previous year's ranking. Each natural, technological, or human event is ranked individually and issues, changes, and action items are assigned during this meeting.

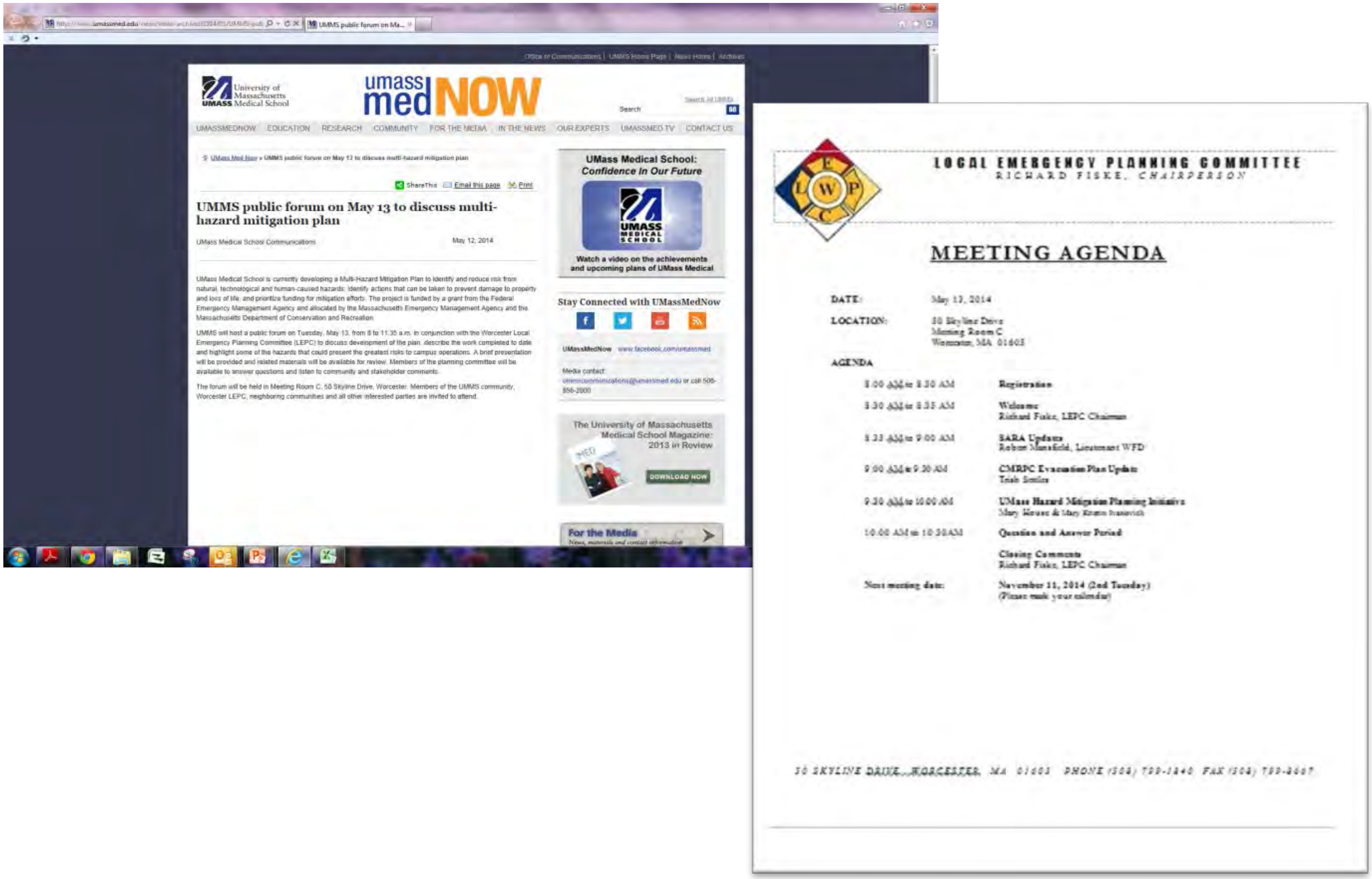
2.3.4 Public Meeting No. 1

On May 13, 2014 the first public meeting regarding this hazard mitigation planning process was held in conjunction with the regularly scheduled LEPC meeting at the Worcester Emergency Management facility at 50 Skyline Drive in Worcester. Members of the public were invited to attend and the meeting was advertised using a variety of venues with support from the UMMS Office of Community and Government Relations (see Figure 2). The means for advertising consisted of:

- LEPC Meeting Announcement
- Posting on UMMS web site
- Personal email invitations

***Photo:** UMMS Hazard Mitigation Plan – Public Meeting No. 1*

Figure 2: Public Meeting No. 1 Advertising Efforts

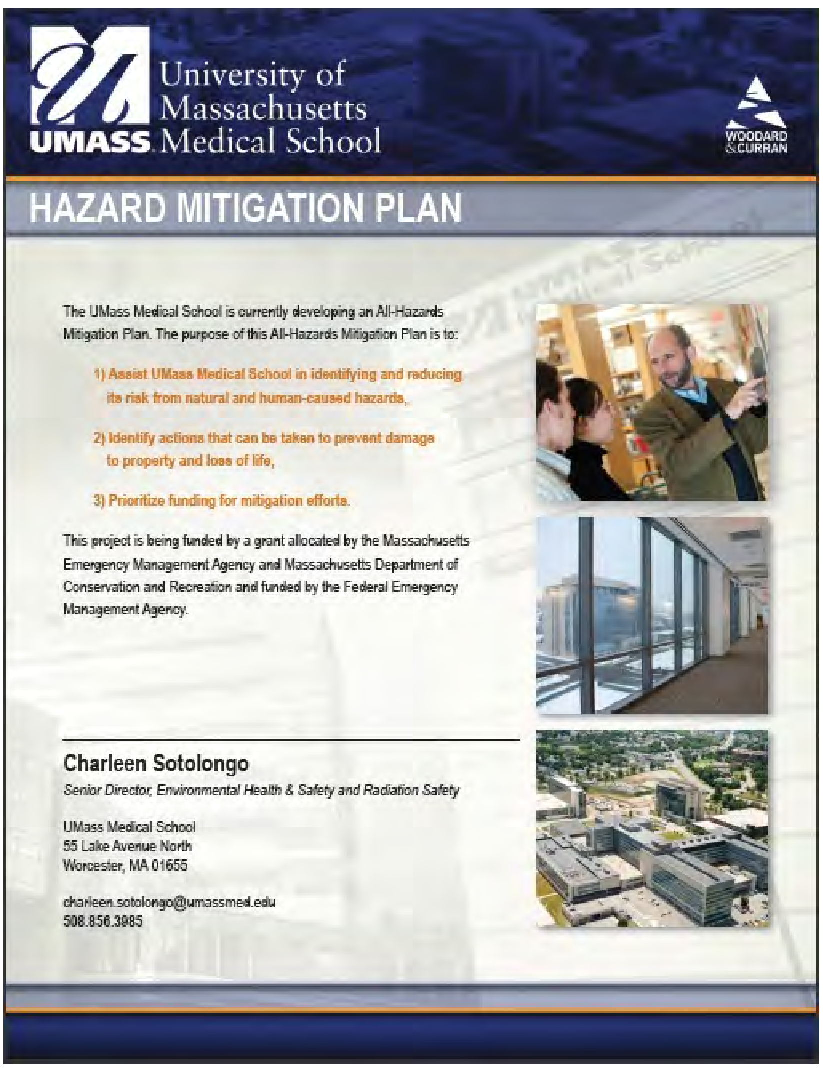


The topic of the UMMS hazard mitigation plan was a specific agenda item at the LEPC meeting. A short presentation was made and summary materials were provided for the meeting. A description of each is provided below and the actual public meeting handout is presented in Figure 3.

- Hazard Mitigation Power Point presentation: A Power Point presentation focused on the hazard mitigation planning process was presented with dialog and questions taken throughout.
- Handout: A handout was presented that listed the main goals of the project and who at UMMS to contact for further information.
- Comments: Throughout the room blank handouts with space to write comments, questions or thoughts were provided.

The LEPC public meeting was attended by UMMS campus representatives, LEPC members, and Woodard & Curran. While the planning process was discussed among the various attendees, no specific comments were provided that were not already captured in previous interviews, stakeholder meetings or focus groups. Public meeting materials are provided in Appendix F.

Figure 3: Public Meeting No. 1 Meeting Materials



UMASS University of Massachusetts Medical School

WOODARD & CURRAN

HAZARD MITIGATION PLAN

The UMass Medical School is currently developing an All-Hazards Mitigation Plan. The purpose of this All-Hazards Mitigation Plan is to:

1) Assist UMass Medical School in identifying and reducing its risk from natural and human-caused hazards,

2) Identify actions that can be taken to prevent damage to property and loss of life,

3) Prioritize funding for mitigation efforts.

This project is being funded by a grant allocated by the Massachusetts Emergency Management Agency and Massachusetts Department of Conservation and Recreation and funded by the Federal Emergency Management Agency.

Charleen Sotolongo

Senior Director, Environmental Health & Safety and Radiation Safety

UMass Medical School
55 Lake Avenue North
Worcester, MA 01655

charleen.sotolongo@umassmed.edu
508.856.3985

2.3.5 Hazard Identification and Risk Assessment Meeting

On May 13, 2014 a hazard identification and risk assessment meeting was held at UMMS to initiate the hazard identification and risk assessment process. The representatives in attendance are listed in Table 2-1. The meeting agenda, sign in sheet and Power Point presentation are provided in Appendix D. The topics reviewed during this meeting are presented in Table 2-5.

Table 2-5: Topics Reviewed During Hazard Identification and Risk Assessment Meeting

Topic	Details
Overview of Hazard Mitigation Planning Process and Meeting Goal	A brief overview of the hazard mitigation planning process was provided as a review for meeting attendees. The meeting goal was to reach consensus on a ranked list of natural and human hazards that could impact the campus.
Overview of Potential Hazards	Campus specific considerations associated with hazard events were presented to the stakeholders and included summaries of previous studies, ongoing campus planning, and hazard mapping. Abbreviated hazard event profiles were presented.
Summary of Interview Discussions	Common themes shared by interviewees and specific hazard events mentioned were reviewed. Considerations resulting from the interviews were discussed as well as initial mitigation projects identified to address potential hazards.
Hazard Ranking Methodology	The hazard ranking methodology was reviewed with the stakeholders and consisted of ranking the categories of frequency, severity, duration and intensity with a 0 to 5 scale. The categories were grouped into probability and consequence factors that could be weighted.
Group Workshop Hazard Ranking	The stakeholder group reviewed the list of natural and human hazards identified and ranked each category using the 0 to 5 scale. The weighting of probability and consequence were assigned to reach a total rank for each hazard. Based on the numerical value of the ranking, each hazard was further categorized in groups of severe, high, medium, and low.

Upon completion of the meeting, the campus stakeholders were provided with the finalized list of ranked hazards to reflect upon and make further modifications as necessary.

2.3.6 Hazard Mitigation Goals, Hazard Profiles, Loss Estimates and Projects Meeting

On July 24, 2014 a hazard mitigation goals, hazard profiles, loss estimates and projects meeting was conducted at UMMS. The representatives in attendance are listed in Table 2-1.

The meeting agenda, sign in sheet and Power Point presentation are provided in Appendix E.

The topics reviewed during this meeting are presented in Table 2-6.

Table 2-6: Topics Reviewed During Hazard Mitigation Goals, Hazard Profiles, Loss Estimates and Projects Meeting

Topic	Details
Hazard mitigation goals and objectives	The hazard mitigation goals, objectives and projects developed for the campus were presented to the stakeholder group for initial review and comment. Goals and objectives were tied to specific hazard events and mitigation projects were identified to address hazards.
Hazard event profiles	Detailed hazard event profiles were presented for natural hazards and high ranking human hazards. The hazard rankings previously identified were reviewed against those profiles to determine if any modifications to the rankings were necessary. No modifications to the rankings were made.
Building ratings	The methodology to assign building critically values was reviewed with the stakeholder group as well as the initial assignment of building critically values. As a result of discussion, modifications were made to the building criticality values.
Loss estimates	The methodology for developing loss estimates was reviewed and findings associated with both specific hazards and non-hazard specific events were presented. A quantitative assessment was completed for non-hazard specific loss of function and earthquakes. Qualitative assessments were completed for other hazard events.
Hazard mitigation projects	Specific hazard mitigation projects identified to address the various hazards that could impact campus were presented in relation to the specific hazard addressed and plan goals and objectives.
Next Steps	Stakeholders were briefed on upcoming tasks to be completed and incorporated into the draft plan. The mechanism for reviewing and posting the draft plan were also discussed. Stakeholders were notified of a second public meeting to be scheduled in the fall 2014.

After the meeting, revised goals, objectives, hazard mitigation projects, and building criticality assignments were provided to the stakeholder group for further review and comment.

2.3.7 Campus Mitigation Projects Focus Groups

In order to develop the most comprehensive list of viable hazard mitigation actions and projects, small campus focus groups were held with the Facilities, EH&S and IT groups to complete a more in-depth review of the existing list of hazard mitigation actions and projects. These focus groups were also completed on July 24, 2014 and were attended by representatives outlined in Table 2-1.

As a result of the focus groups, additional mitigation actions and projects were identified and insights were provided as to the highest priority from each group's perspective. Some of the themes resulting from this discussion consisted of the following:

- Concern over potential power, water and IT losses,
- Business continuity impacts, and

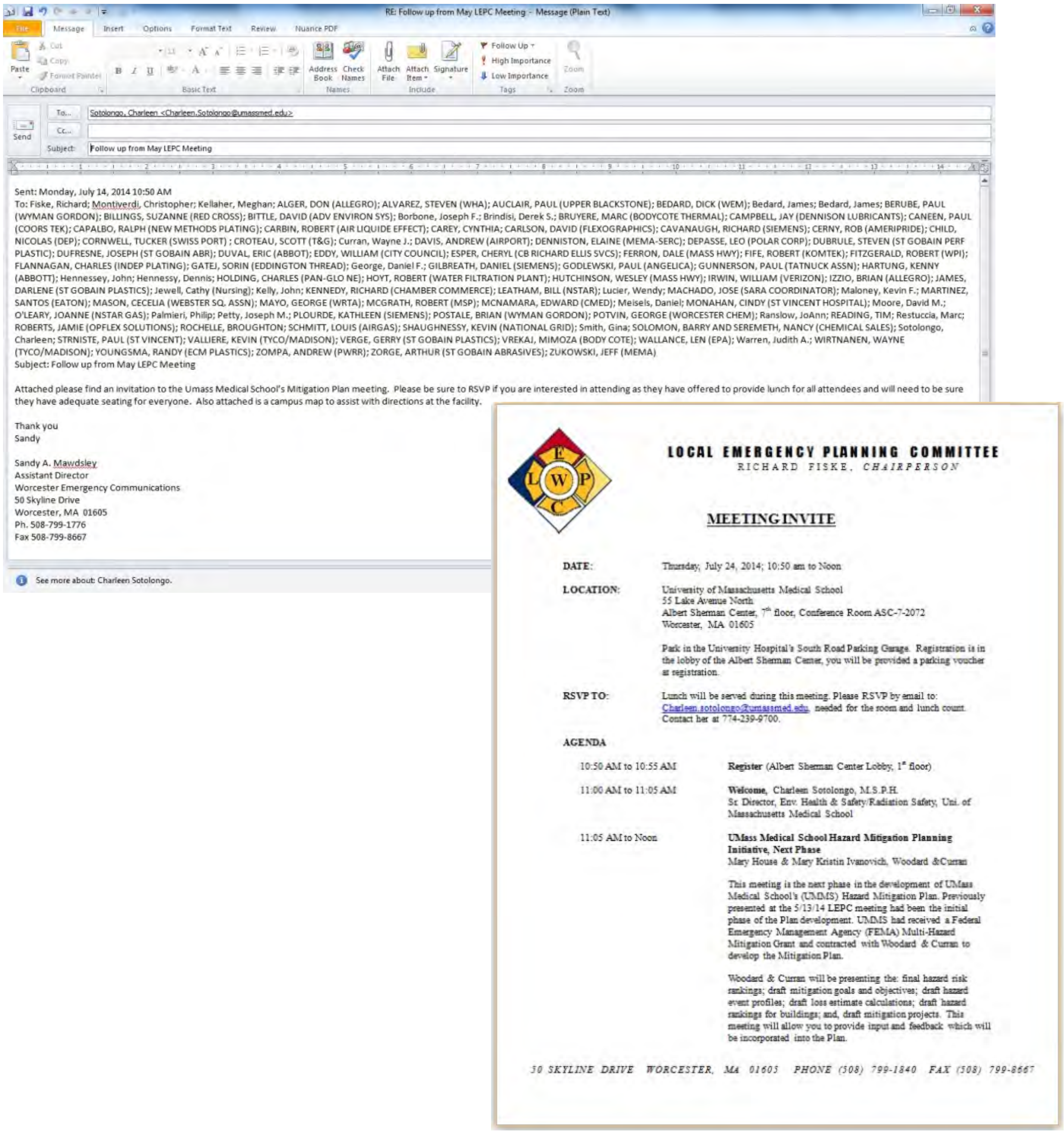
- Building redundancy in essential systems.

Specific mitigation projects identified are outlined in **Section 6.1**.

2.3.8 Community Outreach Meeting

To further community involvement and input in the development of the UMMS Multi-Hazard Mitigation Plan, UMMS held an invitation only community outreach meeting targeted to representatives of the Worcester LEPC. Members of the LEPC were invited via email (see **Figure 4**).

Figure 4: LEPC July 24, 2014 Meeting Invitation and Agenda



To... Sotolongo, Charleen <Charleen.Sotolongo@umassmed.edu>
Cc...
Subject: Follow up from May LEPC Meeting

Sent: Monday, July 14, 2014 10:50 AM
To: Fiske, Richard; Montiverdi, Christopher; Kellaher, Meghan; ALGER, DON (ALLEGRO); ALVAREZ, STEVEN (WHA); AUCLAIR, PAUL (UPPER BLACKSTONE); BEDARD, DICK (WEM); Bedard, James; Bedard, James; BERUBE, PAUL (WYMAN GORDON); BILLINGS, SUZANNE (RED CROSS); BITTLE, DAVID (ADV ENVIRON SYS); Borbone, Joseph F.; Brindisi, Derek S.; BRUYERE, MARC (BODYCOTE THERMAL); CAMPBELL, JAY (DENNISON LUBRICANTS); CANEEN, PAUL (COORS TEK); CAPALBO, RALPH (NEW METHODS PLATING); CARBIN, ROBERT (AIR LIQUIDE EFFECT); CAREY, CYNTHIA; CARLSON, DAVID (FLEXOGRAPHICS); CAVANAUGH, RICHARD (SIEMENS); CERNY, ROB (AMERIPRIDE); CHILD, NICOLAS (DEP); CORNWELL, TUCKER (SWISS PORT) ; CROTEAU, SCOTT (T&G); Curran, Wayne J.; DAVIS, ANDREW (AIRPORT); DENNISTON, ELAINE (MEMA-SERC); DEPASSE, LEO (POLAR CORP); DUBRULE, STEVEN (ST GOBAIN PERF PLASTIC); DUFRESNE, JOSEPH (ST GOBAIN ABR); DUVAL, ERIC (ABBOT); EDDY, WILLIAM (CITY COUNCIL); ESPER, CHERYL (CB RICHARD ELLIS SVCS); FERRON, DALE (MASS HWY); FIFE, ROBERT (KOMTEK); FITZGERALD, ROBERT (WPI); FLANNAGAN, CHARLES (INDEP PLATING); GATEJ, SORIN (EDDINGTON THREAD); George, Daniel F.; GILBREATH, DANIEL (SIEMENS); GODLEWSKI, PAUL (ANGELICA); GUNNERSON, PAUL (TATNUCK ASSN); HARTUNG, KENNY (ABBOTT); Hennessey, John; Hennessy, Dennis; HOLDING, CHARLES (PAN-GLO NE); HOYT, ROBERT (WATER FILTRATION PLANT); HUTCHINSON, WESLEY (MASS HWY); IRWIN, WILLIAM (VERIZON); IZZIO, BRIAN (ALLEGRO); JAMES, DARLENE (ST GOBAIN PLASTICS); Jewell, Cathy (Nursing); Kelly, John; KENNEDY, RICHARD (CHAMBER COMMERCE); LEATHAM, BILL (NSTAR); Lucier, Wendy; MACHADO, JOSE (SARA COORDINATOR); Maloney, Kevin F.; MARTINEZ, SANTOS (EATON); MASON, CECELIA (WEBSTER SQ. ASSN); MAYO, GEORGE (WRTA); MCGRATH, ROBERT (MSP); MCNAMARA, EDWARD (CMED); Meisels, Daniel; MONAHAN, CINDY (ST VINCENT HOSPITAL); Moore, David M.; O'LEARY, JOANNE (NSTAR GAS); Palmieri, Philip; Petty, Joseph M.; PLOURDE, KATHLEEN (SIEMENS); POSTALE, BRIAN (WYMAN GORDON); POTVIN, GEORGE (WORCESTER CHEM); Ranslow, JoAnn; READING, TIM; Restuccia, Marc; ROBERTS, JAMIE (OPFLEX SOLUTIONS); ROCHELLE, BROUGHTON; SCHMITT, LOUIS (AIRGAS); SHAUGHNESSY, KEVIN (NATIONAL GRID); Smith, Gina; SOLOMON, BARRY AND SEREMETH, NANCY (CHEMICAL SALES); Sotolongo, Charleen; STRNISTE, PAUL (ST VINCENT); VALLIERE, KEVIN (TYCO/MADISON); VERGE, GERRY (ST GOBAIN PLASTICS); VREKAJ, MIMOZA (BODY COTE); WALLANCE, LEN (EPA); Warren, Judith A.; WIRTNANEN, WAYNE (TYCO/MADISON); YOUNGSMA, RANDY (ECM PLASTICS); ZOMPA, ANDREW (PWRR); ZORGE, ARTHUR (ST GOBAIN ABRASIVES); ZUKOWSKI, JEFF (MEMA)
Subject: Follow up from May LEPC Meeting

Attached please find an invitation to the Umass Medical School's Mitigation Plan meeting. Please be sure to RSVP if you are interested in attending as they have offered to provide lunch for all attendees and will need to be sure they have adequate seating for everyone. Also attached is a campus map to assist with directions at the facility.

Thank you
Sandy

Sandy A. Mawdsley
Assistant Director
Worcester Emergency Communications
50 Skyline Drive
Worcester, MA 01605
Ph. 508-799-1776
Fax 508-799-8667

See more about: Charleen Sotolongo.

LOCAL EMERGENCY PLANNING COMMITTEE
RICHARD FISKE, *CHAIRPERSON*

MEETING INVITE

DATE: Thursday, July 24, 2014; 10:50 am to Noon

LOCATION: University of Massachusetts Medical School
55 Lake Avenue North
Albert Sherman Center, 7th floor, Conference Room ASC-7-2072
Worcester, MA 01605

Park in the University Hospital's South Road Parking Garage. Registration is in the lobby of the Albert Sherman Center, you will be provided a parking voucher at registration.

RSVP TO: Lunch will be served during this meeting. Please RSVP by email to: Charleen.sotolongo@umassmed.edu, needed for the room and lunch count. Contact her at 774-239-9700.

AGENDA

10:50 AM to 10:55 AM — **Register** (Albert Sherman Center Lobby, 1st floor)

11:00 AM to 11:05 AM — **Welcome,** Charleen Sotolongo, M.S.P.H.
Sr. Director, Env. Health & Safety/Radiation Safety, Uni. of Massachusetts Medical School

11:05 AM to Noon — **UMass Medical School Hazard Mitigation Planning Initiative, Next Phase**
Mary House & Mary Kristin Ivanovich, Woodard &Curran

This meeting is the next phase in the development of UMass Medical School's (UMMS) Hazard Mitigation Plan. Previously presented at the 5/13/14 LEPC meeting had been the initial phase of the Plan development. UMMS had received a Federal Emergency Management Agency (FEMA) Multi-Hazard Mitigation Grant and contracted with Woodard & Curran to develop the Mitigation Plan.

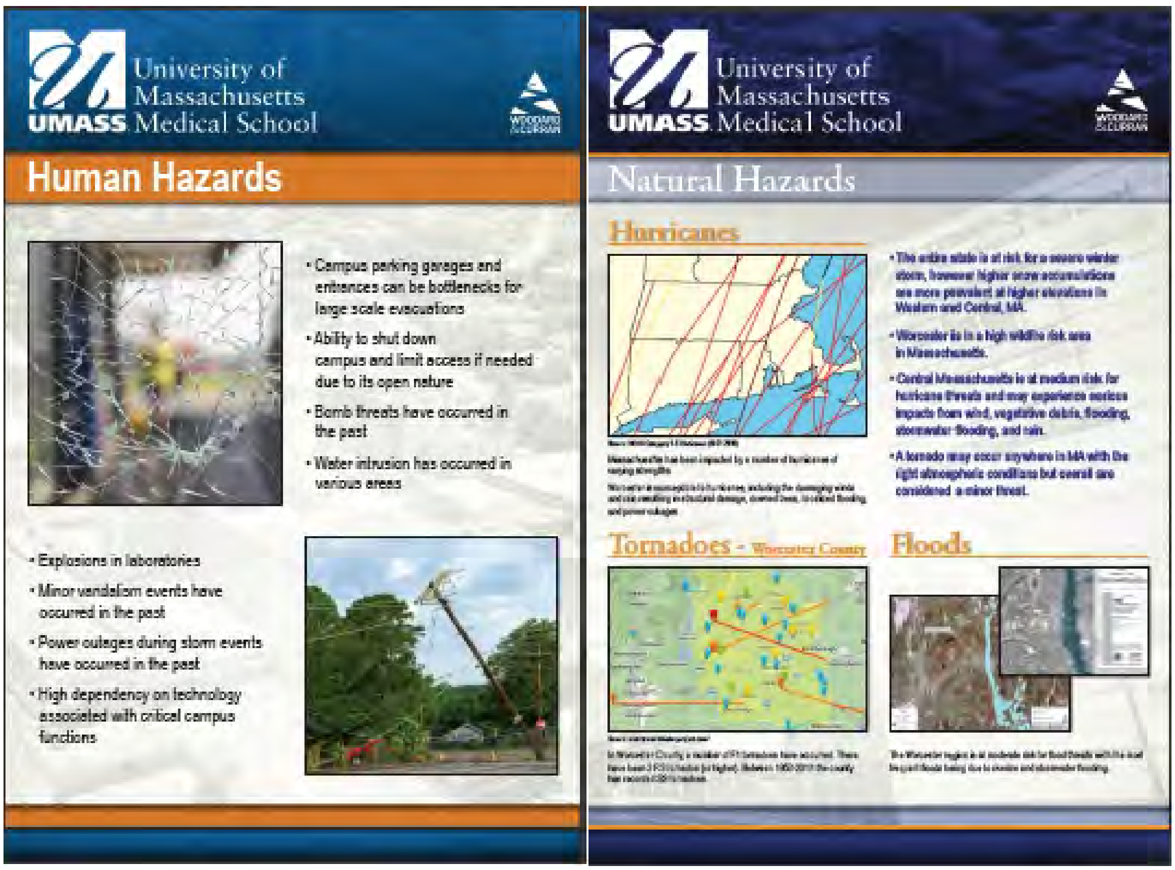
Woodard & Curran will be presenting the: final hazard risk rankings; draft mitigation goals and objectives; draft hazard event profiles; draft loss estimate calculations; draft hazard rankings for buildings; and, draft mitigation projects. This meeting will allow you to provide input and feedback which will be incorporated into the Plan.

50 SKYLINE DRIVE WORCESTER, MA 01605 PHONE (508) 799-1840 FAX (508) 799-8667

A short presentation was made and summary materials were provided for the meeting. A description of each is provided below and the actual community forum posters are presented in Figure 5.

- Hazard Mitigation Power Point presentation: A Power Point presentation focused on the hazard mitigation goals was presented with dialog and questions taken throughout.
- Handout: A handout was presented that listed mitigation actions identified.

Figure 5: Community Forum Posters



Primary topics of discussion during the meeting consisted of the following:

- *Temporary parking alternatives*: Should UMMS parking areas be unusable due to a hazard event, the City of Worcester would not be able to provide temporary alternative parking solutions that would be sufficient for the number of cars potentially displaced.
- *Identification of essential personnel*: Since UMMS and the UMass Memorial Hospital have shared personnel services, essential personnel must be on-site even during hazard events. There was a discussion of how the Worcester Police department might be able to identify essential personnel via a badging system in the current absence of a statewide system. The Worcester Management Agency made a suggestion for UMMS to develop a procedure for how to identify essential personnel and distribute that information to the City of Worcester Public Safety Office.

Public meeting materials are provided in Appendix F.

2.3.9 Presentation of Draft Hazard Mitigation Plan Facilitated Review Meeting

On ________, a meeting was held at UMMS to present the written draft plan to the Hazard Mitigation Planning representatives and other campus stakeholders. The representatives in attendance are listed in Table 2-2. The meeting agenda, sign in sheet and Power Point presentation are provided in Appendix G.

The written draft was issued prior to the meeting such that stakeholders would have an opportunity to review the draft prior to the meeting. During the meeting, a facilitated review of the draft was provided highlighting key areas to focus upon. Feedback on the draft was solicited and recorded for incorporation into the final version of the Plan. Table 2-9 outlines the topics discussed at the meeting.

Table 2-9: Topics Reviewed During Facilitated Review Meeting of the Draft Hazard Mitigation Plan

Topic	Details
Hazard Mitigation Plan Organization	The organization of the UMMS Multi-Hazard Mitigation Plan was reviewed. State and regional hazard information is presented first followed by campus specific hazard event profiles.
Risk Assessment	Risk rankings were reviewed for any additional comments. Additional focus was placed on reviewing rankings for the categories of students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure.
Mitigation Actions	Hazard mitigation projects were reviewed for any additional comments. Additional focus was placed on the estimated project cost, responsible party, and project priority ranking.
Plan Implementation, Maintenance & Adoption	The plan implementation, maintenance and adoption was reviewed so that the hazard mitigation planning team understood the process of plan implementation and the expectations of the team moving forward.

No specific comments on the draft Hazard Mitigation Plan were received during the facilitated review meeting. Upon completion of the meeting, the campus stakeholders were encouraged to complete a final review of the Hazard Mitigation Plan with a specific focus on the areas presented in Table 2-9.

2.3.10 Public Meeting No. 2

On _________ the second public meeting presenting the draft UMMS Multi-Hazard Mitigation Plan was held on the UMMS campus. The meeting was advertised using a variety of venues with support from the UMMS Public Relations department (see Figure 6).

Figure 6: Public Meeting No. 2 Advertising Efforts

The means for advertising consisted of:

- Posting on UMMS web site
- UMMS News
- Listing on area web sites

The draft UMMS Hazard Mitigation Plan was posted on the UMMS web site prior to the meeting to provide the public with an opportunity to review and provide comment if desired.

The format of the public meeting was designed to be casual, informative, and conducive to receive input. The room was set up in the following stations where the public could learn about or provide input into the Plan:

- Hazard Mitigation Plan Power Point presentation: An automated Power Point presentation focused on the major components of the Hazard Mitigation Plan was continually displayed with a new slide projected every 20-30 seconds.
- Hazard Posters: Posters focused on some of the top hazards to potentially impact the campus were set up for viewing purposes. One poster focused specifically on flooding, while the second poster focused on other types of common hazards such as winter storms.
- Hard Copy DRAFT UMMS Hazard Mitigation Plan: A hard copy of the full draft hazard mitigation plan was available for review.
- Comments: Throughout the room blank handouts with space to write any comments, questions or thoughts were provided.

There were no specific comments received on the draft Hazard Mitigation Plan during the public meeting. There was discussion of potential funding mechanisms for specific hazard mitigation projects and future grant opportunities that could be explored.

Public meeting materials are provided in Appendix H.

3. HAZARD IDENTIFICATION, PROFILES AND RISK ASSESSMENT

3.1 INTRODUCTION AND BACKGROUND

The risk assessment process that was conducted for this planning effort focused on utilizing relevant data, anecdotal information and historical records to allow UMMS the opportunity to clearly identify natural and human hazards that have and may impact the campus and then prioritize specific mitigation actions that can potentially reduce losses from future hazard events. The four basic components of the risk assessment include:

- ✓ Identify Hazards – determine which hazards pose a threat to the subject area,
- ✓ Profile Hazard Events – collect data about specific hazards and prepare relevant maps to the extent possible,
- ✓ Inventory Assets – prepare an inventory that associates a value to structures/key assets in identified hazard areas, and
- ✓ Estimate Losses – predicting if possible, the extent of damage to structures/key assets in the identified hazard areas.

The risk assessment is a critical step that provides the foundation for the rest of the hazard mitigation planning process. The risk assessment process focused the attention of the Hazard Mitigation Planning Team on the areas most in need of mitigation planning and actions by evaluating which populations and assets are most vulnerable to hazards and to what extent injuries and damages may occur. A more detailed description of how the risk assessment process was completed is in Table 3-1.

Table 3-1: Risk Assessment Process

Risk Assessment Steps	Detailed Description
Step 1: Identify Hazards	• Identifying hazards includes considering each hazard that has or may affect the campus and then reduce the list to the hazards that are most likely to have an impact in the future (not limited only to ones that have affected the campus recently). Hazard events may include flooding, fire, extreme wind events, winter storms, active shooter, terrorism as well as others. • Hazards were identified that have impacted or could impact the campus including but not limited to: natural disasters (flood, storm surge, winter storm, etc.), fire, hazardous material event (on- or off-campus), health-related event (communicable disease, foodborne illness, etc.), utility/facilities failure (loss of power, gas leak, loss of heat, etc.), IT/MIS disturbance (server loss, security breech, etc.) and campus security events (bomb threat, active shooter, civil disturbance, etc.). Hazards were prioritized/ranked based on likelihood of occurrence and severity of impact to life, personal injury, property damage, and/or economic impact.
Step 2: Profile Hazard Events	• Once hazards were identified, the next step was to answer the question – *how bad can it get?* Hazards have unique characteristics that define what they are and the damage they cause. • Existing FEMA, MEMA, NOAA, NCDC and other data sources were utilized and information from local/regional/state hazard mitigation plans, historical anecdotes, and descriptions of past emergency incidents were reviewed and synthesized to help determine an accurate profile for each hazard event. A working base map was developed specific to the

Risk Assessment Steps	Detailed Description
	campus regarding the hazard profiles.
Step 3: Inventory Assets	• The purpose of inventorying assets was to determine what structures/key assets have been or could be affected by the previously identified hazards. • The planning team worked together to identify the critical assets on campus including buildings, infrastructure, essential facilities, lifeline utility systems, vulnerable populations and areas with special considerations (historic, cultural, natural resource areas, etc.). Information was gathered during interviews/meetings regarding the number of structures, value of structures, size of buildings, replacement value, contents value, function/operational use or value, displacement cost per day, occupancy or capacity and people affected. Current development efforts and future development plans were considered as well.
Step 4: Estimate Losses	• Estimating losses provides a general sense of how campus assets could be affected by hazard events. The extent of loss can vary depending on age of the asset, construction, construction materials, contents, displacement cost, operational use and overall value. Loss calculations estimate potential exposure of the assets, population, operations and infrastructure to hazard events. • The planning team estimated the possible extent of damages and the potential monetary impact from each hazard identified using the FEMA guidance document *“Understanding Your Risks – Identifying Hazards and Estimating Losses*” (FEMA 386-2). Information obtained during the previous three risk assessment steps was utilized. The planning team did consider the use of HAZUS for this task, but determined that at the campus level, the methodology in 386-2 provided better results. The methodology for estimating losses was used to the extent possible for floods and earthquakes and for all other hazards a qualitative analysis approach was implemented.

3.2 DISASTER DECLARATIONS

For the purposes of this Hazard Mitigation Plan, the term hazard is defined as an extreme natural or human event that poses a risk to people, infrastructure, operations or resources. Identifying hazards includes detailing geographically where an event has occurred historically, where it is likely to occur in the future, and how substantial the event may be. The natural hazards that have been identified and included in this section received their initial consideration from FEMA Guidance documentation. The hazards were then filtered by utilizing current and historical data points from various sources including but not limited to NOAA, the US Census, state and regional Hazard Mitigation Plans and regional and local specialty plans. Finally, UMMS analyzed the findings of each natural hazard and cross referenced the information with anecdotal data points and then developed a final list of natural hazards that have and may continue to impact the Worcester campus and owned buildings on satellite campuses.

Since 1953, there have been 47 Major Presidential and Emergency Disaster Declarations (see Table 3-2) to affect Massachusetts. Of those declarations, 24 have impacted Worcester County.

Table 3-2: Massachusetts Major and Emergency Disaster Declarations 1953 – Present

Disaster No.	Date Declared	Incident Description	Impact to Worcester County
4110	4/19/2013	Severe Winter Storm, Snowstorm, Flooding	X
3362	4/17/2013	Massachusetts Explosions	
4097	12/19/2012	Hurricane Sandy (Major Disaster)	
3350	10/28/2012	Hurricane Sandy (Emergency Declaration)	X
4051	1/6/2012	Severe Storm And Snowstorm	X
3343	11/1/2011	Severe Storm	X
4028	9/3/2011	Tropical Storm Irene	
3330	8/26/2011	Hurricane Irene	X
1994	6/15/2011	Severe Storms and Tornadoes	X
1959	3/7/2011	Severe Winter Storm and Snowstorm	
3315	9/2/2010	Hurricane Earl	X
3312	5/3/2010	Water Main Break	
1895	3/29/2010	Severe Storm and Flooding	X
1813	1/5/2009	Severe Winter Storm and Flooding	X
3296	12/13/2008	Severe Winter Storm	X
1701	5/16/2007	Severe Storms and Inland and Coastal Flooding	
1642	5/25/2006	Severe Storms and Flooding	
1614	11/10/2005	Severe Storms and Flooding	X
3264	10/19/2005	Severe Storms and Flooding	
3252	9/13/2005	Hurricane Katrina Evacuation	X
3201	2/17/2005	Snow	X
1512	4/21/2004	Flooding	X
3191	1/15/2004	Snow	X
3175	3/11/2003	Snowstorm	X
1364	4/10/2001	Severe Storms & Flooding	X
3165	3/28/2001	Snowstorm	
3153	12/6/1999	Fire	X
1224	6/23/1998	Heavy Rain And Flooding	X
1142	10/25/1996	Severe Storms/Flooding	
3119	10/23/1996	Extreme Weather/Flooding	
1090	1/24/1996	Blizzard	
2116	9/12/1995	Russell Fire	
3103	3/16/1993	Blizzards, High Winds and Record Snowfall	X
975	12/21/1992	Winter Coastal Storm	X
920	11/4/1991	Severe Coastal Storm	
914	8/26/1991	Hurricane Bob	X
790	4/18/1987	Severe Storms, Flooding	X
751	10/28/1985	Hurricane Gloria	X
650	12/3/1981	Urban Fire	
546	2/10/1978	Coastal Storms, Flood, Ice, Snow	
3059	2/7/1978	Blizzards and Snowstorms	
405	10/16/1973	Fire (City of Chelsea)	

Disaster No.	Date Declared	Incident Description	Impact to Worcester County
357	9/28/1972	Toxic Algae in Coastal Waters	
325	3/6/1972	Severe Storms, Flooding	
43	8/20/1955	Hurricane, Floods	
22	9/2/1954	Hurricane	
7	6/11/1953	Tornado	

The Commonwealth of Massachusetts State Hazard Mitigation Plan 2010 identified natural hazards that have and may impact the state by grouping them into categories which included flood related hazards, coastal related hazards, atmospheric related and winter related hazards, other natural hazards, geologic hazards and non-natural hazards. For the purposes of this plan, the project team took into consideration the grouped natural hazards and cross referenced them with any regional or local plans and then evaluated the final list of natural hazards on an individual basis. Each campus has a different list of natural hazards that could be of concern. Table 3-3 details the natural hazards that were evaluated by UMMS.

3.3 NATURAL HAZARDS IMPACTING CAMPUS

Each natural hazard in this section is profiled and the vulnerability of the UMMS campus. Each profile includes a description of the hazard, its location, severity and extent of the hazard, and impact of the hazard on life, property and operations. Of the natural hazards that have been considered for this project, UMMS was found to be susceptible to fourteen of them (see Table 3-3). A qualitative or quantitative analysis for each hazard was conducted which is detailed in the sections that follow.

Table 3-3: Quantitative/Qualitative UMMS Natural Hazard Risk Ranking

Natural Hazard	UMMS Susceptible?	Quantitative/Qualitative
Drought	Yes	Qualitative
Hailstorm	Yes	Qualitative
Coastal Storm/Nor'Easter	Yes	Qualitative
Extreme Heat	Yes	Qualitative
Thunderstorm/Lightning	Yes	Qualitative
Tornado	Yes	Qualitative
Earthquake	Yes	Quantitative and Qualitative
Ice Storm	Yes	Qualitative
Windstorm	Yes	Qualitative
Flood	Yes	Quantitative and Qualitative
Winter Storm	Yes	Qualitative
Dam Failure	Yes	Qualitative
Wildfire	Yes	Qualitative
Hurricane	Yes	Qualitative
Ice Jam	No	Not Applicable
Avalanche	No	Not Applicable
Volcano	No	Not Applicable
Landslide	No	Not Applicable
Tsunami	No	Not Applicable

3.3.1 Hazards Not Profiled

Throughout the hazard identification process, it became evident that there were a number of natural hazards that were not relevant to UMMS and though initially considered, were not profiled for this plan. Table 3-4 indicates what these hazards were and why they were not included in this evaluation.

Table 3-4: Natural Hazards Not Profiled

Hazard Type	Hazard Description	How Susceptibility Was Determined	Susceptibility Factors
Landslide	The sliding down of a mass of earth or rock from a mountain or cliff. When a slope is greater than 10 degrees and/or vegetative cover is low and soil water is high, a slide is more likely.	Review of Massachusetts State Hazard Mitigation Plan	The plan notes that based on the US data set for landslides, areas along the Connecticut River in western Massachusetts and the greater Boston area have the highest risk to landslide. Due to the location of UMMS, it was determined that the likelihood of campus being impacted was minimal so evaluation of this hazard was not prioritized.
Avalanche	A rapid fall or slide of a large mass of snow down a mountainside.	Review of Massachusetts State Hazard Mitigation Plan	Avalanches are not included in the MA State Hazard Mitigation Plan.
Volcano	A mountain that opens downward to a reservoir of molten rock below the surface of the earth. Volcanoes erupt when pressure from gases and the molten rock beneath becomes strong enough to cause an explosion.	Review of Massachusetts State Hazard Mitigation Plan	No volcanoes are located within the vicinity of the UMass campuses.
Ice Jam	Formation of ice over a body of water that limits the flow of the water due to freezing. Ice jam. Flooding occurs when warm temperatures and heavy rain cause the snow to melt rapidly, causing frozen rivers or lakes to overflow. The ice that is formed on top of the body of water breaks into small pieces of varying sizes.	Review of Massachusetts State Hazard Mitigation Plan	Ice jams are discussed in the State Plan as mostly occurring in the western part of the state. The major hazard associated with an ice jam is flooding. Evaluation of this hazard was not prioritized.
Tsunami	An occurrence characterized by a series of waves that are generated by an undersea disturbance such as an earthquake. The speed of a tsunami can range from 500 miles per hour to 20-30 miles per hour in shallower coastline conditions.	Review of Massachusetts State Hazard Mitigation Plan	Tsunami is listed as a potential hazard in the State Plan for coastal areas of Massachusetts. The UMMS campus is located within an inland community, the City of Worcester.

3.4 NATURAL HAZARD RANKINGS

As a result of on-campus interviews and a follow up group meeting, in May 2014, the UMMS Hazard Mitigation Planning Committee ranked the natural hazards that have or may impact the campus in the future according to a Hazard Ranking of Low, Medium, High or Severe. A qualitative ranking (on a scale of 0 to 5) in the categories of frequency, severity, duration and intensity was prepared after the hazards were identified and vetted. For UMMS, the hazards were then weighted regarding the probability (40% which included rankings of frequency, duration and intensity) that the hazard would impact the campus and the consequences (60% which included rankings of severity) that would be realized by the campus.

Probability

Frequency + Duration + Intensity/3 = Probability

Consequence

Severity

Total

*Probability *.4 + Consequence * .6 = Total*

Hazard rankings were assigned based on the overall probability and consequence total. UMMS received an overall low, medium or high for each identified hazard. Table 3-5 below summarizes the ranges that UMMS used for the natural hazard rankings.

Table 3-5: Natural Hazard Numerical Ranking Ranges

	Low	Medium	High	Severe
UMMS	1.0-2.0	2.0-2.5	2.5-3.50	3.50+

In general, hazards with a low estimated frequency, duration, severity and intensity are expected to have minimal to no impact on the campus. Hazards with a high frequency, duration, severity and intensity were given a higher mitigation priority. Higher rankings may be more likely to occur on a regular basis or within the next five years and could result in substantial impacts on campus with regard to economic damage, loss of function and operations of the campus and human injury. (Table 3-6 provides a summary of the rankings).

Table 3-6: UMMS Natural Hazard Risk Ranking Summary

Natural Hazard	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability F,D,I (40%)	Consequence S (60%)	Total	Ranking L,M,H,S
Drought	1	1	1	1	1.00	1.00	1.00	L
Hailstorm	1	1	1	1	1.00	1.00	1.00	L
Coastal Storm/Nor'Easter	3	2	2	2	2.33	2.00	2.13	M
Extreme Heat	1	2	3	2	1.67	3.00	2.47	M
Thunderstorm/Lightning	3	2	2	2	2.33	2.00	2.13	M
Tornado	1	1	3	3	1.67	3.00	2.47	M
Earthquake	1	1	3	3	1.67	3.00	2.47	M
Ice Storm	2	3	3	3	2.67	3.00	2.87	H
Windstorm	4	2	2	3	3.00	2.00	2.40	M
Flood	1	2	2	2	1.67	2.00	1.87	L
Winter Storm	4	3	3	2	3.00	3.00	3.00	H
Dam Failure	1	2	2	1	1.33	2.00	1.73	L
Wildfire	1	2	2	2	1.67	2.00	1.87	L
Hurricane	2	4	4	4	3.33	4.00	3.73	S

3.5 NATURAL HAZARD PROFILES

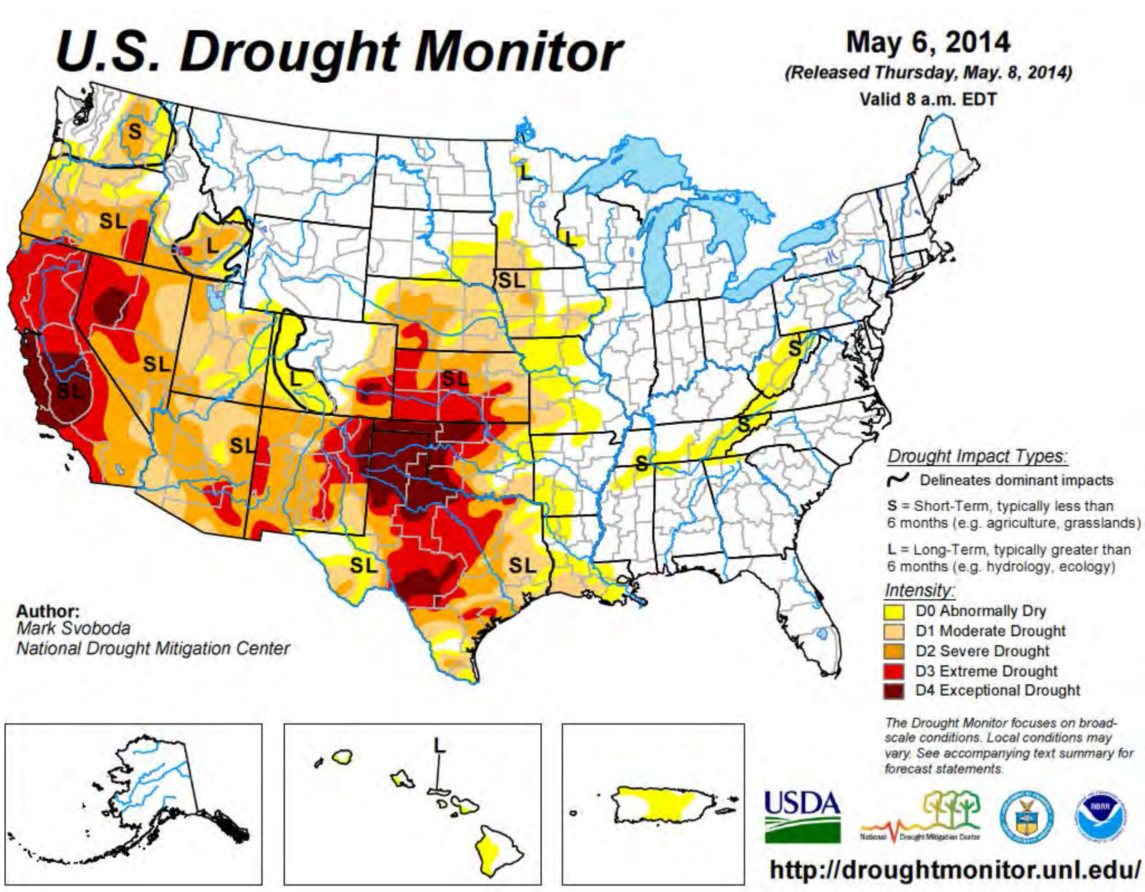
3.5.1 Drought

Drought occurs when there is an insufficient amount of moisture that has adverse impacts on people, animals or vegetation over a geographic area. Drought can occur over a prolonged period of time where the lack of precipitation directly impacts the hydrologic balance of the environment. Examples of impact include water supply shortages, dry soils that may result in crop failure and changed fish and wildlife behavior including death. Other weather characteristics like consistently high temperatures and low humidity can exacerbate the problem. Results of prolonged drought periods can also have a disastrous economic impact on communities and regions that rely upon water for agriculture and tourism type activities.

3.5.1.1 Location of Drought

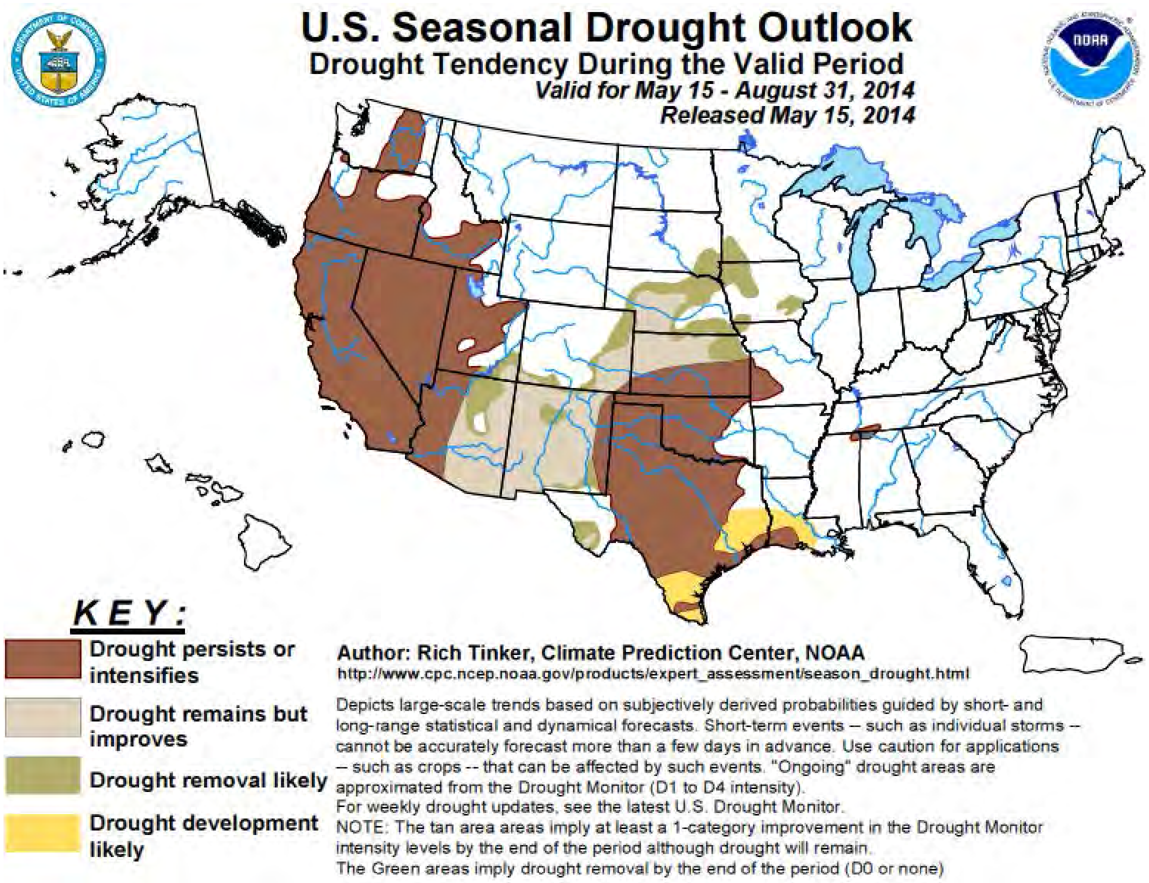
Massachusetts is often considered a “water-rich” state and Worcester typically receives more than 45 inches of rainfall, about 70 inches of snowfall and more than 45 inches of other precipitation (e.g., rain, freezing rain, sleet, etc.) on an annual basis. Massachusetts and Worcester are not immune from experiencing drought conditions and they most often occur when there has been a dry winter. As of May 2014, Massachusetts is not experiencing drought conditions (see Figure 7 below). However, between November 2013 and January 2014, Worcester’s drought status fluctuated between abnormally dry and moderate drought due to lack of rain and very low soil moisture and stream/river flow.

Figure 7: Drought Monitor



NOAA also produces a seasonal drought outlook that depicts large, long-term trends for the United States. NOAA's drought outlook through August 31, 2014 indicates Massachusetts and Worcester are not anticipated to experience drought conditions (see Figure 8).

Figure 8: U.S. Seasonal Drought Outlook



3.5.1.2 Severity and Extent of Drought

During 2012, the US Department of Agriculture (USDA) declared a federal drought disaster in 26 states which was the largest, single drought disaster declaration ever made by USDA. By November 2012, approximately 80% of the United States was designated a drought disaster-affected area.

According to the Massachusetts Drought Management Plan, a number of drought indices are available to assess the various impacts of dry conditions. The state uses a multi-index system that takes advantage of several of these indices to determine the severity of a given drought or extended period of dry conditions.

3.5.1.3 Drought Indices[1]

The following describe the seven drought indices used by the Commonwealth to assess the drought level in Massachusetts:

[1] Massachusetts Drought Management Plan, 2013

- Standardized Precipitation Index (SPI) – an index reflecting soil moisture and precipitation conditions; calculated monthly using Massachusetts Rainfall Database at Department of Conservation and Recreation (DCR), Office of Water Resources. The SPI values are calculated for previous 1-, 3-, 6-, or 12 month periods.
- Crop Moisture Index (CMI) – an index that reflects short-term soil moisture conditions as used for agriculture; available from the National Climate Data Center.
- Keetch-Bynam Drought Index (KBDI) – an index for forest fire control designed to assess fire potential. The index is continuous relating to the flammability of organic material in the ground and attempt to measure the amount of precipitation needed to return the soil to full field capacity. The KBDI is reported weekly by the DCR Bureau of Fire Control.
- Precipitation – a comparison of measured precipitation amounts to historic normal precipitation. Cumulative amounts for 3-, 6- and 12-month periods are factored into the drought determination. This data is available from the DCR, Office of Water Resources.
- Groundwater levels – an index based on the number of consecutive months ground-water levels are below normal (lowest 25% of period of record). USGS provides monthly groundwater conditions maps showing areas of above normal, normal, and below normal groundwater levels.
- Streamflows – an index based on the number of consecutive months streamflow levels are below normal (lowest 25% of period of record). Streamflow conditions maps showing areas of above normal, normal and below normal streamflow are provided monthly by the USGS.
- Reservoirs – an index based on the level of small, medium, and large index reservoirs across the state. The reservoir level compared to normal conditions is considered. The DCR Office of Water Resources, as part of its monthly conditions report, maintains a list of index water supply reservoirs and their percent full.

Table 3-7 defined the drought indices for Massachusetts according to the 2013 Drought Management Plan.

Table 3-7: Drought Indices (Massachusetts Drought Management Plan, 2013)

Drought Level	SPI	CMI*	KBDI*	Precipitation	Groundwater	Streamflow	Reservoir***
Normal	3-month >-1.5 or 6-month >-1.0 or 12-month > -1.0	0.0 to -1.0 slightly dry	< 200	1 month below normal	2 consecutive months below normal**	1 month below normal**	Reservoir levels at/near normal for the time of year
Advisory	3-month=-1.5 to -2 or 6-month=-1 to-1.5 or 12 month= -1 to -1.5	-1.0 to –1.9 abnormally dry	200-400	2 month cumulative below 65% of normal	3 consecutive months below normal**	At least 2 out of 3 consecutive months below normal**	Small index Reservoirs below normal
Watch	3-month <-2 or 6-month=-1.5 to-3 or 12 month=-1.5 to -2	-2.0 to –2.9 excessively dry	400-600	1 of the following criteria met: 3 month cumulative. < 65% or 6 month cumulative < 70% or 12 month cumulative < 70%	4 to 5 consecutive months below normal**	At least 4 out of 5 consecutive months below normal**	Medium index Reservoirs below normal
Warning	6-month < 3 or 12-month= -2 to -2.5	< -2.9 severely dry	600-800	1 of the following criteria met: 3 month cumulative < 65% and 6 month cumulative <65% or 6 month cumulative <65% and 12 month cumulative <65% or 3 month cumulative <65% and 12 month cumulative <65%	6 to 7 consecutive months below normal**	At least 6 out of 7 consecutive months below normal**	Large index reservoirs below normal
Emergency	12-month < -2.5	<-2.9 severely dry	600-800	Same criteria as Warning and Previous month was Warning or Emergency	>8 months below normal	>7 months below normal	Continuation of previous month's conditions

*The Crop Moisture Index (CMI) is subject to frequent change. The drought level is based on the repeated or extended occurrence at a given level.

** Below normal for groundwater and streamflow is being within the lowest 25th percentile of the period of record

*** Water suppliers should be consulted to determine if below normal reservoir conditions are due to operational issues

3.5.1.4 Impact of Drought on Life, Property and Operations

Drought can substantially impact varying sectors like agriculture, wildfire and recreation, energy, municipal and fish and wildlife. Decreasing flow of streams and rivers due to lack of precipitation can secondarily impact drinking water supplies, wildlife and recreational activities. It can also impact other users such as power generation and water and wastewater utilities. In a campus setting, drought conditions could impact landscaping, laboratory functions, food service, and drinking water for students and faculty.

3.5.1.5 Previous Occurrences of Drought Hazard

According to FEMA, there has never been a Presidential Disaster Declaration made for a drought in the Commonwealth of Massachusetts. At UMMS, there are no records of a drought impacting the campus. For eastern Massachusetts in general, specific details from the National Climatic Data Center (NCDC) Storm Events Database were available regarding two drought occurrences between 2000 and 2013.

- April 2012 – The U.S. Drought Monitor declared a severe drought across over southern Worcester County, including the City of Worcester, from April 12 – April 24. Precipitation had been half of the normal amount between January 2012 and April 2012 and rivers and streams were running at low levels during the spring run-off season. One major impact of this meteorological drought was an increase in fire danger.
- April 1999 – Worcester Municipal Airport recorded the second driest April on record with a monthly precipitation of 0.92 inches.

3.5.1.6 Probability of Future Occurrence of Drought Hazard

While drought is listed in the State Hazard Mitigation Plan as having a widespread statewide impact, it was ranked as having a low frequency of occurrence. The most severe drought on record in Massachusetts occurred between 1961 and 1969. The Worcester, Massachusetts area has experienced two drought scenarios of note in the past fifteen years, or an average of 0.13 drought events per year. Past drought occurrences can be an indicator of the probability of future drought events, both long and short term.

3.5.1.7 Vulnerability to Drought Hazard

UMMS receives its water supply from the City of Worcester, which obtains its drinking water from ten reservoirs located outside the City of Worcester. In addition to the ten active reservoirs, The City of Worcester has two inactive wells and two inactive reservoirs available in the event of an emergency, such as a water shortage or water contamination. Table 3-8 includes information about the location, size, and activation status for the reservoirs that supply water to the City of Worcester.

Table 3-8: City of Worcester Water Sources

Water Source Name	Location	Status	Storage Capacity (million gallons)
Lynde Brook Reservoir	Leicester	Active	717.4
Kettle Brook Reservoir 1	Leicester	Active	19.3
Kettle Brook Reservoir 2	Leicester	Active	127.3
Kettle Brook Reservoir 3	Leicester, Paxton	Active	152.3
Kettle Brook Reservoir 4	Paxton	Active	513.7
Holden Reservoir 1	Holden	Active	729.3

Water Source Name	Location	Status	Storage Capacity (million gallons)
Holden Reservoir 2	Holden	Active	257.4
Kendall Reservoir	Holden	Active	792.2
Pine Hill Reservoir	Paxton, Holden, Rutland	Active	2,971
Quinapoxet Reservoir	Holden, Princeton	Active	1,100
Coal Mine Brook Well	Lake Ave North, Worcester	Inactive	Data not available
Shrewsbury Well	Holden Street, Shrewsbury	Inactive	Data not available
Wachusett Reservoir	Boyleston, Clinton, Holden, Hubbardston, Leominster, Rutland, Sterling, Princeton, West Boyleston	Inactive	6,500
Quabbin Aqueduct	South Barre to West Boylston	Inactive	4,120

Table 3-8 summarizes drought information reviewed for the geographic areas (local, regional, state) that are associated with overall drought conditions and UMMS. According to the Central Massachusetts Regional Planning Commission (CMRPC), the region has no record of a drought-related declaration, though certain parts of Massachusetts do experience drought conditions at times. Frequency of occurrence is low, and should a drought event occur, impacts would vary throughout the region. Drought susceptibility factors for UMMS are presented in Table 3-9.

Table 3-9: Drought Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State of Massachusetts (2013) Hazard Mitigation Plan • Review of FEMA's Multi-Hazard Identification and Risk Assessment • Anecdotal Information from UMMS • NOAA NCDC North American Drought Monitor Map and data • UMass Memorial Medical Center HVA (2014)	• According to the NCDC North American drought monitor, Massachusetts is not currently (as of May 2014) suffering from any type of drought condition. • Drought was ranked in the State Hazard Mitigation Plan as having a low frequency of occurrence, with minor to serious severity, and having a widespread statewide impact. • Massachusetts has a Drought Management Task Force who prepared a Drought Management Plan that notes western Massachusetts may be more vulnerable than eastern Massachusetts to severe drought conditions. • Massachusetts has experienced multi-year drought periods and the most severe drought on record in the northeastern U.S. was during 1961-69. • There was one record of a drought event during the last 10 years affecting the City of Worcester, where UMMS is located. • UMass Memorial Medical Center ranked identified drought as a low vulnerability hazard in 2014.

3.5.1.8 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a drought hazard event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a drought utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-10).

Table 3-10: Risk Assessment – Drought Hazard

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Drought	1	1	1	1	1.00	1.00	1.00	L

After reviewing the initial ranking of low and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-11).

Table 3-11: Qualitative Risk Assessment – Drought Hazard

	Drought Hazard - Qualitative Ranking
Risk Ranking	Low
Students, Faculty & Staff	Low
Existing Buildings	Low
Future Buildings	Low
Operations	Low
Critical Infrastructure	Low

As a result of considering these additional factors, the overall ranking remained low.

3.5.1.9 Future Development Considerations

UMMS will consider drought hazard scenario planning during discussions about the future of endeavors of the campus. Measures should be in place to position the campus favorably should a drought scenario occur that would impact the water supply to UMMS and/or the ability of UMMS to conduct day to day activities. The following considerations will be incorporated into future planning activities.

- Adequate fire suppression ability for emergency response activities at UMMS,
- Possibility of capturing and reusing water at UMMS for a variety of purposes,
- Development of emergency procedures, or a clear understanding of City of Worcester emergency procedures for back up or interim water supply options and connections should there be disruption of service to the City of Worcester.

3.5.2 Hailstorm

A hailstorm is considered to be associated with hail when irregular pellets or balls of ice more than 5mm in size are present. Hail is formed when an updraft in a thunderstorm carries rain into parts of the atmosphere where the temperature is below freezing. Any thunderstorm that produces hail that reaches the ground is known as a hailstorm.

3.5.2.1 Location of Hailstorm

Hail can occur anywhere in Massachusetts and is typically part of a larger storm system such as severe thunderstorms and tornado events.

3.5.2.2 Severity and Extent of Hailstorm

Table 3-12 illustrates common terms to describe hail and what size diameter is associated with that description.

Table 3-12: Hail Descriptions and Diameter Sizes

Description	Diameter (inches)
Pea	0.25
Marble or Mothball	0.50
Penny or Dime	0.75
Nickel	0.88
Quarter	1.00
Half Dollar	1.25
Walnut or Ping Pong Ball	1.50
Golfball	1.75
Hen's Egg	2.00
Tennis Ball	2.50
Baseball	2.75
Tea Cup	3.00
Grapefruit	4.00
Softball	4.5

The presence of large hail indicates very strong updrafts and downdrafts within a thunderstorm, which can also be a possible indicator for tornado activity. The National Weather Service classifies a thunderstorm as severe is if the storm produces hail greater or equal to 0.75 inch in diameter. When hail does occur, it typically lasts for several minutes.

3.5.2.3 Impact of Hailstorm on Life, Property and Operations

According to NOAA, hail causes $1 billion in damage to crops and property each year in the United States. Agriculture is most affected due to crop damage, even from small size hail. Damage to vehicles, roofs, and landscaping are also common. The impact of hail on public safety is usually minimal unless large diameter hail occurs.

3.5.2.4 Previous Occurrences of Hailstorm Hazard

At UMMS, there are no records of a hailstorm impacting the buildings. The NCDC tracks storm events and the information in Table 3-13 was available for the City of Worcester and other nearby communities regarding hail occurrences.

Table 3-13: Hail Event Data for Worcester and Surrounding Communities 2000 - 2014

Location	Date	Size	Death	Injury	Property Damage
SHREWSBURY	06/18/13	1.00 in	0	0	0.00 K
WORCESTER COUNTY	6/01/2011	2.00 in.	0	0	55.00K
WORCESTER	9/13/2010	1.00 in.	0	0	0.00 K
LEICESTER	7/21/2010	0.88 in.	0	0	0.00 K
SHREWSBURY	5/26/2010	1.00 in.	0	0	0.00K
NORTHBOROUGH	07/08/09	0.75 in.	0	0	0.00 K
WESTBOROUGH / AUBURN	7/07/2009	0.75 in.	0	0	0.00 K
WORCESTER COUNTY	5/24/2009	2.00 in.	0	0	55.00K
WORCESTER	7/01/2008	1.00 in.	0	0	0.00 K
WORCESTER	7/01/2008	0.75 in.	0	0	0.00 K
WORCESTER	6/23/2008	0.75 in.	0	0	0.00 K
HOLDEN	8/02/2006	0.75 in.	0	0	0.00 K
AUBURN	7/11/2006	0.75 in.	0	0	0.00 K
LEICESTER	6/20/2006	0.88 in.	0	0	0.00 K
NORTHBOROUGH	8/20/2004	1.25 in.	0	0	25.00 K
SHREWSBURY	8/22/2003	0.75 in.	0	0	0.00K
NORTHBOROUGH	5/27/2002	0.75 in.	0	0	0.00 K
WEST BOYLSTON	7/10/2001	0.75 in.	0	0	0.00 K
LEICESTER	05/10/2000	0.75 in.	0	0	0.00 K
Source: NCDC Storm Events Database http://www.ncdc.noaa.gov/stormevents/					

Specific details from the more substantial hail events in Worcester County from January 1, 2000 through May 2014 include the following:

- June 1, 2011 – Thunderstorms formed ahead of a cold front creating a favorable environment for tornado formation. An EF-3 tornado touched down in West Springfield through Sturbridge. Parts of Worcester County experienced hail up to two inches in diameter as a result of this storm.
- September 13, 2010 – Showers and thunderstorms produced large hail up to 1.5 inch diameter in Worcester with surrounding areas experiencing damaging winds and hail as a result of the storm.
- May 26, 2010 – Showers and thunderstorms resulted in hail (1.0 inch in diameter) in Shrewsbury. Showers and thunderstorms produced significant wind damage throughout much of the Connecticut River Valley in Massachusetts.
- May 24, 2009 – Severe thunderstorms produced hail in several areas of Worcester County. Golf size hail (1.75 inch in diameter) in Shrewsbury dented cars and 2.0 inch diameter hail in Grafton caused damage to the screens and vinyl siding of a house and broke car windows.
- August 10, 2008 – Hail was produced during thunderstorms due to cold upper level temperatures creating an unstable atmosphere. Quarter-sized hail fell in parts of Worcester and surrounding areas experienced damaging flooding, winds, and lightening as a result of the storm.

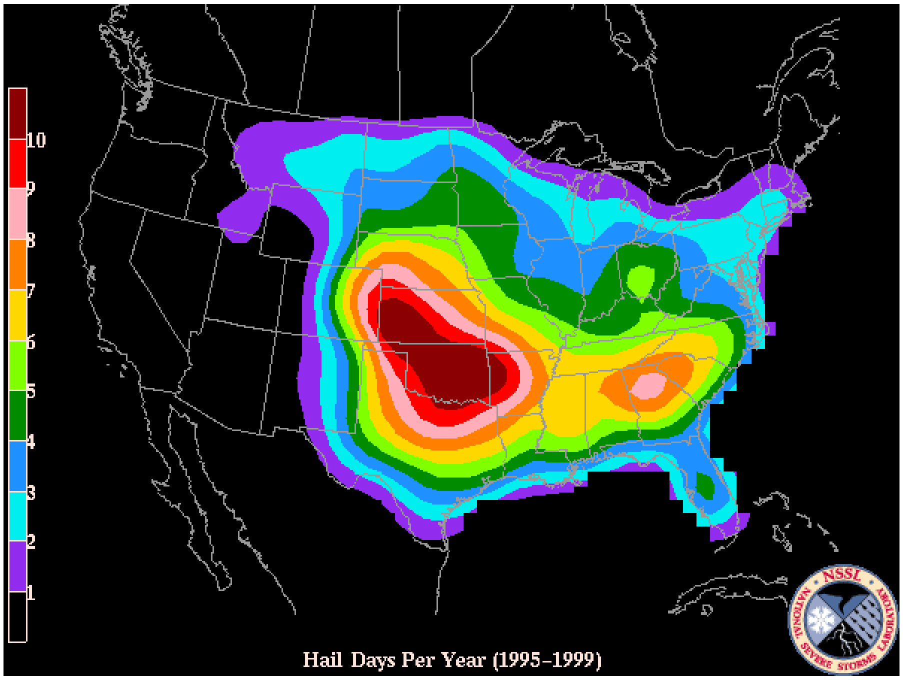
- July 1, 2008 – A cold front hit southern New England causing thunderstorms with wind and hail. Penny sized hail fell in areas of Worcester as part of the storm. Areas near Worcester experienced flooding and/or damaging thunderstorm wind as part of this storm system.
- June 23, 2008 – A mesoscale convective system produced 0.75 inch diameter hail and strong winds in Worcester, Massachusetts and the surrounding area.
- August 20, 2004 – Severe thunderstorms brought gusty winds and large hail to western, central and northeast Massachusetts. In Northborough, the storm produced 1.25 inch diameter hail.
- August 22, 2003 – Severe thunderstorms produced 0.75 inch hail in Shrewsbury. Downed trees, wires, and large branches were reported throughout much of Worcester County.

3.5.2.5 Probability of Future Occurrence of Hailstorm Hazard

The probability of a future occurrence of a hailstorm event at UMMS is likely. Thunderstorm/lightning events are certain to occur in the future and hail can sometimes be associated with those events. In general, southern New England experiences 10-15 days per year in which there are severe thunderstorms and hail is often associated with these events. Large hailstones can fall faster than 100 mph and can be very costly in terms of economic losses.

NOAA's National Severe Storm Laboratory (NSSL) has estimated the likelihood for hail at least 0.75 inches in diameter or damaging hail on a given day in the United States. Figure 9 shows that the probability for hail with a diameter of at least 0.75 inches or damaging hail occurring within 25 miles of Worcester, Massachusetts is one to two days per year based on hail data collected from 1995 to 1999.

Figure 9: Hail[2] Days Per Year in the United States, NOAA's (NSSL)



Source: http://www.nssl.noaa.gov/projects/hazard/totalthreat.html

[2] Hail was included in this figure if the hail was at least 0.75 inches in diameter or damaging.

3.5.2.6 Vulnerability to Hailstorm Hazard

UMMS is located in a region that is vulnerable to hailstorm events. Hail typically occurs during other events such as thunderstorm/lightning, complex winter storms, and tornadoes, all of which this area of Massachusetts is vulnerable to. Table 3-14 discusses UMMS's susceptibility to a Hailstorm event.

Table 3-14: UMMS Hailstorm Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State of Massachusetts (2013) Hazard Mitigation Plan • Review of FEMA's Multi-Hazard Identification and Risk Assessment	• Thunderstorms are discussed in the state plan which notes that the entire state is susceptible and that hail is a common occurrence during these events. • Hailstorms causing property damage have occurred in Worcester County.

3.5.2.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a hailstorm hazard event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a hailstorm utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-15).

Table 3-15: Risk Assessment – Hailstorm Hazard

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Hailstorm	1	1	1	1	1.00	1.00	1.00	L

After reviewing the initial ranking of low and conducting further research, specific consideration was given to how a hail event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-16).

Table 3-16: Qualitative Risk Assessment – Hailstorm Hazard

	Hailstorm Hazard - Qualitative Ranking
Risk Ranking	Low
Students, Faculty & Staff	Low
Existing Buildings	Low
Future Buildings	Low
Operations	Low
Critical Infrastructure	Low

As a result of considering these additional factors, the overall ranking remained low.

3.5.2.8 Future Development Considerations

UMMS will consider hailstorm hazard scenario planning during future endeavors and continue to implement measures to mitigate the impact of hail occurrences. Preventing a hail event is not plausible, but limiting the effects on UMMS is feasible. Future considerations include the following:

- Coordinate communication and tracking of weather and emergency information with City of Worcester officials, and
- Coordinate outreach to the public with consistent messaging, information, and instructions via public broadcast, websites, email, and social media for watches and warnings issued by the National Weather Service.

3.5.3 Nor'easter

Nor'Easters are common occurrences in the eastern United States and Massachusetts. They are capable of causing substantial damage to coastal (and at times, inland) areas due to strong winds (can be hurricane force), storm surge and substantial rainfall or snow amounts. A storm is specifically a Nor'easter when the wind blows in from the northeast and pushes the storm up the east coast of the United States. These types of storms can occur anytime of the year, but are more common in the winter months.

3.5.3.1 Location of Nor'easter

Massachusetts falls within the designated area known as the North Atlantic Coast, which is generally considered to be the coastal area from Long Island, NY to northern Maine. The North Atlantic Coast is most vulnerable to nor'easters, tropical storms and reduced strength hurricanes because the flooding, erosion and wind damage can be substantial to physical property and natural surroundings. A nor'easter includes a cyclonic storm that moves along the east coast that most often includes snow accumulations over nine inches, gale force winds, and storm surge that can cause severe flooding near the coastline. One or two nor'easters typically impact the Massachusetts coastline (and inland areas) per year between October and April and causes shoreline erosion, flooding and property damage.

3.5.3.2 Severity and Extent of Nor'easter

Nor'easter events can have a range of impacts on communities located along the shoreline. Heavy sustained winds and rainfall coupled with a high tide and wind driven storm surge can cause more of an impact than just a regular storm event. Contributing to the severity of coastal storms is climate change and sea level rise which increase the volume of water in the ocean from melting ice sheets and glaciers. According to a report by the Coastal Zone Management (CZM) office "Preparing for the Storm" during the past 100 years, the relative sea level has risen nearly 10 inches. The Intergovernmental Panel on Climate Change (IPCC) has predicted that sea level rise and the risks that it poses to the built environment and shorelines will continue to accelerate over the next 100 years as well.

3.5.3.3 Impact of Nor'Easter on Life, Property and Operations

In Massachusetts, nor'easters are regular events that cover large geographic areas. Coastal and adjacent low-lying areas are most often inundated by seawater and one area of concern is coastal flooding due to storm surge during these events. High winds, erosion, heavy surf and heavy rain can all impact life, property and operations. Depending on the length and strength of the storm, death or serious injury, property damage and operations of local government and businesses can all occur. UMMS is not in a coastal location, but a common secondary impact of a nor'easter, is short and long term electrical power outages which could impact campus.

3.5.3.4 Previous Occurrences of Nor'easter

According to FEMA, there have been two Presidential Disaster Declarations made for "nor'easters" in the Commonwealth of Massachusetts (Table 3-17). While Worcester County was not a designated area for all of the Presidential Disaster Declarations for Nor'easters in Massachusetts, UMMS has experienced varying degrees of impacts from these storms, including significant snowfall accumulations.

Table 3-17: Massachusetts Nor'easter Major Disaster Declarations (1954 – Present)

	Disaster No.	Incident Period	Date Disaster Declared	Worcester County a Designated Area?
Severe Storms and Inland and Coastal Flooding	1701	4/15/2007 – 4/25/2007	5/16/2007	No
Massachusetts Winter Coastal Storm	975	12/11/1992 – 12/13/1992	12/21/1992	Yes
Coastal Storms, Flood, Ice and Snow	546	2/6/1978 – 2/8/1978	2/10/1978	No
Source: FEMA Disaster Declarations 1954 – Present				

The National Climatic Data Center (NCDC) tracks storm events and one event was listed for Worcester County regarding nor'easter occurrences:

- March 31 – April 1, 1997 - resulted in 33 inches of snow in Worcester and about 250,000 customers were left without power in the Commonwealth of Massachusetts.

NOAA's National Climatic Data Center, State of the Climate: National Snow and Ice for Annual 2013 highlights a nor'easter event that occurred on February 7 – 10, 2013 that impacted the East Coast of the United States, including Worcester, Massachusetts. This nor'easter was rated a Category 3 (major) on NOAA's Northeast Snow Impact Scale (NESIS) due, in part, to the heavy snowfall in the Boston metropolitan areas.

3.5.3.5 Probability of Coastal Storm/Nor'easter Hazard

Coastal Storms/Nor'easters are certain to occur in the future and will continue to impact the City of Worcester and UMMS.

3.5.3.6 Vulnerability to Coastal Storm/Nor'easter Hazard

UMMS is vulnerable to future nor'easter events. The susceptibility criteria are detailed in Table 3-18.

Table 3-18: Nor'easter Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Massachusetts Hazard Mitigation Plan (2013) • Review of FEMA's Multi-Hazard Identification and Risk Assessment • Central Massachusetts Region Wide Pre-Disaster Mitigation Plan (2012) • Worcester, MA website www.worcesterMA.gov • Anecdotal Information from UMMS	• Nor'easters are discussed in the state plan as a common cause of flooding and snowstorms. • The state plan notes that Nor'easters have an average frequency of 1 or 2 per year with a storm surge equal to or greater than 2.0 feet. The duration of high surge and winds in a Nor'easter can be from 12 hours to 3 days. • The Worcester, MA website states the Great Northeast Blizzard of 1978 killed 100 people and injured more than 4,000 people in the northeast.

3.5.3.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a Nor'easter hazard event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Nor'easter utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-19).

Table 3-19: Risk Assessment – Nor'easter Hazard

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Nor'easter	3	2	2	2	2.33	2.00	2.13	M

After reviewing the initial ranking of medium and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-20).

Table 3-20: Qualitative Risk Assessment – Nor'easter Hazard

	Nor'easter Hazard - Qualitative Ranking
Risk Ranking	Medium
Students, Faculty & Staff	Low
Existing Buildings	Low
Future Buildings	Low
Operations	Medium
Critical Infrastructure	Medium

As a result of considering these additional factors, the overall ranking remained medium.

3.5.3.8 Future Development Considerations

Nor'easters are of mild concern to UMMS. During future planning, the following items will be considered:

- Evaluate Nor'easter impacts after storm events and plan for recovery and redevelopment once existing conditions are known.
- Ensure that there are multiple ingress/egress routes available for faculty, staff and students that can be utilized during a Nor'easter event.

3.5.4 Winter Storm/Blizzard

Winter storms typically consist of varying forms of precipitation including snow, sleet, freezing rain, or a mix of these wintry conditions. Blizzards are the most dangerous and severe type of winter storm and are characterized by strong, sustained winds of at least 35 mph that last for a prolonged period of time – typically 3 hours or more. An ice storm is another form of winter storm that is defined as an event which results in the accumulation of at least .25-inch of ice on exposed surfaces and they occur when moisture falls and freezes immediately upon impact on trees, powerlines, roads, structures and other surfaces. These types of storms can down trees, cause lengthy, widespread power outages, damage property and even cause fatalities.

3.5.4.1 Location of Winter Storm/Blizzard

The entire State of Massachusetts is at risk for winter storm events. According to the State Hazard Mitigation Plan, higher snow accumulations are more common at higher elevations in Central and Western parts of the state.

3.5.4.2 Severity and Extent of Winter Storm/Blizzard

Winter storms can include snow storms with strong winds (often referred to as blizzards), extreme cold spells that can cause rivers to freeze resulting in ice jams that can lead to flooding, ice storms that produce heavy accumulations of ice, and heavy snow storms that result in above average snow accumulations.

NOAA's National Climatic Data Center (NCDC) implemented the Regional Snowfall Index (RSI) to categorize significant snowstorms impacting the eastern two thirds of the United States. The RSI includes a regional index for the northeastern United States (including Massachusetts) and accounts for snowfall accumulations, population data, and area affected (see Figure 10). The index is similar to the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes.

Figure 10: NCDC Regional Snowfall Index (RSI)

Category	RSI Value	Description
1	1–3	Notable
2	3–6	Significant
3	6–10	Major
4	10–18	Crippling
5	18.0+	Extreme

Source: http://www.ncdc.noaa.gov/snow-and-ice/rsi/?nesis

3.5.4.3 Impact of Winter Storm/Blizzard on Life, Property and Operations

Winter Storms can result in fatalities that are most often not directly related to the storm itself. Fatalities due to traffic accidents on icy roads, heart attacks from excessive shoveling, and hypothermia from prolonged exposure to the cold occur. Risks related to snow and ice are most often associated with automobile accidents followed by individuals caught outside in the storm. Fatalities due to cold exposure are most often associated with infants and the elderly that are most susceptible.

Impacts to property and operations are usually temporary and include snow removal. However, heavy snow can lead to significant snow removal costs, infrastructure damages (such as weight of snow on roofs), and loss of business that can financially impact communities. Other potential impacts include knocked down trees, power lines, and utility poles. Freezing temperatures can result in downed trees, power lines, utility poles, ice jams that can cause flooding, and building pipe bursts due to poor insulation or lack of heat.

Winter storms and blizzards impact UMMS students and staff, particularly when travelling to and from campus during or immediately following these events. Some departments on campus require onsite staffing even during winter storms/blizzards. UMMS tends to receive a large call volume during winter storms and events, presumably due to staff and students checking on the closure status of the campus or staff calling out of work. This high call volume sometimes leads to the temporary failure of carrier lines. In addition, in heavy snow, UMMS staff report the air ducts at MassBiologics (Mattapan) can become blocked and flat roofs have leaked from heavy snow loads.

3.5.4.4 Previous Occurrences of Winter Storm/Blizzard Hazard

Since 1954, there have been six Major Disaster Declarations in the State of Massachusetts due to some form of winter storm and five of those have resulted in Worcester County receiving a designated area status from FEMA (see Table 3-21).

Table 3-21: Massachusetts Winter Storm Major Disaster Declarations (1954-Present)

	Disaster No.	Incident Period	Date Disaster Declared	Worcester County a Designated Area?
Severe Winter Storm, Snowstorm, Flooding	4110	2/8/2013 – 2/9/2013	4/19/2013	Yes
Severe Storm and Snowstorm	4051	10/29/2011 – 10/30/2011	1/6/2012	Yes
Severe Winter Storm and Flooding	1813	12/11/2008 – 12/18/2008	1/5/2009	Yes
Blizzard	1090	1/7/1996 – 1/13/1996	1/24/1996	Yes
Winter Coastal Storm	975	12/11/1992 – 12/13/1992	12/21/1992	Yes
Coastal Storm, Flood, Ice, Snow	546	2/6/1978 – 2/8/1978	2/10/1978	No
Source: FEMA Disaster Declarations 1954 – Present				

The NCDC storm event information presented in Table 3-22 was available for Worcester County regarding winter storm and blizzard occurrences.

Table 3-22: Winter Storm/Blizzard Data for Worcester County (January 1, 2000 - February 28, 2013)

Location (County)	Date	Type	Death	Injury	Property Damage
SOUTHERN WORCESTER	2/8/2013	Blizzard	0	0	0.00K
SOUTHERN WORCESTER	2/1/2011	Winter Storm	0	0	552.00K
SOUTHERN WORCESTER	1/21/2011	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	1/18/2011	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	1/11/2011	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	12/26/2010	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	1/28/2009	Winter Storm	0	0	5.00K
SOUTHERN WORCESTER	1/7/2009	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	3/16/2007	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	2/13/2007	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	2/12/2006	Winter Storm	0	0	10.00K
SOUTHERN WORCESTER	3/12/2005	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	3/1/2005	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	1/22/2005	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	1/5/2005	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	12/5/2003	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	3/6/2003	Winter Storm	0	0	75.00K
SOUTHERN WORCESTER	2/17/2003	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	2/7/2003	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	1/3/2003	Winter Storm	0	0	0.00K
SOUTHERN WORCESTER	12/25/2002	Winter Storm	0	0	0.00K
Source: NCDC Storm Events Database http://www.ncdc.noaa.gov/stormevents/					

Specific details from the more significant events noted in the table above that have impacted Worcester include:

- February 8, 2013 - a historic blizzard dumped almost 3 feet of snow in Worcester between February 8 and February 9. This blizzard produced wind gusts of 35 to 50 miles per hour in Worcester. Blizzard conditions were observed at Worcester Regional Airport for a total of eight hours.
- February 1, 2011 – A total of 9 to 15 inches of snow fell across southern Worcester County on February 1 and 2. Up to one quarter of an inch of ice accumulated on isolated locations. Roof collapses occurred to 16 structures due to the heavy snowfall that totaled 92.6 inches by the end of the snow season. Most of this snow fell between December 26 and February 2.
- January 22, 2005 – Worcester Airport received 24.1 inches of snow, which was a top 5 snowstorm for Worcester since records began.
- March 6, 2003 – A total of 5 to 10 inches of snow fell across sections of south central and southeast Massachusetts, with Worcester's snowfall totaling 5 inches. Damage included several vehicle accidents.

Hundreds of people were stranded for several hours after authorities shut down a ten-mile stretch of I-95 from Attleboro to the Rhode Island border.

- February 17, 2003 – A major winter storm impacted southern New England with heavy snow and strong winds. Worcester received 16 inches of snow from February 17-18.

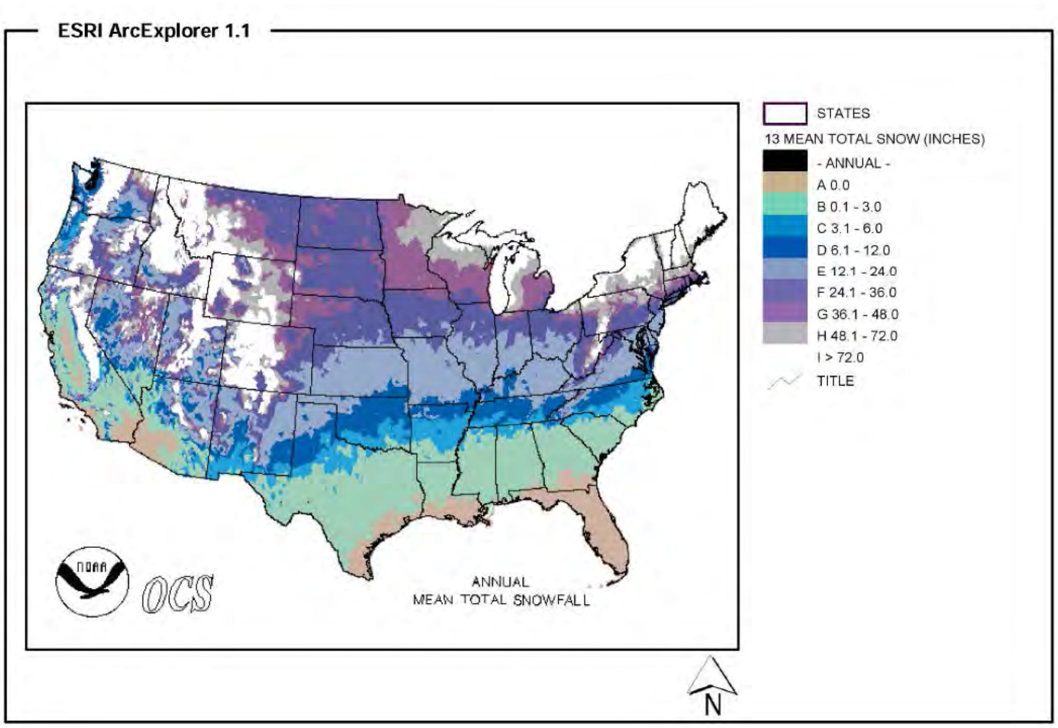
3.5.4.5 Probability of Winter Storm/Blizzard Hazard

The probability of future winter storms impacting UMMS is virtually certain on an annual basis. According to the CMRPC, winter storms have a high frequency in the Worcester region.

3.5.4.6 Vulnerability to Winter Storm/Blizzard Hazard

Data gathered by the National Climatic Data Center (NCDC) indicates that Massachusetts has an annual mean total snowfall between 48 inches and 72 inches (see Figure 11). A review of NOAA's US Snow Monitoring Snowfall Maps for years 2000 to 2010 show the Worcester, Massachusetts area receives an annual average snowfall total between 45 and 60 inches.

Figure 11: Annual Mean Total Snowfall



Source: http://www.threatsummary.forestthreats.org/images/maps/Snowfall_173.jpg

Some of the criteria that were used to determine susceptibility to a winter storm are provided in Table 3-23.

Table 3-23: UMMS Winter Storm/Blizzard Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State Hazard Mitigation Plan (2013) • Central Massachusetts Region Wide Pre-Disaster Mitigation Plan (2012) • Worcester, MA website www.worcesterMA.gov • UMMS Emergency Operation Plan (2011) • UMass Memorial Medical Center vulnerability analysis • Anecdotal Information from UMMS • UMass Memorial Medical Center HVA (2014)	• The state plan notes that although the entire state may be considered at risk, higher snow accumulations appear to be prevalent at higher elevations in Western and Central Massachusetts, and along the coast where snowfall can be enhanced by additional ocean moisture. • The state plan notes that ice storms can arise in any part of the state, however they most frequently occur in the higher elevations of Western and Central Massachusetts. From 1971 to 2009, there have been about 40 ice storm events which impacted at least one or more counties in the Commonwealth. • The Worcester, MA city website notes a blizzard on April 1, 1997 produced 33 inches of snow in Worcester in 24 hours and winter storms in 2008 and on October 30, 2011 a snowstorm resulted in wide-spread power outages and downed tree limbs. • UMMS EOP states there is a strong history of winter storms in the area. • UMass Memorial Medical Center identified Winter Storm as a high vulnerability in 2014. • It was reported anecdotally that UMMS has concerns about student and staff travel during winter storms/blizzards, infrastructure failure of carrier lines due to large call volume, and snow on roofs causing leakage on campus buildings.

3.5.4.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a winter storm/blizzard event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability, and consequence of a winter storm/blizzard utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-24).

Table 3-24: Risk Assessment – Winter Storm/Blizzard

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Winter Storm, Blizzard	4	3	3	2	3.00	3.00	3.00	H

After reviewing the initial ranking of high and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-25).

Table 3-25: Qualitative Risk Assessment – Winter Storm/Blizzard Hazard

	Winter Storm/Blizzard Hazard - Qualitative Ranking
Risk Ranking	High
Students, Faculty & Staff	High
Existing Buildings	Medium
Future Buildings	Medium
Operations	High
Critical Infrastructure	Medium

As a result of considering these additional factors, the overall ranking remained high.

3.5.4.8 Future Development Considerations

UMMS will continue to consider winter storm events during future development and redevelopment endeavors and continue to mitigate the impact of winter storm occurrences. This includes the following mitigation measures:

- Coordinate weather and emergency information with City of Worcester officials.
- Coordinate outreach to the public with consistent messaging, information, and instructions via public broadcast, websites, email, and social media for watches and warnings issued by the National Weather Service.
- Continue to offer and improve remote access to campus resources.
- Coordinate outreach to the UMMS population for winter storm guidance preparation.

3.5.5 Extreme Heat

Extreme heat conditions, sometimes referred to as heat waves, vary throughout the United States. In New England, an extreme heat event is typically recognized when temperatures reach 90°F or higher for three or more consecutive days, although temperature readings below 90°F can constitute an extreme heat event when humidity levels are taken into account. The extended heat event may cause negative impacts to human health. Extreme heat conditions can be accompanied by poor air quality, further impacting persons with breathing ailments, such as asthma.

3.5.5.1 Location of Extreme Heat

Extreme heat events can occur throughout New England, including Worcester, Massachusetts. Urban areas are typically more vulnerable to extreme heat events due, in part, to the urban heat island effect. Air and surface temperatures in urban areas can be approximately 10°F higher than surrounding areas with open land, in part, due to the lack of trees and natural vegetation to provide shade and absorb carbon dioxide, replacement of vegetation with impervious materials, and waste heat from industry, vehicles, and air conditioning.

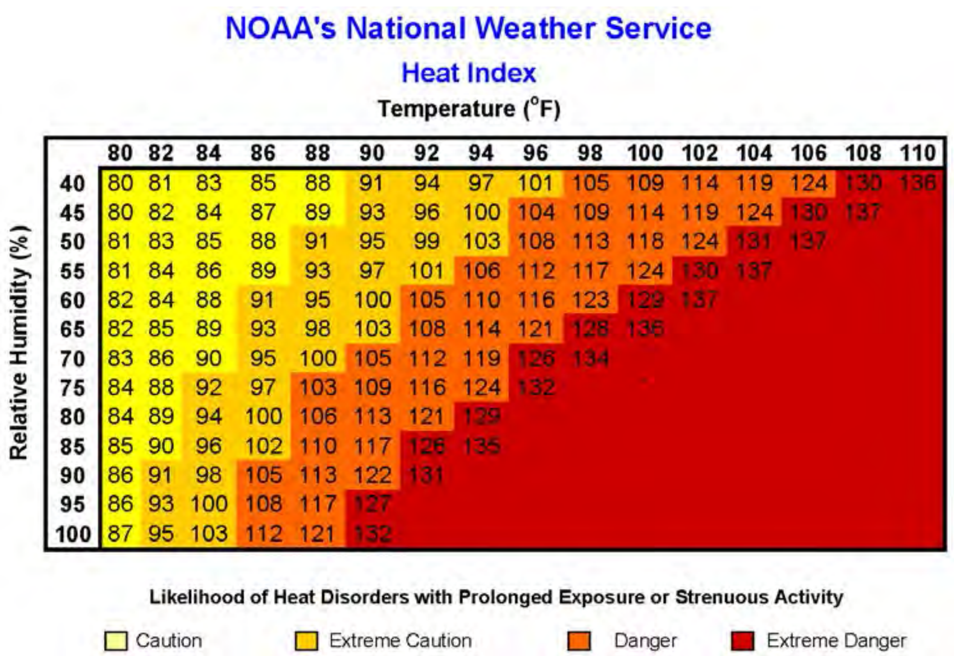
3.5.5.2 Severity and Extent of Extreme Heat

The Worcester Climate Action Plan states the average temperature of Massachusetts has increased by 2% over the last 100 years. IPCC projections indicate it is virtually certain there will be more frequent extreme heat events over most land areas as average global temperatures increase and it is very likely that extreme heat events will occur more often and last longer.

3.5.5.3 Impact of Extreme Heat on Life, Property and Operations

Impacts to human life can be evaluated in accordance with the NOAA National Weather Service Heat Index (see Figure 12). The varying levels of humidity and temperature can create either cautionary, extreme cautionary, dangerous or extremely dangerous conditions.

Figure 12: NOAA National Weather Service Heat Index



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

Source: http://nws.noaa.gov/os/heat/index.shtml

Heat-related illnesses include heat cramps, heat exhaustion, and heat stroke. Anyone can experience heat-related illness, but the following groups of people have greater risk of impact by a heat-related illness:

- People performing strenuous activities outdoors,
- People with a mental illness,
- People with physical illness, especially high blood pressure or heart disease,
- Young children and infants, and
- People aged 65 or older.

In addition to heat-related illnesses, extreme heat events place a burden on electrical utilities with the increased power consumption due, in part, to increased air conditioner usage. The increased power consumption can cause electrical utilities to experience brown-outs or black-outs, resulting in a temporary loss of power to service areas.

3.5.5.4 Previous Occurrences of Extreme Heat

According to FEMA, there has never been a Presidential Disaster Declaration made for extreme temperatures in the Commonwealth of Massachusetts. At UMMS, staff report approximately 10 years ago, there was a problem with the power plant on a hot day resulting in the heating, ventilation, and air conditioning (HVAC) system fans running heavily but not cooling the buildings.

Specific details from the NCDC Storm Events Database were available regarding one excessive heat occurrence between 2000 and 2013 for the Massachusetts area.

- July 6, 2010 – High humidity and temperatures nearing 100 degrees were reported. Heat index values were in the range of 100 to 106 for most of Southern New England.

Other data sources note the following information about Massachusetts extreme heat events:

- July 16, 2013 – Worcester experienced temperatures above 90°F for five consecutive days.
- 2012 - In 2012, Massachusetts experienced a total of 27 broken heat records.
- July 22, 2011 – Very hot temperatures were experienced in Southern New England. A southwest low level flow increased humidity levels and heat index values rose above 105 degrees for a period of a few hours.
- July 14, 2006 – Southern New England, including Worcester County, experienced hot temperatures over several days with the heat index making temperatures feel like the 90°F to 100°F.
- August 9, 2001 – A record high minimum temperature record was broken for Worcester, Massachusetts with the high minimum temperature of 74°F (old record 72°F in 1909).

3.5.5.5 Probability of Extreme Heat Hazard

According to the CMRPC regional Hazard Mitigation Plan, the frequency of an extreme heat event occurring in Worcester County is extremely low.

3.5.5.6 Vulnerability to Extreme Heat Hazard

The City of Worcester has been impacted by extreme heat in the past. Table 3-26 indicates the susceptibility criteria used to determine vulnerability to extreme heat.

Table 3-26: Extreme Heat Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Massachusetts Hazard Mitigation Plan (2013) • Central Massachusetts Region Wide Pre-Disaster Mitigation Plan (2012) • Telegram.com • National Weather Service Special Weather Statement (2006) • Anecdotal Information from UMMS • UMass Memorial Medical Center HVA (2014)	• The state plan notes that temperature extremes can occur throughout the entire state. The coastal areas have lower daily averages than the inland parts of the state, but do not carry the same extreme temperature records. Areas that are more prone to heat include inland urban areas. • All areas of Massachusetts are vulnerable to electricity shortages. Shorter-duration heat waves (2-3 days) may cause demand surges, generator stresses/outages, and transmission problems. A prolonged heat wave may lead to electricity supply problems, rolling blackouts, and health and safety risks if priority users cannot be supplied with power. • CMRPC notes low frequency of extreme heat events. • Worcester experienced multiple day extreme heat events in the past. • UMMS staff report experiencing extreme heat events on campus in the past with one extreme heat event resulting in a problem with the HVAC system which was not providing adequate cooling. • UMass Memorial Medical Center identified Extreme Heat as a low vulnerability in 2014.

3.5.5.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for an extreme heat event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of an extreme heat event utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-27).

Table 3-27: Risk Assessment – Extreme Heat

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Extreme Heat	1	2	3	2	1.67	3.00	2.47	M

After reviewing the initial ranking of medium and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-28).

Table 3-28: Qualitative Risk Assessment – Extreme Heat

	Winter Storm/Blizzard Hazard - Qualitative Ranking
Risk Ranking	Medium
Students, Faculty & Staff	Medium
Existing Buildings	Low
Future Buildings	Low
Operations	Low
Critical Infrastructure	Medium

As a result of considering these additional factors, the overall ranking remained medium.

3.5.5.8 Future Development Considerations

UMMS will monitor and participate in any Extreme Heat Programs implemented by the City of Worcester to the extent that is possible and appropriate. UMMS will also monitor and participate in any programs or help with other identified needs by communicating with local and emergency officials in the City and surrounding areas.

On campus, concerns were communicated regarding the ability to control the temperature of buildings during extreme heat situations, particularly if there is an accompanying power outage. Protecting research and manufacturing at the Worcester campus and MassBiologics is critical. Ensuring that refrigerated trucks are available if needed and in the longer term, investigating the potential upgrade of HVAC systems will also be considered.

3.5.6 Thunderstorm/Lightning

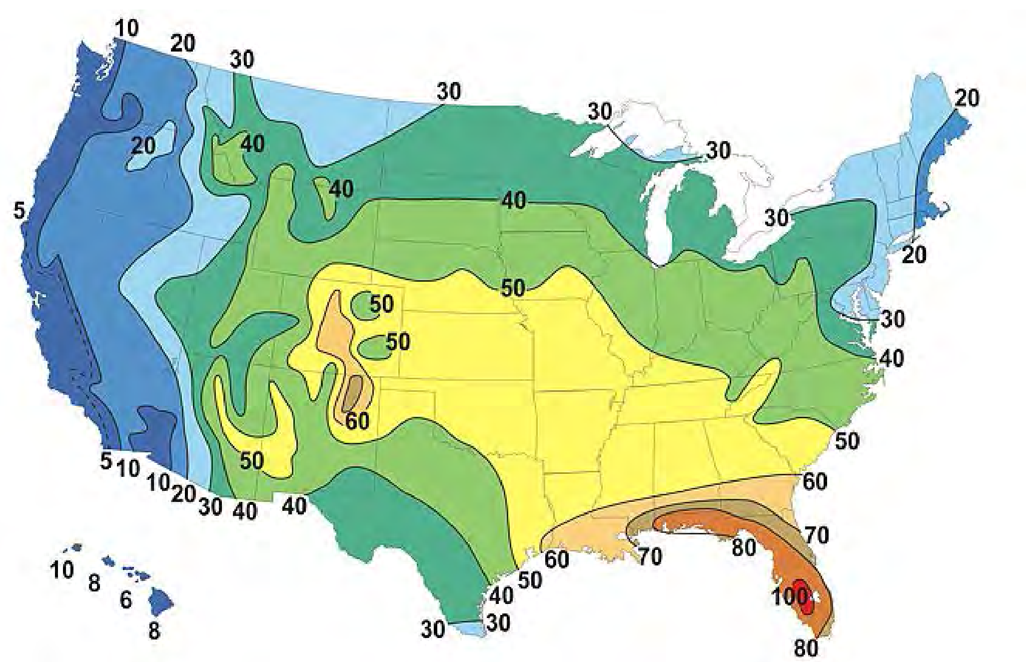
According to NOAA, a thunderstorm is "*a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder.*" NOAA defines lightning as *"a visible electrical discharge produced by a thunderstorm. The discharge may occur within or between clouds, between the cloud and air, between a cloud and the ground or between the ground and a cloud.*" Compared to a hurricane or winter storm, thunderstorms impact smaller geographic areas and generally last a shorter amount of time. Approximately 10% of the 100,000 thunderstorms that occur annually are classified as severe. Thunderstorms need moisture, unstable air and lift to form in the atmosphere.

3.5.6.1 Location of Thunderstorm/Lightning

Thunderstorms and lightning can occur in any part of Massachusetts. Figure 13 shows the average number of thunderstorm days in the United States. Based on the information in Figure 13, Worcester averages approximately 30 thunderstorm days per year. The eastern half of Massachusetts averages approximately 10 more thunderstorm days than the western half of the Commonwealth on an annual basis.

Figure 14 shows cloud-to-ground flash density (lightning) from 2005 to 2012 in the northeast states. Massachusetts experiences less thunderstorm and lightning frequency on average than in the central and southern parts of the United States.

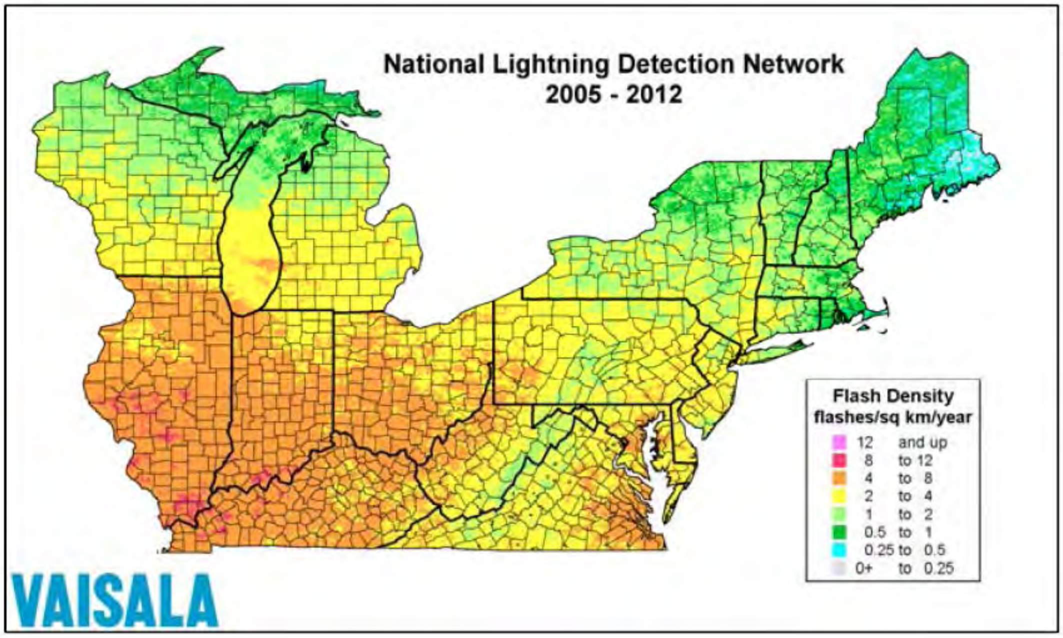
Figure 13: Average Number of Thunder Storm Days in the U.S (NOAA)



Source: http://www.srh.noaa.gov/jetstream/tstorms/tstorms_intro.htm

During a 7-year study period, Vaisala observed that lightning occurs less frequently over northern New England as compared to the rest of the United States. When thunderstorms do occur, the storms are less frequent and less intense.

Figure 14: Cloud to Ground Lightning Incidence in the U.S. (Vaisala)



Source: Vaisala Media Backgrounder, June 2013. http://www.vaisala.com/Vaisala%20Documents/Corporate-mediakits/NLDN%20Northeast%20US.pdf

3.5.6.2 Severity and Extent of Thunderstorm/Lightning

Most thunderstorms and lightning occur during June, July, and August. NOAA uses wind speed and hail size to define a thunderstorm's severity. Non-severe thunderstorms include those with heavy rainfall that can cause flash flooding and those that produce lightning. A severe thunderstorm includes at least one of the following:

- wind gusts of 57.5 mph faster; or
- hail that is one inch or greater in diameter.

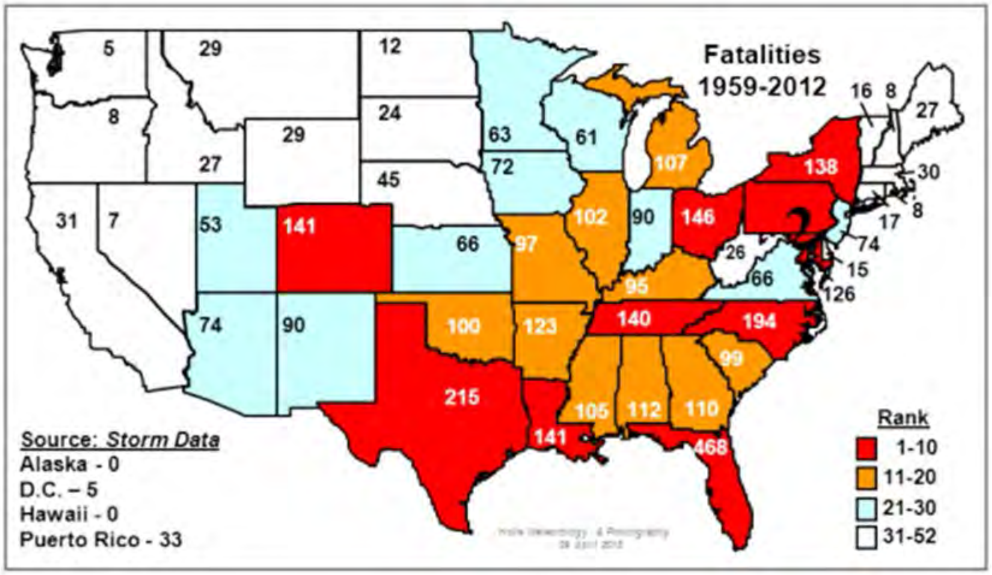
NOAA issues a severe thunderstorm watch if conditions are favorable for the development of a severe thunderstorm. A warning is issued if a storm spotter or radar data indicates a severe thunderstorm is occurring. Severe thunderstorms also have the potential to produce tornadoes that may warrant tornado watches and warnings.

3.5.6.3 Impact of Thunderstorm/Lightning on Life, Property and Operations

The largest hazard associated with thunderstorms is wind damage that can have impacts on human life and structures. In addition to rain and lightning, thunderstorms can cause other hazards such as hail, winds, tornadoes, or flash floods discussed in other hazard profile sections.

One hazard specifically associated with thunderstorms is lightning. Fatalities, although rare, can occur from a lightning strike. In the United States, 99 percent of fatalities have occurred outside of a large substantial building or fully-enclosed metal-topped vehicle. Based on information from Vaisala, for all of the United States, approximately 34 people were killed by lightning per year from 2003 to 2012, resulting in 349 total fatalities. Of those 349 fatalities, four occurred in Massachusetts. As another form of comparison, Figure 15 shows that 30 fatalities have occurred in Massachusetts from 1959 to 2012.

Figure 15: Lightning Fatalities by State, 1959-2012



Source: Vaisala Storm Data http://www.lightningsafety.noaa.gov/stats/59-12_State_Ltg._Fatality_Map-rates.pdf

3.5.6.4 Previous Occurrences of Thunderstorm/Lightning

Table 3-29 summarizes lightning occurrences for Worcester County and thunderstorm wind events for Worcester provided by NOAA's National Climatic Data Center (NCDC).

Table 3-29: Thunderstorm Wind and Lightning Event Data for Worcester County (March 1, 2006 – June 10, 2014)

Location	Event Type	Date	Death	Injury	Property Damage
WORCESTER COUNTY	Lightning	9/02/2013	0	2	0.00K
ROCKY HILL	Lightning	6/17/2013	0	0	100.00K
RUTLAND	Lightning	5/29/2013	0	0	50.00K
BOYLSTON CENTER	Lightning	6/22/2012	0	1	0.00K
WORCESTER	Lightning	6/22/2012	0	0	45.00K
WORCESTER	Thunderstorm Wind	5/29/2012	0	0	5.00K
WORCESTER COUNTY	Thunderstorm Wind	6/09/2011	0	0	15.00K
WORCESTER COUNTY	Thunderstorm Wind	6/08/2011	0	0	45.00K
WORCESTER COUNTY	Thunderstorm Wind	6/01/2011	0	0	50.00K
SOUTH WORCESTER	Lightning	8/16/2010	0	0	10.00K
WORCESTER	Lightning	7/21/2010	0	0	20.00K
ASHBURNHAM	Lightning	7/19/2010	0	0	150.00K
WHALOM	Lightning	7/19/2010	0	0	30.00K
WORCESTER	Thunderstorm Wind	6/06/2010	0	0	15.00K

Location	Event Type	Date	Death	Injury	Property Damage
WORCESTER	Thunderstorm Wind	6/01/2010	0	0	1.00K
WORCESTER COUNTY	Thunderstorm Wind	5/24/2009	0	0	15.00K
WORCESTER COUNTY	Thunderstorm Wind	5/09/2009	0	0	7.00K
WORCESTER	Thunderstorm Wind	8/10/2008	0	0	1.00K
UPTON	Lightning	7/23/2008	0	0	15.00K
WORCESTER	Thunderstorm Wind	7/01/2008	0	0	3.00K
BARRE	Lightning	6/29/2008	0	0	5.00K
WORCESTER	Thunderstorm Wind	6/29/2008	0	0	3.00K
WORCESTER	Thunderstorm Wind	6/10/2008	0	0	100.00K
WHALOM	Lightning	9/8/2007	0	0	10.00K
WORCESTER	Thunderstorm Wind	8/03/2007	0	0	0.00K
LEOMINSTER	Lightning	5/16/2007	0	0	300.00K
ATHOL	Lightning	7/11/2006	0	0	15.00K
BARRE	Lightning	6/29/2006	0	0	50.00K
WORCESTER	Thunderstorm Wind	6/20/2006	0	0	20.00K
WEST BROOKFIELD	Lightning	6/1/2006	0	0	15.00K
SPENCER	Lightning	5/21/2006	0	0	100.00K
CHARLTON	Lightning	5/21/2006	0	0	75.00K
FITCHBURG	Lightning	3/13/2006	0	0	50.00K
Source: NCDC Storm Events Database http://www.ncdc.noaa.gov/stormevents/					

Specific details from the more significant lightning events noted in Table 3-29 that have occurred in Worcester County include:

- September 2, 2013 – Showers and thunderstorms spread across New England for three days resulting in heavy rain and flash flooding. Lightning struck a house in Worcester County resulting in two teenagers outside feeling the lightening shock; one teen was transported to the hospital and stayed overnight in the hospital, the other declined medical treatment. Several houses reported to experience electrical problems after the lightening strike.
- June 17, 2013 – Severe thunderstorms produced damaging winds and lightening in southern New England. A house in Worcester County was struck by lightning that ignited the attic and spread to other areas of the house, causing significant structural damage.
- June 1, 2011 – Several thunderstorm cells entered Western Massachusetts and one eventually produced a tornado in Hampden County. In Worcester County, several downed trees, tree limbs, and wires were reported as a result of the thunderstorm wind produced with the storms.
- July 19, 2010 – Scattered severe thunderstorms produced wind damage and large hail mainly in central Massachusetts. Lightning ignited a building and a garage in Worcester County.
- June 10, 2008 – Widespread thunderstorms developed over New England with Worcester receiving substantial damage from strong wind gusts associated with the thunderstorm. Damage in Worcester

included numerous downed trees (including 30 – 40 downed trees in St. John's Cemetery), several downed tree limbs, two utility polls downed, a garage door blown off a building, and several shattered windows caused by blown debris. A wind gust of 68 miles per hour was recorded at Worcester Regional Airport.

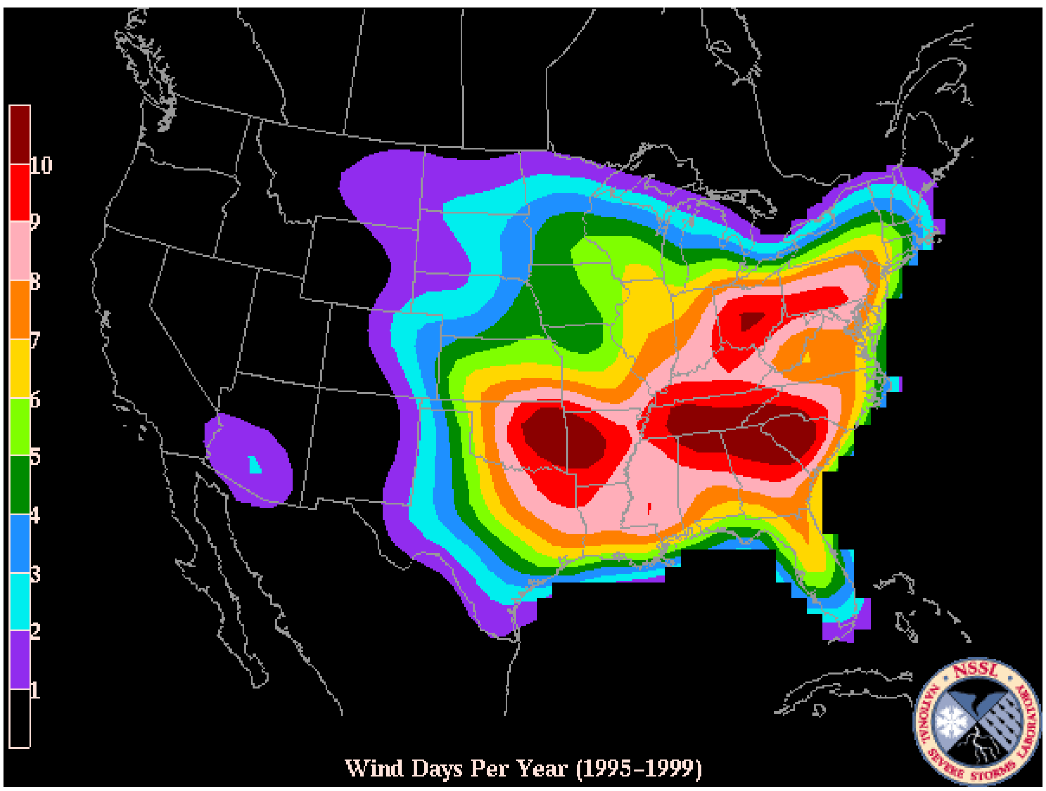
- May 16, 2007 – A widespread thunderstorm outbreak resulted in wind damage with downed trees and power lines across Massachusetts. Downed trees were reported in Shrewsbury and hail fell in Worcester.
- June 27, 2002 – Severe thunderstorms moved through parts of central and northeast Massachusetts resulting in downed trees, power lines, and large branches in areas that included Worcester County.

3.5.6.5 Probability of Thunderstorm/Lightning Hazard

The probability of a future thunderstorm/lightning occurrence in the City of Worcester is likely. Future thunderstorm and/or lightning events will continue to cause minor property damage throughout the City Worcester and threaten human life as well.

NOAA's National Severe Storm Laboratory (NSSL) has estimated the likelihood for thunderstorm winds of at least 50 knots on a given day in the United States. Figure 16 shows that the probability for thunderstorm winds occurring within 25 miles of Worcester, Massachusetts is three to four days per year based on thunderstorm wind data collected from 1995 to 1999.

Figure 16: Thunderstorm Wind Days Per Year in the United States, NOAA's (NSSL)

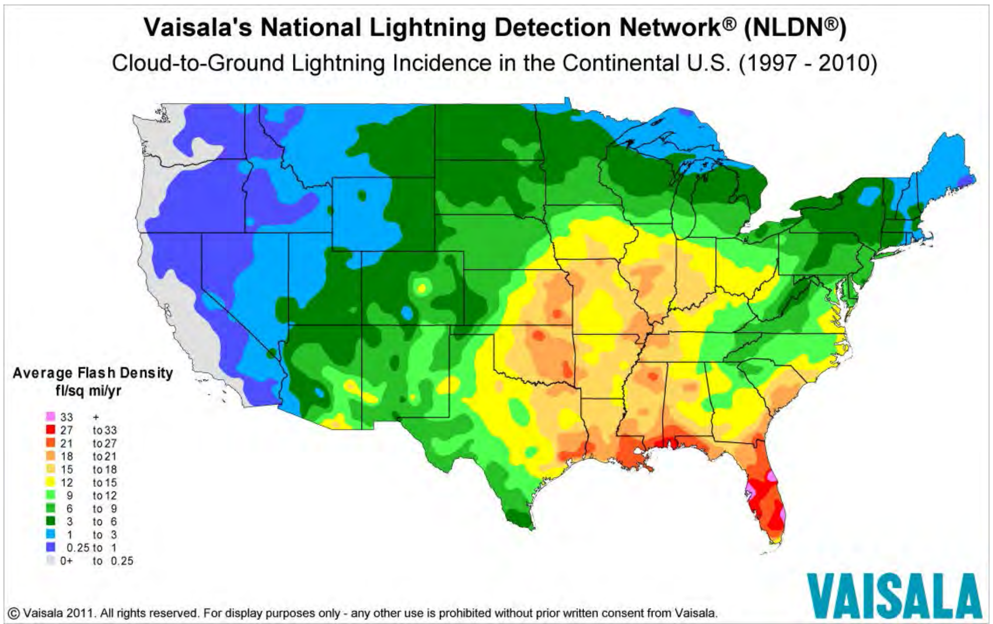


Source: http://www.nssl.noaa.gov/projects/hazard/totalthreat.html

3.5.6.6 Vulnerability to Thunderstorm/Lightning Hazard

UMMS is in an area that is vulnerable to thunderstorm and lightning events, however UMMS is not as susceptible as other areas of the United States. Figure 17 indicates Vaisala's National Lightning Detection Network display data representing Cloud to Ground Lightning Incidences between 1997 – 2010.

Figure 17: Cloud to Ground Lightning Incidents in the U.S. – Vaisala NLDN



Souce: http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx

In addition, the UMMS vulnerability to thunderstorm and lightning events was also determined by evaluating state and local planning documents as well as gathering anecdotal information from UMMS staff. The susceptibility criteria considered for thunderstorm and lightning are presented in Table 3-30.

Table 3-30: Thunderstorm & Lightning Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Massachusetts Hazard Mitigation Plan (2013) • Review of FEMA's Multi-Hazard Identification and Risk Assessment • CMRPC Regional Hazard Mitigation Plan • Anecdotal Information from UMMS • UMass Memorial Medical Center HVA (2014)	• Thunderstorms are discussed in the state plan which notes that the entire state is susceptible. It notes that one of the more damaging storms was in 1998 and impacted Worcester County among others. • CMRPC plan notes that the central Massachusetts region frequently experiences thunderstorm and lightning events, although they typically have resulted in minor damage. • UMMS staff reported to have experienced power outages at the UMMS campus during thunderstorm events in the past. • UMass Memorial identified Thunderstorm/Lightning as a medium vulnerability in 2014.

3.5.6.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a thunderstorm/lightning event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a thunderstorm/lightning event utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-31).

Table 3-31: Risk Assessment – Thunderstorm/Lightning Event

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Thunderstorm /Lightning	3	2	2	2	2.33	2.00	2.13	M

After reviewing the initial ranking of **medium** and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-32).

Table 3-32: Qualitative Risk Assessment – Thunderstorm/Lightning

	Thunderstorm/Lightning Hazard - Qualitative Ranking
Risk Ranking	Medium
Students, Faculty & Staff	Medium
Existing Buildings	Low
Future Buildings	Low
Operations	Low
Critical Infrastructure	Medium

As a result of considering these additional factors, the overall ranking remained **medium.**

3.5.6.8 Future Development Considerations

Incidents that cause an associated power outage are of particular concern to the UMMS campus. UMMS will consider thunderstorm/ lightning hazard scenario planning during future development and redevelopment of the campus to mitigate the impact of thunderstorm/lightning occurrences. This includes the following mitigation measures:

- Coordinate weather and emergency information with City of Worcester officials.
- Coordinate outreach to the public with consistent messaging, information, and instructions via public broadcast, websites, email, and social media for watches and warnings issued by the National Weather Service.
- Coordinate outreach to UMMS stakeholders regarding the dangers of thunderstorm and lightning.

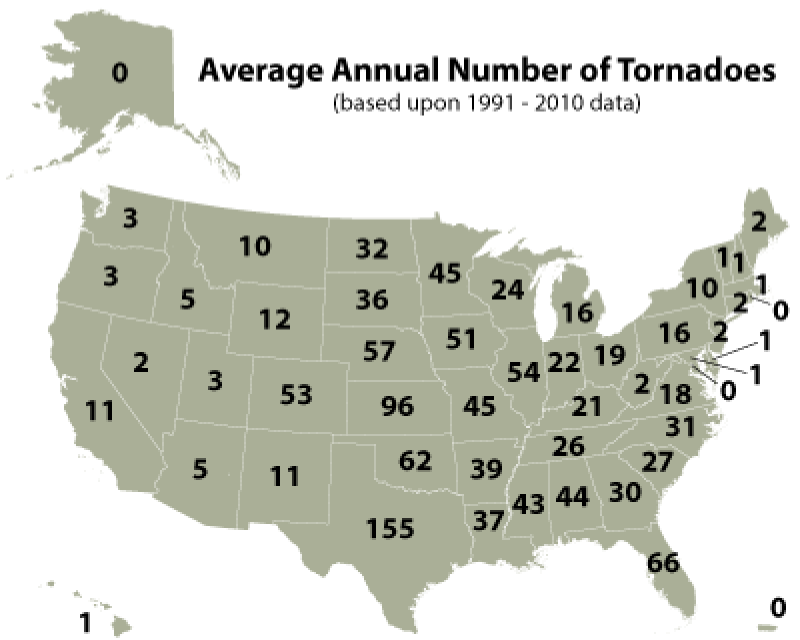
3.5.7 Tornado

Tornadoes are most commonly associated with a violently rotating visible funnel cloud that is a rotating air column which has contact with the ground. Typically, a loud roaring noise, compared to the sound of a freight train, is associated with a tornado. Speeds of a tornado can range from 40mph to 300mph and are measured on what is known as the Fujita scale (see **Figure** 19). Generation of a tornado can be associated with thunderstorm activity where cool, dry air meets warm, humid air. Damage from a tornado can vary widely and be minimal to completely catastrophic. On a local level, a tornado is the most destructive of all atmospheric conditions. In Massachusetts, tornadoes are not a common occurrence.

3.5.7.1 Location of Tornado

Based on the wind zone map provided in the Windstorm Section (**Figure** 29, **Section** 3.5.10.2), Massachusetts is located in Wind Zone II that can include wind speeds up to 160 mph, which may be associated with tornadoes. Tornadoes can occur in any region of Massachusetts. Based on NOAA/NWS data from 1991 to 2010, on average, Massachusetts experiences one tornado per year (see **Figure** 18). Tornadoes are most likely to occur in the late afternoon/early evening.

Figure 18: Average Annual Number of Tornadoes (NOAA/NWS)



Source: National Weather Service JetStream – Online School for Weather: Thunderstorm Hazards – Tornadoes
http://www.srh.noaa.gov/jetstream/tstorms/tornado.htm

3.5.7.2 Severity and Extent of Tornado

Tornadoes are rated using the Enhanced Fujita (EF) Scale (see **Figure 19**) which provides a rating of the wind speed from the tornado event to a category from EF0 to EF5. The degree of damage helps to define the rating of an individual storm. The Fujita scale has been in use since 2007.

Figure 19: Enhanced Fujita Scale

EF Scale Rating	3-Second Gust Speed (mph)	Type of Damage
EF0	65-85	Light Damage
EF1	86-110	Moderate Damage
EF2	111-135	Considerable Damage
EF3	136-165	Severe Damage
EF4	166-200	Devastating Damage
EF5	>200	Incredible Damage
EF No Rating	> EF5	Inconceivable Damage

Adapted from http://www.wunderground.com/resources/severe/fujita_scale.asp?MR=1

3.5.7.3 Impact of Tornado on Life, Property and Operations

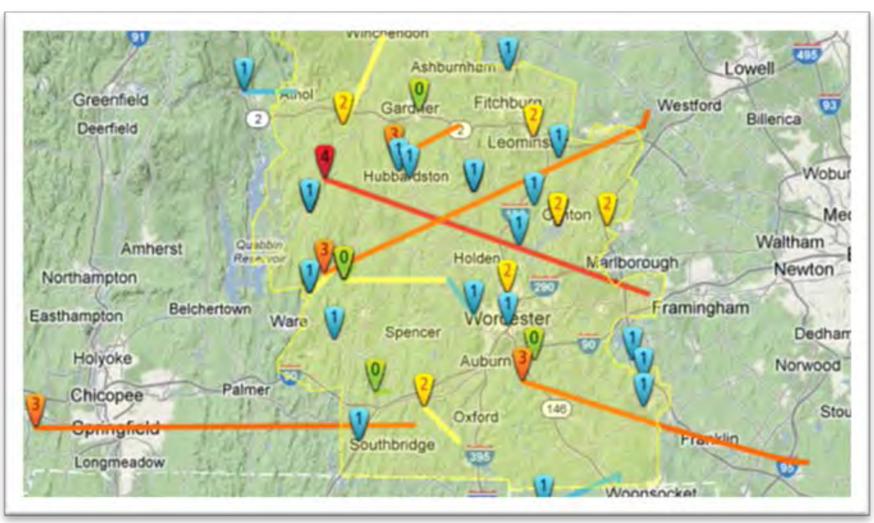
Tornadoes can have significant impacts on human health, property, and campus infrastructure. The most prevalent impact is excessive winds and wind damage. Injuries and fatalities most often result from flying debris. Other injuries and fatalities are associated with building damage and collapses, being trapped inside cars or trailers, or being outside without cover. After a tornado has passed, there are additional health hazards associated with downed power lines, damaged buildings that may be unsafe to exit or enter, and the inability to obtain emergency care.

Property and operational impacts include damage to residential and commercial buildings, trees and vegetation, and exposed infrastructure that can be completely destroyed by a tornado. Damaged bridges and infrastructure may be weakened for use resulting in delays for individuals to move within the community to receive basic service. Although tornadoes are confined to certain areas, the impacts on communities affected can be devastating with damage and destruction.

3.5.7.4 Previous Occurrences of Tornadoes

Since 1955, approximately 36 tornadoes have touched down in Worcester County, several of which have impacted the City of Worcester, (see **Figure** 20).

Figure 20: Worcester County Tornadoes 1955 – 2011



Source: http://www.tornadohistoryproject.com/tornado/Massachusetts/Worcester

Since 1954, there have been two Major Disaster Declarations in the State of Massachusetts for Tornadoes (see Table 3-33). At least one of these instances impacted Worcester County directly. The State Hazard Mitigation plan indicates that a tornado may occur anywhere in Massachusetts with the right atmospheric conditions.

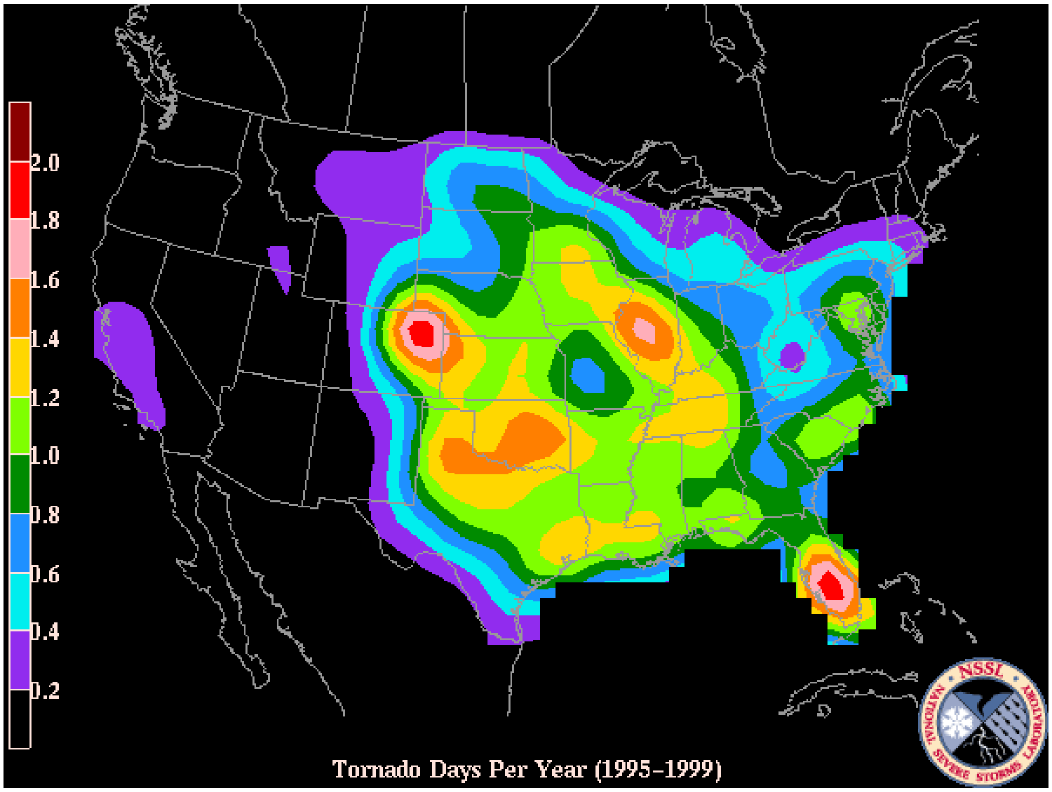
Table 3-33: Massachusetts Tornado Major Disaster Declarations (1954 – Present)

	Disaster No.	Incident Period	Date Disaster Declared	Worcester County a Designated Area?
Severe Storms and Tornadoes	1994	6/1/2011	6/15/2011	Yes
Tornado	7	6/11/1953	6/11/1953	Unknown
Source: FEMA Disaster Declarations 1954 - Present				

3.5.7.5 Probability of Tornado Hazard

NOAA's National Severe Storm Laboratory (NSSL) has estimated the likelihood for a tornado on a given day in the United States. Figure 21 shows that the probability for a tornado occurring within 25 miles of Worcester, Massachusetts is 0.2 to 0.4 days per year based on tornado data collected from 1995 to 1999.

Figure 21: Tornado Days Per Year in the United States, NOAA's (NSSL)



Source: http://www.nssl.noaa.gov/projects/hazard/totalthreat.html

3.5.7.6 Vulnerability to Tornado Hazard

The Massachusetts State Hazard Mitigation Plan notes that the state has a definite vulnerability towards tornadoes. The greatest risk is from central to northeastern Massachusetts which includes Worcester County. In New England, there averages 6 tornado touch downs per year while Massachusetts averages approximately 2.6 tornado events per year. Tornado susceptibility criteria are outlined in Table 3-34.

Table 3-34: Tornado Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State Hazard Mitigation Plan (2013) • CMRPC Regional Hazard Mitigation Plan • Tornado History Project (online) • Anecdotal Information from UMMS • UMass Memorial Medical Center HVA (2014)	• The state plan notes that a Tornado may occur anywhere in Massachusetts with the right atmospheric conditions. • The state plan and several of the regional/city plans acknowledge that Massachusetts has a definite vulnerability to tornadoes, with an average annual occurrence of 2.6 tornadoes per year since 1951. • According to the NCDC, between 1991 – 2010, Massachusetts has averaged one tornado per year. • Tornadoes are ranked as a medium threat in terms of frequency, with the potential for causing serious or extensive damage in the State Hazard Mitigation Plan. • Between 1951 and 2011, there have been 156 tornadoes in Massachusetts which have resulted in 105 fatalities and 1,559 injuries. • Between 1955 – 2011, Worcester County has recorded 33 tornados. • In Worcester County, a number of F1 tornadoes have occurred over the years. There have been five F3 tornados (or higher) that have impacted Worcester County since 1955. • UMMS staff and students report that tornadoes have been in the Worcester area in the past. • UMass Memorial Medical Center identified tornado as a medium vulnerability in 2014.

3.5.7.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a tornado event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a tornado event utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-35).

Table 3-35: Risk Assessment - Tornado Event

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Tornado	1	1	3	3	1.67	3.00	2.47	M

After reviewing the initial ranking of medium and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-36).

Table 3-36: Qualitative Risk Assessment – Tornado

	Tornado Hazard - Qualitative Ranking
Risk Ranking	Medium
Students, Faculty & Staff	Low
Existing Buildings	Medium
Future Buildings	Low
Operations	Low
Critical Infrastructure	Medium

As a result of considering these additional factors, the overall ranking remained medium.

3.5.7.8 Future Development Considerations

UMMS should include tornado hazard scenario planning during their future development and redevelopment efforts and continue to implement measures to mitigate the impact of tornado occurrences. This includes the following mitigation measures:

- Coordinate weather and emergency information with City of Worcester officials,
- Coordinate outreach to the public with consistent messaging, information, and instructions via public broadcast, websites, email, and social media for watches and warnings issued by the National Weather Service.
- Coordinate outreach to the campus population for tornado guidance preparation.

3.5.8 Earthquake

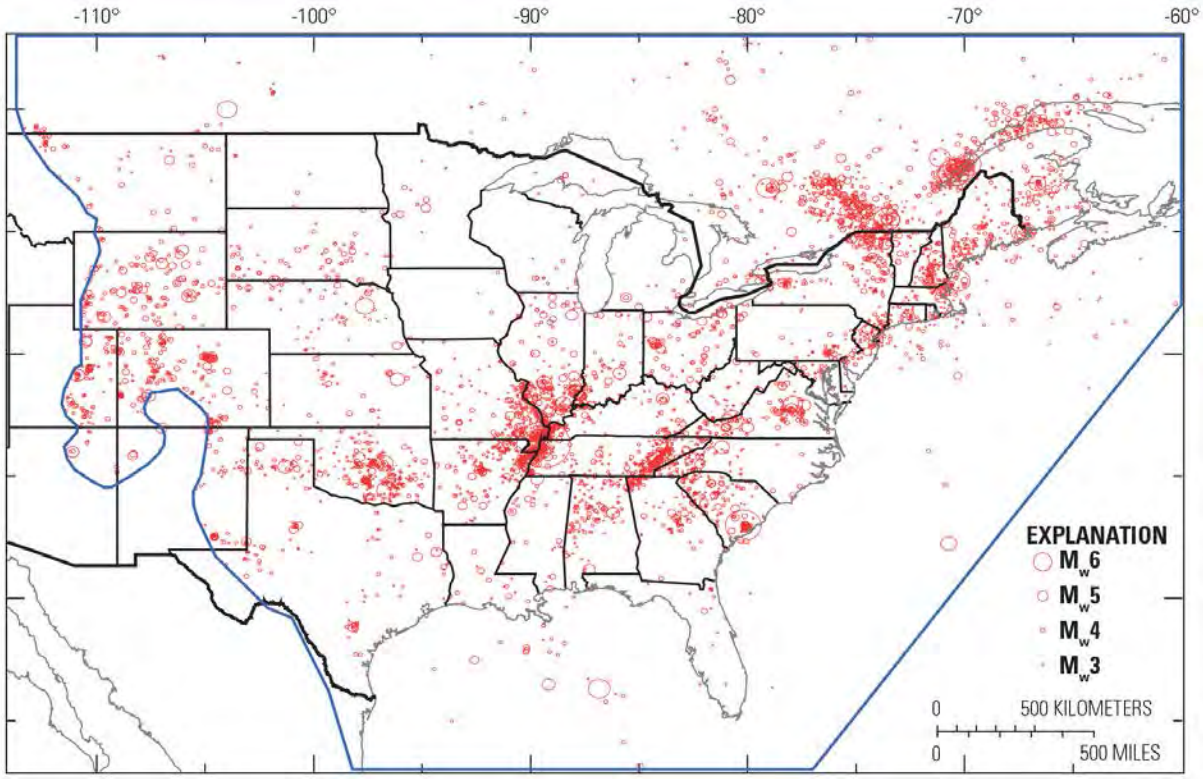
Earthquakes are the result of a release of energy (which can be observed by shifting and fracturing of rock materials beneath the surface) in the Earth's crust that creates seismic activity. Seismic activity is defined by the frequency, type and size of earthquakes that occur. Earthquakes are measured in by the Richter magnitude scale which assigns a value number to each earthquake event as a form of measuring the energy released. Unfortunately, earthquakes can be large in magnitude, impact thousands of square miles and cause billions of dollars in damage to property.

Earthquakes have been detected all over New England and northeastern Massachusetts. The State of Massachusetts Hazard Mitigation Plan notes that the New England epicenters do not follow major mapped faults of the region, nor are they confined to specific geologic structures or terrain. In addition, past earthquakes in New England have not aligned along fault lines that are known or mapped by geologists. Due to the wide ranging occurrences of earthquakes in New England, it is suspected that a strong event could occur anywhere in the region.

3.5.8.1 Location of Earthquake

Earthquakes are possible in Massachusetts and the USGS map (prepared by the Earthquake hazard program) in Figure 22 below indicates where earthquakes having a moment magnitude (M_W) of at least 2.5 have occurred in the central and eastern portions of the United States since 1700. Central Massachusetts experiences less earthquakes than many other areas of the eastern and central United States.

Figure 22: USGS Earthquake Catalog (2014)

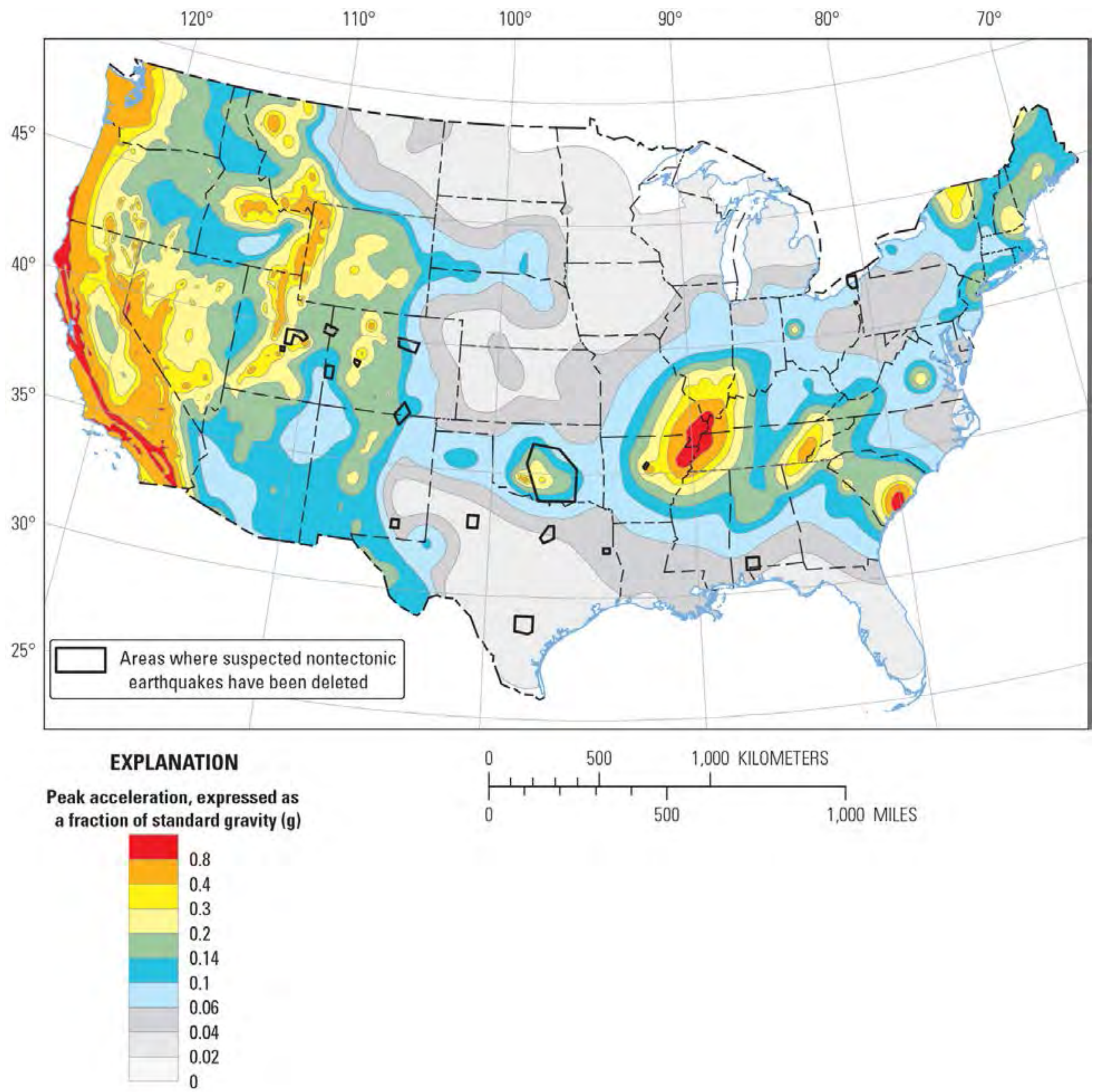


Source: USGS Documentation for the 2014 Update of the United States National Seismic Hazard Maps

3.5.8.2 Severity and Extent of Earthquake

Earthquake impacts are measured by how much energy releases from the epicenter of the event and how far any given location is from the epicenter. Severity can be expressed for an earthquake by comparing the acceleration of the event to normal acceleration due to gravity. Peak ground acceleration (PGA) is how the strength of the ground movements can be measured and is expressed as a percent of the established rate of acceleration due to gravity (see Figure 23). Magnitude (measure of total energy released) and intensity (measure of earthquake effects at a specific place) are the terms used to commonly describe severity of an earthquake. Based on the information from the USGS National Seismic Hazard Map in Figure 23 below, the earthquake peak ground acceleration that has a 2% chance of being exceeded in 50 years has a value of approximately 0.14 gravity (g) for Worcester, Massachusetts.

Figure 23: USGS Peak Ground Acceleration Map (2014)



Source: http://earthquake.usgs.gov/hazards/products/conterminous/2014/2014_pga2pct50yrs.pdf

Earthquakes are measured by magnitude and intensity. One way to describe the intensity of an earthquake is the Modified Mercalli Intensity (MMI) Scale (see Table 3-37). The scale identifies 12 increasing levels of intensity, which are designated by Roman numerals. The measured energy at the earthquake's source is the magnitude (see Table 3-38). The intensity is a measurement of the strength of shaking caused by the earthquake at a certain location.

Table 3-37: Modified Mercalli Intensity Scale – Earthquake Intensity

MMI Scale Number	Typical Earthquake Impacts
I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: http://earthquake.usgs.gov/learn/topics/mag_vs_int.php

Table 3-38: Earthquake Magnitude Scale

Magnitude	Earthquake Effects	Estimated Number Each Year
2.5 or less	Usually not felt, but can be recorded by seismograph.	900,000
2.5 to 5.4	Often felt, but only causes minor damage.	30,000
5.5 to 6.0	Slight damage to buildings and other structures.	500
6.1 to 6.9	May cause a lot of damage in very populated areas.	100
7.0 to 7.9	Major earthquake. Serious damage.	20
8.0 or greater	Great earthquake. Can totally destroy communities near the epicenter.	One every 5 to 10 years

3.5.8.3 Impact of Earthquake on Life, Property and Operations

The impacts from an earthquake, depending on its magnitude and intensity can vary widely from no change to devastating losses. The main effect of an earthquake is ground shaking that can cause severe damage to buildings, utilities and other structures (bridges, roads, etc.). Other impacts may include:

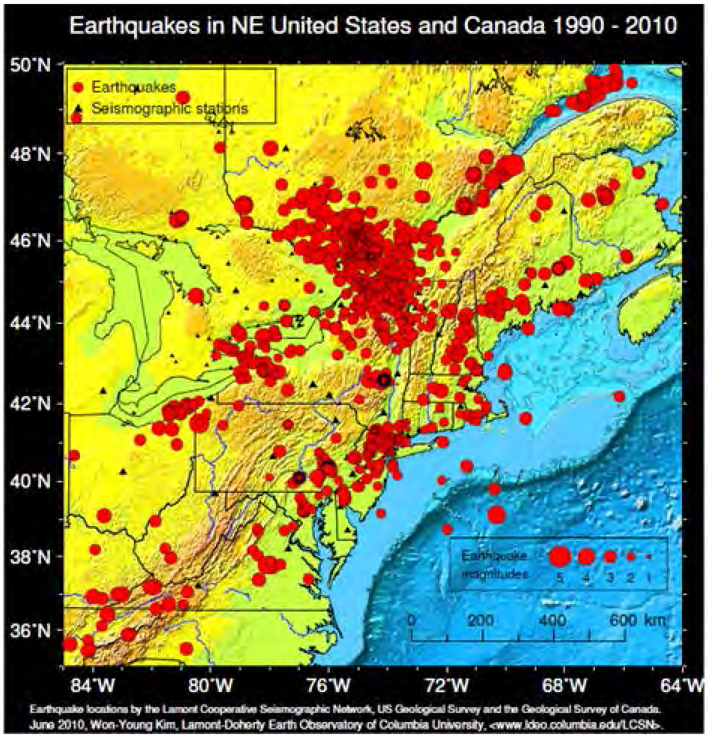
- Landslide or avalanche due to slope instability,
- Fire due to damaged electrical or gas infrastructure,
- Rupture of water supply tanks, pipelines or aqueducts,
- Hazardous material spills,
- Soil liquefaction due to water saturated ground material,
- Tsunami which can be the result of large earthquakes (they are usually not seen unless the earthquake is a 7.5 or higher),
- Flood which is often a secondary impact of an earthquake, and
- Human injury and loss of life.

3.5.8.4 Previous Occurrences of Earthquakes

According to FEMA, there has never been a Presidential Disaster Declaration made for an earthquake in the State of Massachusetts. Between 1638 – 2007, Massachusetts has experienced 355 earthquakes of varying magnitudes.[3] According to the State Hazard Mitigation Plan, the last major earthquake to affect Massachusetts was more than 200 years ago in 1755, with an estimated magnitude of about 6.0 to 6.25. The epicenter was probably located off the coast of Cape Ann, north of Boston. The area of greatest damage in Massachusetts stretched along the northern coast of the state from Cape Ann to Boston. There have been other damaging earthquakes centered in New England in the past. The 1727 earthquake at Newbury, Massachusetts caused local damage to masonry chimneys and buildings; its magnitude is estimated to have been about 5.6. In 1940 there was a pair of magnitude 5.5 earthquakes centered in the Ossipee Mountains of New Hampshire, and in 1904 there was a magnitude 5.7 earthquake at Eastport, Maine. Both of these earthquakes caused minor damage near their epicenters and were felt throughout Massachusetts. Figure 24 shows earthquakes in New England, the U.S., and Canada from 1990-2010.

[3] The Northeast States Emergency Consortium, "Earthquakes," [http://www.nesec.org/hazards/earthquakes.cfm.html#history], May 2013

Figure 24: Earthquakes in New England, United States and Canada 1990-2010



Source: http://www.ldeo.columbia.edu/LCSN/Report/NE_Seismicity_1990-2010_color.pdf

The Lamont-Doherty Cooperative Seismograhic Network (LCSN) monitors earthquake activity in New England, and elsewhere. According to LCSN, Massachusetts has experienced four earthquakes in the first half of 2014 (see Table 3-39).

Table 3-39: 2014 Earthquake Events in Massachusetts Through May 2014

Date	Magnitude	Location
March 28, 2014	2.2	8 mi WSW of Lawrence, MA
March 7, 2014	1.7	19 mi WSW of Norwood, MA
February 11, 2014	2.4	5 mi S of New Bedford, MA
January 9, 2014	1.9	4 mi N of New Bedford, MA

3.5.8.5 Probability of Earthquake Hazard

According to USGS, known faults and fault lines east of the Rocky Mountains are unreliable guides to predict the likelihood of earthquakes. An earthquake is as likely to occur on an unknown fault as it is on a fault that has been documented and studied, if not more likely. Earthquakes are most likely to occur in places or regions that they have been located in during the past.

Worcester is located in a region where there is a moderate history of seismic activity and historic earthquake events have occurred at a magnitude of 6.0. Earthquake events are unpredictable and can occur anytime. The possibility does exist that a future earthquake could occur at a substantial magnitude to cause severe impacts to UMMS.

3.5.8.6 Vulnerability to Earthquake Hazard

According to the State Hazard Mitigation Plan, the entire Commonwealth of Massachusetts is vulnerable to experiencing the shaking effects of an earthquake. Northeastern Massachusetts has greater vulnerability to potential earthquake activity than the rest of the Commonwealth, and western Massachusetts can experience shaking from earthquakes in New York. Earthquakes are rare in central Massachusetts where UMMS is located and when they do occur, they are small.

Table 3-40 indicates additional details regarding UMMS' vulnerability to an earthquake hazard.

Table 3-40: Earthquake Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State Hazard Mitigation Plan (2013) • CMRPC Pre-Disaster Hazard Mitigation Plan (2012) • Anecdotal Information from UMMS • UMass Memorial Medical Center HVA (2014)	• The state plan discusses earthquakes and the fact that they have been detected all over New England. • CMRPC plan notes that earthquakes are extremely rare in the central Massachusetts region and when they do occur, they are small and considered to be a low threat in the region. • UMMS has a general concern that an earthquake event could cause infrastructure issues on campus. An evaluation was done 20 years ago and there were concerns about West Garage parking structures. • UMass Memorial Medical Center identified Earthquake as a low vulnerability in 2014.

3.5.8.7 Loss Estimates

During the initial planning process, UMMS identified a list of assets to evaluate which included buildings and associated characteristics. To determine what would be impacted by an earthquake event, the methodology outlined in the FEMA 386-2 guidance document was used to specifically determine how an earthquake may impact assets on the UMMS campus.

A loss estimate was prepared to further determine how UMMS assets would be affected by an earthquake hazard event. Utilizing the FEMA guidance document "Understanding Your Risks – Identifying Hazards and Estimating Losses (FEMA 386-2)" calculations were conducted for Estimated Building Damage Sustained, Contents Damage Ratio, Estimated Contents Damage Sustained and then a Total Damage Sustained was calculated see Table 3-41. (The information presented in this table is a rough estimate and should not be used for any other purpose other than this hazard mitigation planning effort.)

There are no historical records available regarding an earthquake's damage to UMMS or its assets. The quantitative assessment for an earthquake event is based on if an event damaged 5% of the assets. Damages to human life are not considered in this calculation.

Estimating losses to structure and contents due to an earthquake on each campus utilized the following information:

- Year constructed
- Insurable replacement value
- PGA zone
- Building damage ratio (FEMA 386-2)
- Loss of function days (FEMA 386-2)

Several calculations were made utilizing this information, they include:

Content Damage Ratio

building damage ratio/2 = content damage ratio

Estimated Contents Damage Sustained

*insurable replacement value*contents damage ratio = estimated contents damage sustained*

Table 3-41 details the calculations that were made for an earthquake event and indicate what assets may be impacted at UMMS. Figure 25, Figure 26, Figure 27 and Figure 28 indicate graphically which buildings would be impacted based on the rankings in Table 3-41 where a high, medium or low ranking level was assigned based on these calculations.

Table 3-41: UMMS Campus Buildings - Estimated Loss to Structure & Contents Due to Earthquake

Existing Buildings	Date Construction Completed	Insurable Contents Value	PGA Zone	Building Damage Ratio	Estimated Building Damage Sustained	Contents Damage Ratio (%)	Estimated Contents Damage Sustained	Total Sustained Damage	Loss of Function Days	Ranking
ACC (Ambulatory Care Center)	2009	$180,000,000	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
(ASC) Albert Sherman Center	2012	$510,000,000	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Power Plant	1973	$157,500,000	0.05	0.10%	$157,500.0	0.05%	$78,750.0	$236,250.0	0	High
Medical School	1975	$441,389,618	0.05	0.10%	$441,389.6	0.05%	$220,694.8	$662,084.4	0	High
Teaching Hospital	1976	$530,551,500	0.05	0.10%	$530,551.5	0.05%	$265,275.8	$795,827.3	0	High
Lakeside Emergency Wing	2003	$311,267,250	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
South Garage / Public Safety	2004	$37,500,000	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Benedict Building	1991	$38,223,053	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
BNRI	1999	$32,824,296	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
CCNI	2002	$1,275,000	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
West Parking Garage	1985	$105,148,424	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Shaw Building	1951	$21,537,701	0.05	0.20%	$43,075.4	0.10%	$21,537.7	$64,613.1	0	Medium
South Street Bldg 1	1983	$143,960,457	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
South Street Bldg 2	1985	$67,746,098	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Plantation (North) Garage	2013	$45,000,000	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Aaron Lazare Research Building	2001	$292,445,993	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Helipad	2006	$3,750,000	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Stoddard Building	1926	$4,335,372	0.05	0.20%	$8,670.7	0.10%	$4,335.4	$13,006.1	0	Medium
Fuller Lab	1950	$7,857,482	0.05	0.20%	$15,715.0	0.10%	$7,857.5	$23,572.4	0	Medium
Higgins Building	1952	$1,336,314	0.05	0.20%	$2,672.6	0.10%	$1,336.3	$4,008.9	0	Medium
Chang Building	1954	$7,946,276	0.05	0.20%	$15,892.6	0.10%	$7,946.3	$23,838.8	0	Medium
Reed Lab (Rose & Gordon)	1965	$16,027,278	0.05	0.20%	$32,054.6	0.10%	$16,027.3	$48,081.8	0	Medium
Hoagland-Pincus Conference Center	1967	$7,070,510	0.05	0.20%	$14,141.0	0.10%	$7,070.5	$21,211.5	0	Medium
Machine Shop	1963	$300,000	0.05	0.20%	$600.0	0.10%	$300.0	$900.0	0	Low
Behavioral Barn	1968	$90,000	0.05	0.20%	$180.0	0.10%	$90.0	$270.0	0	Low
Marine Animal Bldg	1960	$75,000	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Mattapan II	2009	$88,416,657	0.05	0.20%	$176,833.3	0.10%	$88,416.7	$265,250.0	0	High
Massachusetts Biologic Filling Facility	2005	$299,688,605	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Century Drive	1991	$24,616,140	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Biotech One	1986	$28,828,667	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Biotech Two	1986	$66,879,275	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Biotech Three	1991	$50,888,573	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Biotech Four	1994	$45,991,367	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Biotech Five	1999	$50,456,214	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low
Biotech 3 Parking Garage	1991	$3,480,750	0.05	0.00%	$0.0	0.00%	$0.0	$0.0	0	Low

Note: Utilized FEMA 386-2. loss estimation tables by category did not include an educational institution, so for the purposes of this analysis, we utilized the Professional Office category. Once the category was selected, we utilized a PGA value of .05 to select the appropriate building damage ratio % and loss of function days.

Figure 25: Earthquake Vulnerability Assessment by Building – Worcester Campus

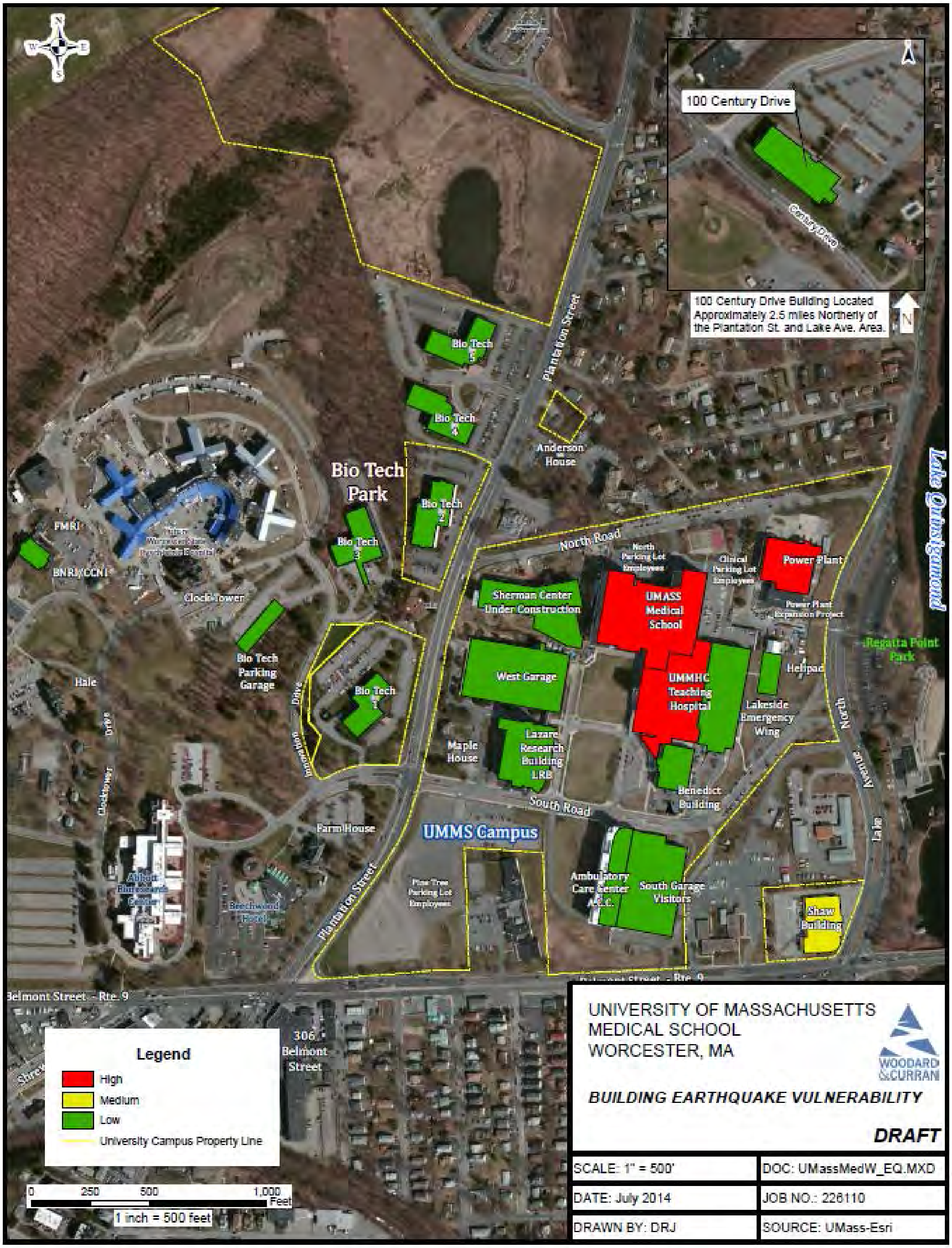


Figure 26: Earthquake Vulnerability Assessment by Building – Shrewsbury, South Street

Figure 27: Earthquake Vulnerability Assessment by Building – Shrewsbury, Maple Avenue

Figure 28: Earthquake Vulnerability Assessment by Building – Mattapan

3.5.8.8 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for an earthquake hazard event and its impact to UMMS, the risk assessment for this natural hazard has been prepared utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences and is presented in Table 3-42.

Table 3-42: Risk Assessment – Earthquake Hazard

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Earthquake	1	1	3	3	1.67	3.00	2.47	M

After reviewing the initial ranking of medium and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-43).

Table 3-43: Qualitative Risk Assessment – Earthquake Hazard

	Earthquake Hazard - Qualitative Ranking
Risk Ranking	Medium
Students, Faculty & Staff	Low
Existing Buildings	Low
Future Buildings	Low
Operations	Medium
Critical Infrastructure	Medium

As a result of considering these additional factors, the overall ranking remained medium.

3.5.8.9 Future Development Considerations

UMMS will include earthquake hazard scenario planning during future development and redevelopment efforts. Mitigation measures to lessen the impact of an earthquake occurrence for consideration include:

- Stay familiar with changes to the International Code Council (ICC) building codes which are published every three years. In addition, work with City of Worcester officials to stay informed regarding any regulatory changes that could impact campus.
- Continue to communicate with the campus population regarding consistent messaging, information, and instructions via public broadcast, websites, email, and social media for emergency information including safety information, the location of shelters, and additional information.
- Coordinate emergency information with City of Worcester officials and other UMass System campuses.

3.5.9 Ice Storm

Ice storms are a type of winter storm that consists of freezing rain and can create ice build-ups which when they occur, can cause substantial damage. Ice storm warnings are issued by the National Weather Service when there is more than ¼ inch of ice accumulation anticipated.

3.5.9.1 Location of Ice Storm

An ice storm can occur in any part of Massachusetts, but most frequently occur in the higher elevations of Western and Central parts of the Commonwealth.

3.5.9.2 Severity and Extent of Ice Storm

An ice storm may occur as part of a winter storm and cause some of the same impacts such as temporary utility loss (power outages), treacherous traveling due to poor road condition, business/school cancellations and in some cases direct human impacts such as frostbite or freezing due to over exposure.

The Weather Channel describes the varying degrees of an ice storm as summarized in Table 3-44.

Table 3-44: Weather Channel Ice Storm Categories

Category	Description
Nuisance	• Less than ¼ inch of ice • Windshields are coated • Bridges may be slippery • Light ice on trees
Disruptive	• ¼ to ½ inch of ice • Tree limbs may be sagging due to ice weight • Most roads are icy • Power outages
Crippling	• ½ inch or more of ice • Widespread tree and powerline damage • Roads impassable or dangerous
Source: http://www.weather.com/news/weather-winter/ice-storm-damage-impacts-20121123	

The severity of the effects of an ice storm increases as the amount and rate of precipitation increases. In addition, storms with a low forward velocity are in an area for a longer duration and tend to have more severe effects. Storms that are in full force during the morning or evening rush hours tend to have magnified consequences because more people are out on the roadways and directly exposed.

3.5.9.3 Impact of Ice Storm on Life, Property and Operations

Ice storms may have similar impacts to winter storms on life, property, and operations and can result in fatalities that may be directly related to the storm itself. Fatalities due to traffic accidents on icy roads are typical. Risks related to ice are most often associated with automobile accidents followed by individuals caught outside in the storm.

Impacts to property and operations are usually temporary and include ice buildup removal. However, ice storms can lead to significant infrastructure damages and business loss that can financially impact communities. Other potential direct impacts of ice include knocked down trees, power lines, and utility poles which may lead to power and/or internet outages. Freezing temperatures can further result in downed trees, downed power lines, downed utility poles, ice jams that can cause flooding, and building pipe bursts due to poor insulation or lack of heat.

3.5.9.4 Previous Occurrences of Ice Storms

Ice storm events have occurred historically in Massachusetts, including Worcester. The NCDC tracks ice storm events and the information in Table 3-45 was available for ice storm occurrences in Worcester County from the year 2000 to June 2014. The most recent substantial ice storm event was in December 2008, which caused widespread power outages throughout the area, including Worcester County. According to FEMA, there was a Presidential

Disaster Declaration made for the December 2008 event which was categorized as a severe winter storm that had associated ice storm characteristics. Damage from the storm throughout New England was measured in millions of dollars in property damage, lost business and clean-up costs.

Table 3-45: Ice Storm Event Data for Worcester County January 1, 2000 – June 1, 2014

Location	Date	Death	Injury	Property Damage
WORCESTER COUNTY	12/11/2008	0	0	23.00 M
NORTHERN WORCESTER COUNTY	2/01/2008	0	0	0.00 K
NORTHERN WORCESTER COUNTY	1/15/2007	0	1	15.00 K
WORCESTER COUNTY	11/16/2002	0	0	300.00K
Source: NCDC Storm Events Database http://www.ncdc.noaa.gov/stormevents/				

3.5.9.5 Probability of Ice Storm Hazard

Ice storms have been recorded in New England since 1929. The U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory estimates a 40 – 90 year return period for an event with a uniform ice thickness of between 0.75 and 1.25 inches. On average, a one-inch ice storm is likely every fifty years.

3.5.9.6 Vulnerability to Ice Storm Hazard

UMMS has experienced ice storm events in recent years. Table 3-46 indicates susceptibility criteria reviewed as related to the selection of an ice storm as a hazard of concern for UMMS.

Table 3-46: Ice Storm Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State Hazard Mitigation Plan (2014) • Review of FEMA's Multi-Hazard Identification and Risk Assessment • CMRPC Pre-Disaster Hazard Mitigation Plan • Anecdotal Information from UMMS • UMass Memorial Medical Center HVA (2014)	• The state plan notes that between 1971 - 2009, 40 ice storm events have occurred in the Commonwealth of varying degrees. • Ice conditions could impact fiber/power lines or make access to facilities difficult. • The state plan notes that ice storms most frequently occur in the higher elevations of Western and Central Massachusetts. • CMRPC plan notes that ice precipitation may be an occasional threat in inland areas and higher elevations of Massachusetts. • UMMS staff reports that ice storms can be very disruptive to campus, particularly due to power outages, IT outages, and access to campus from home. • UMass Memorial Medical Center identified ice storm as a medium vulnerability in 2014.

3.5.9.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for an ice storm event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of an ice storm event utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-47).

Table 3-47: Risk Assessment - Ice Storm Event

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Ice Storm	2	3	3	3	2.67	3.00	2.87	H

After reviewing the initial ranking of high and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-48).

Table 3-48: Qualitative Risk Assessment – Ice Storm

	Ice Storm Hazard - Qualitative Ranking
Risk Ranking	High
Students, Faculty & Staff	High
Existing Buildings	Medium
Future Buildings	Low
Operations	Medium
Critical Infrastructure	High

As a result of considering these additional factors, the overall ranking remained high.

3.5.9.8 Future Development Considerations

UMMS will continue to consider ice storm events during future development and redevelopment endeavors and continue to mitigate the impact of ice storm occurrences. This includes the following mitigation measures:

- Coordinate weather and emergency information with City of Worcester officials.
- Combat concern over loss of power and IT access during ice storm events by having a plan in place to keep systems operational.
- Coordinate outreach to the public with consistent messaging, information, and instructions via public broadcast, websites, email, and social media for watches and warnings issued by the National Weather Service.
- Coordinate outreach to the campus population for ice storm guidance preparation and possible impacts.

3.5.10 Windstorm

In general, wind is the horizontal motion of the air past a given point. Wind is in constant motion and windstorms can occur suddenly and without warning. Differences in air pressure is how a wind event begins and pressure that is higher at one place versus another sets up a force that pushes from the high toward the low pressure. Wind is used to describe the prevailing direction from which the air is blowing with the speed given usually in miles per hour or knots. Extreme wind events are most often associated with a larger meteorological event such as a winter storm, hurricane, tornado, nor'easter, or severe thunderstorm. In the absence of any accompanying characteristics of these other events, the event would be considered a windstorm.

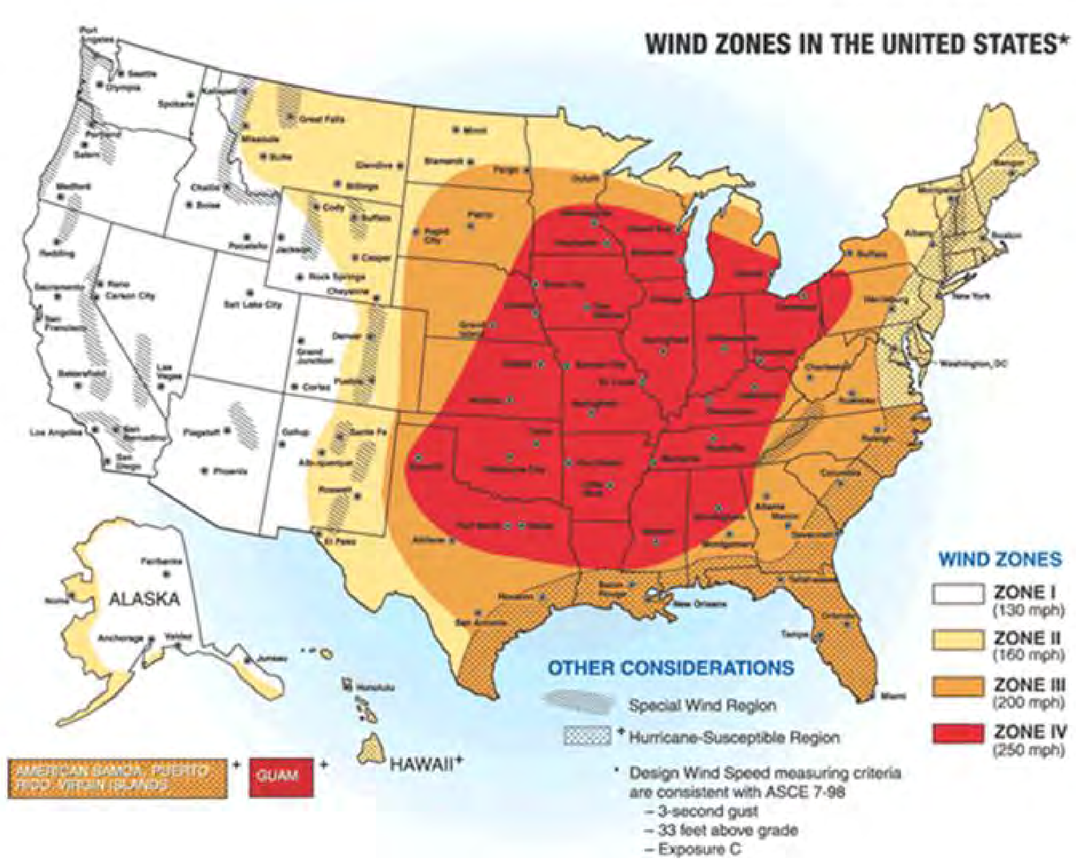
3.5.10.1 Location of Windstorm

Worcester, and the entire Commonwealth of Massachusetts, is at risk for experiencing windstorm events and/or extreme wind events associated with other weather conditions. The State Hazard Mitigation Plan notes that Massachusetts is susceptible to high wind from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms, tornados, and nor'easters.

3.5.10.2 Severity and Extent of Windstorm

FEMA maintains a Winds Zone map (see Figure 29) that indicates the United States' susceptibility to wind speeds and highlights special wind and hurricane-susceptible regions. Massachusetts, including Worcester, is located in a Zone II, meaning it is susceptible to winds of up to 160mph and it is also located in a hurricane susceptible region.

Figure 29: Wind Zones in the United States



Source: http://www.fema.gov/safe-rooms/wind-zones-united-states

3.5.10.3 Impact of Windstorm on Life, Property and Operations

The CMPRC plan indicates wind-blown debris, including tree branches and trees, can cause power outages and downed trees and tree branches in the road can create dangerous driving conditions. Windblown debris can pose a hazard to humans who are outside or near windows impacted by blowing debris. In addition, structural damage can also occur from windblown debris. Worcester building code requires that structures be designed to withstand wind forces up to 90 miles per hour.

3.5.10.4 Previous Occurrences of Windstorms

Windstorm events will remain a regular occurrence in the City of Worcester and could impact UMMS. The probability of future occurrences is certain. The entire State of Massachusetts is susceptible to extreme wind events such as hurricanes and tornadoes but also normal windstorms that do not have any other associated characteristics other than the movement of air (i.e., no precipitation).

The NCDC tracks high wind and strong wind events and the information in Table 3-49 was available for high wind (wind gusts greater than 50 knots) and strong wind (wind gusts greater than 30 knots) occurrences in Southern Worcester County from January 2004 to June 2014.

Table 3-49: High Wind Event Data for Southern Worcester County January 1, 2004 – June 1, 2014

Location	Date	Wind Speed	Event Type	Death	Injury	Property Damage
SOUTHERN WORCESTER COUNTY	11/27/2013	40 knots estimated gust	Strong Wind	0	0	5.00 K
SOUTHERN WORCESTER COUNTY	10/7/2013	41 knots measured gust	Strong Wind	0	0	5.00 K
SOUTHERN WORCESTER COUNTY	1/31/2013	56 knots estimated gust	High Wind	0	0	65.00 K
SOUTHERN WORCESTER COUNTY	1/20/2013	40 knots measured gust	Strong Wind	0	0	3.00 K
SOUTHERN WORCESTER COUNTY	10/29/2012	58 knots estimated gust	High Wind	0	0	50.00 K
SOUTHERN WORCESTER COUNTY	9/18/2012	40 knots estimated gust	Strong Wind	0	0	5.00 K
SOUTHERN WORCESTER COUNTY	2/25/2012	50 knots measured gust	High Wind	0	0	35.00 K
SOUTHERN WORCESTER COUNTY	2/19/2011	64 knots measured gust	High Wind	0	0	0.00 K
SOUTHERN WORCESTER COUNTY	2/19/2011	41 knots measured sustained	High Wind	0	0	0.00 K
SOUTHERN WORCESTER COUNTY	10/16/2010	30 knots measured sustained	Strong Wind	0	0	5.00 K
SOUTHERN WORCESTER COUNTY	10/1/2010	41 knots measured gust	Strong Wind	0	0	10.00 K
SOUTHERN WORCESTER COUNTY	10/7/2009	41 knots measured gust	Strong Wind	0	0	3.00 K
SOUTHERN WORCESTER COUNTY	3/21/2008	53 knots measured gust	High Wind	0	0	0.00 K
SOUTHERN WORCESTER COUNTY	2/10/2008	56 knots measured gust	High Wind	0	0	0.00 K
SOUTHERN WORCESTER COUNTY	10/29/2006	50 knots estimated gust	High Wind	0	0	5.00 K

Location	Date	Wind Speed	Event Type	Death	Injury	Property Damage
SOUTHERN WORCESTER COUNTY	2/17/2006	65 knots measured gust	High Wind	0	0	40.00 K
SOUTHERN WORCESTER COUNTY	1/18/2006	58 knots estimated gust	High Wind	0	0	40.00 K
SOUTHERN WORCESTER COUNTY	1/18/2006	43 knots measured sustained	High Wind	0	0	5.00 K
SOUTHERN WORCESTER COUNTY	1/15/2006	35 knots measured sustained	High Wind	0	0	5.00 K
SOUTHERN WORCESTER COUNTY	10/16/2005	58 knots estimated gust	High Wind	0	0	5.00 K
SOUTHERN WORCESTER COUNTY	9/29/2005	58 knots estimated gust	High Wind	0	0	30.00 K
SOUTHERN WORCESTER COUNTY	3/08/2005	65 knots measured gust	High Wind	0	0	0.00 K
SOUTHERN WORCESTER COUNTY	12/01/2004	58 knots estimated gust	High Wind	0	0	25.00 K
SOUTHERN WORCESTER COUNTY	11/05/2004	58 knots estimated gust	High Wind	0	0	35.00 K
Source: NCDC Storm Events Database http://www.ncdc.noaa.gov/stormevents/						

Specific details from the more significant high wind events noted in Table 3-49 that have occurred in southern Worcester County include:

- January 31, 2013 – A warm front moved across southern New England and brought rain, warm temperatures, and high winds. Downed power lines and tree damage were a result of the high winds. Worcester Regional Airport recorded a wind gust of 55 mph.
- October 29, 2012 – Superstorm Sandy brought high winds to southern New England, including Worcester. Worcester Regional Airport recorded sustained winds of 40 mph and gusts up to 61 mph.
- February 25, 2012 – Worcester County experienced sustained wind speeds of 38 mph and gusts to 58 mph as a result of low pressure moving across Maine. The high winds caused trees to fall in Worcester, some of which fell on two cars.
- February 17, 2006 – High winds across Massachusetts caused property damage, one death, and three known injuries across the state as a result of downed trees, tree limbs, utility poles, and wires.

3.5.10.5 Probability of Windstorm Hazard

The probability of a future occurrence of a windstorm at UMMS is certain due to their locations and susceptibility to other natural hazards that typically have a wind associated characteristic.

3.5.10.6 Vulnerability to Windstorm Hazard

UMMS has experienced minor windstorm events in recent years. Table 3-50 indicates susceptibility criteria reviewed as related to the selection of a wind storm as a hazard of concern for UMMS.

Table 3-50: UMMS Wind Storm Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State Hazard Mitigation Plan (2013) • Review of FEMA's Multi-Hazard Identification and Risk Assessment • Anecdotal Information from UMMS	• The state plan notes that Massachusetts is susceptible to high wind from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms, Tornados, and Nor'easters. • The state plan also notes that the entire Commonwealth is vulnerable to high winds that can cause a wide range of damage, with the coast typically seeing the most damage impacts. • UMMS staff reported that during a windstorm a piece of wood impaled a building and there was a roof of a building that was unsecure.

3.5.10.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a windstorm event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a windstorm event utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-51).

Table 3-51: Risk Assessment – Windstorm Event

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Windstorm	4	2	2	3	3.00	2.00	2.40	M

After reviewing the initial ranking of **medium** and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-52).

Table 3-52: Qualitative Risk Assessment – Windstorm

	Windstorm Hazard - Qualitative Ranking
Risk Ranking	Medium
Students, Faculty & Staff	Medium
Existing Buildings	Low
Future Buildings	Low
Operations	Low
Critical Infrastructure	Medium

As a result of considering these additional factors, the overall ranking remained **medium.**

3.5.10.8 Future Development Considerations

Future development at UMMS should be constructed, updated and redeveloped with regard to the most up to date building codes and materials to minimize wind damage.

3.5.11 Flood

A flood occurs when a high flow or inundation of water submerges land that is normally dry and causes or threatens damage. The most frequently flooded type of area is land adjacent to a water body and in a defined floodplain. Flooding can be coastal, riverine, or shallow flooding (associated with ponding or urban drainage). Flooding situations can develop slowly or very quickly. Floods can be dangerous because the flow of water can be rapid and impact a neighborhood, community, or the larger watershed area. Varying types of floods can exist including[4]:

- Coastal Flood: Flooding of coastal areas due to the vertical rise above the normal water level caused by strong and persistent onshore wind, high astronomical tide, and/or low atmospheric pressure, resulting in damage, erosion, flooding, fatalities, or injuries. Coastal areas are parts of coastal land zones adjacent to the waters and bays of the oceans. Farther inland, flood events are defined as Flash Flood or Flood. Elevation features determine how far inland the coastal flooding extends.
- Flash Flood: Rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g., intense rainfall, dam failure, ice jam-related), on a widespread or localized basis. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters. Flash floods do not exist for two or three consecutive days.
- Riverine Flooding: Generally means the flooding of rivers and streams over their pre-defined banks. In coastal regions, the riverine floodplain is generally a flat area along a larger river or in low-lying coastal areas. The volume that is manageable depends on the watershed, and climate and land use characteristics.
- Urban Flooding: In densely developed areas, heavy rains/precipitation can produce flooding when groundwater levels are high and there is insufficient drainage infrastructure in place.

Other terminology frequently used to describe flood conditions includes:

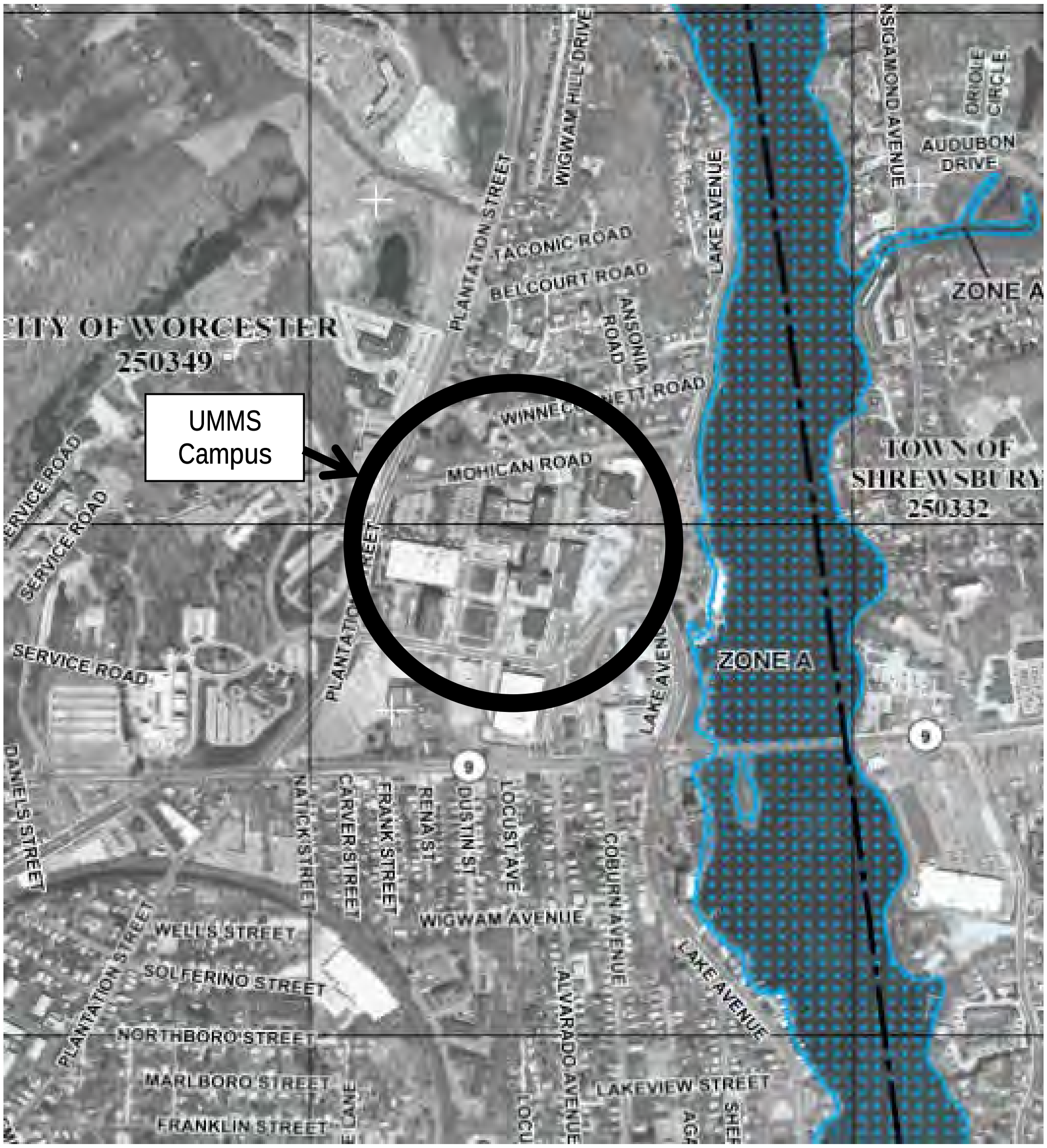
- Base Flood (100-Year Flood) – Flood that has a 1% chance of being equaled or exceeded in any given year. A 100-year flood can occur more than once in a short period of time. The term measures the size of the flood, not frequency of occurrence.
- 500-Year Flood – Flood that has a 0.2% chance of being equaled or exceeded in any given year. The 500-year flood is an infrequent event and can occur between once in eight years to once in fifty years. The term does not mean a flood occurs once in 500 years.

3.5.11.1 Location of Flood

In Massachusetts, flooding is a regular occurrence and often occurs due to other weather events such as a coastal storm, nor'easter, heavy rain, hurricane, or winter storm. According to the State of Massachusetts Hazard Mitigation Plan, flooding affects the majority of communities in the Commonwealth. Figure 30 shows the FEMA Flood Map for the UMMS campus area in Worcester. According to FEMA, Flood Zone A is an area subject to inundation by the 1% annual-chance flood event. The UMMS facilities at South Street and Maple Avenue in Shrewsbury, and MassBiologics in Mattapan are not in flood zones.

[4] National Weather Service Instruction 10-1605 (August 17, 2007), Operations and Services Performance, NWSPD 10-16 Storm Data Preparation document (http://www.nws.noaa.gov/directives)

Figure 30: FEMA Flood Map - UMMS Worcester Campus



Source: FEMA Flood Insurance Rate Map (FIRM) effective July 4, 2011.

3.5.11.2 Severity and Extent of Flood

FEMA designated flood zones according to the level of flood risk and type of flooding for an area. According to FEMA's Flood Insurance Rate Map (FIRM), UMMS is located outside of Flood Zone A. Flood Zone A is an area subject to inundation by the 1% annual-chance flood event. UMMS is most likely to experience secondary flooding impacts due to infrastructure or building failures, such as heavy rain falling faster than the drainage system can remove it.

3.5.11.3 Impact of Flood on Life, Property and Operations

Flooding occurrences can cause substantial negative impacts on life, property and operations in a community or university setting, particularly if proper insurance mechanisms are not in place. Cleaning up assets and infrastructure, housing or relocating faculty and staff and displacement costs can be expensive and extensive. Flooding can also modify the natural environment – particularly in coastal communities. The UMMS campus in Worcester, UMMS buildings in Shrewsbury at South Street and Maple Avenue and the Mattapan buildings are not in FEMA identified floodplains, so an analysis regarding what would be impacted by a flood event was not conducted.

3.5.11.4 Previous Occurrences of Flooding

According to the FEMA, there have been 14 Presidential Disaster Declarations made for flooding incidents in the Commonwealth of Massachusetts and a number of those events impacted Worcester County (see Table 3-53). The UMMS main campus in Worcester has not been directly impacted by flooding events in the past.

Table 3-53: Massachusetts Flooding Major Disaster Declarations (1954 – Present)

	Disaster No.	Incident Period	Date Disaster Declared	Worcester County a Designated Area?
Severe Winter Storm, Snowstorm, Flooding	DR-4110	2/8/2013 – 2/9/2013	4/19/2013	Yes
Severe Storm and Flooding	DR-1895	3/12/2010 – 4/26/2010	3/29/2010	Yes
Severe Winter Storm and Flooding	DR-1813	12/11/2008 – 12/18/2008	1/5/2009	Yes
Severe Storms, Inland and Coastal Flooding	DR-1701	4/15/2007 – 4/25/2007	5/16/2007	No
Severe Storms and Flooding	DR-1642	5/12/2006 – 5/23/2006	5/25/2006	No
Severe Storms and Flooding	DR-1614	10/7/2005 – 10/16/2005	11/10/2005	Yes
Flooding	DR-1512	4/1/2004 – 4/30/2004	4/24/2004	Yes
Severe Storms and Flooding	DR-1364	3/5/2001 – 4/16/2001	4/10/2001	Yes
Heavy Rain and Flooding	DR-1224	6/13/1998-7/6/1998	6/23/1998	Yes
Severe Storms and Flooding	DR-1142	10/20/1996-10/25/1996	10/25/1996	No
Severe Storms and Flooding	DR-790	3/30/1987-4/13/1987	4/18/1987	Yes
Coastal Storms, Flood, Ice, Snow	DR-546	2/6/1978-2/8/1978	2/10/1978	No
Severe Storms, Flooding	DR-325	3/6/1972	3/6/1972	No
Hurricane, Floods	DR-43	8/20/1955	8/20/1955	Unknown

The NCDC tracks storm events and the information in Table 3-54 was available for Worcester regarding flood occurrences.

Table 3-54: Select Flood Event Data for Worcester (Jan 2000 – May 2014)

Location	Date	Deaths	Injury	Property Damage Estimate
Worcester	7/22/2008	0	0	5.00 K
Worcester	2/13/2008	0	0	10.00 K
Worcester	10/28/2006	0	0	5.00 K
Worcester	7/28/2006	0	0	20.00 K
Southern Worcester County	10/15/2005	0	0	100.00 K
Source: NCDC Storm Events Database http://www.ncdc.noaa.gov/stormevents/				

Specific details from the flood events noted in Table 3-54 that have occurred in the City of Worcester area include:

- July 22, 2008 – Heavy rain resulted in street flooding where one car was flooded out in Southern Worcester.
- February 13, 2008 – Rain and snow fell flooding three streets in Worcester and closing the Western Worcester District Court because of roof leaks.
- October 28, 2006 – Significant urban flooding was reported in and around Worcester with rainfall totals of 2 to 4 inches.
- July 28, 2006 – Heavy rainfall resulted in significant urban flooding in Massachusetts, including the City of Worcester. In Worcester, Route 20 in both directions was closed at Route 122.
- October 15, 2005 – Heavy rain and flooding occurred around Massachusetts, resulting in nearly 3,000 evacuations around the Commonwealth. The City of Worcester's Industrial District experienced waters about 7 feet deep and 30 cars and 2 or 3 train boxcars were swept away or lifted up by flood waters.

3.5.11.5 Probability of Flooding Hazard

The State of Massachusetts Hazard Mitigation plan notes that flooding is the most common hazard to affect New England. It is likely that flood events could impact the UMMS main campus in Worcester either directly or indirectly.

3.5.11.6 Vulnerability to Flooding Hazard

The entire Commonwealth of Massachusetts is vulnerable to flooding impacts. Flooding in Worcester is usually associated with rivers and streams overfilling their banks or undersized or poorly maintained infrastructure and drainage systems. Table 3-55 indicates additional details regarding UMMS vulnerability to a flood hazard event.

Table 3-55: Flood Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State Hazard Mitigation Plan (2013) • Review of FEMA's Multi-Hazard Identification and Risk Assessment • CMRPC Pre-Disaster Hazard Mitigation Plan	• The state plan notes that flooding is the most common hazard to affect New England. • CMRPC plan notes that central Massachusetts is at moderate risk for flood threats which may result in serious or extensive damage. • High rains have caused minor flooding in areas occupied by UMMS in the past. • UMass Memorial Medical Center ranked flood as low vulnerability in

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal Information from UMMS • UMass Memorial Medical Center HVA (2014)	2014.

3.5.11.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for flood event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a flood event utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-56).

Table 3-56: Risk Assessment – Flood Event

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Flood	1	2	2	2	1.67	2.00	1.87	L

After reviewing the initial ranking of low and conducting further research, specific consideration was given to how a flood event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-57).

Table 3-57: Qualitative Risk Assessment – Flood

	Flood Hazard - Qualitative Ranking
Risk Ranking	Low
Students, Faculty & Staff	Low
Existing Buildings	Low
Future Buildings	Low
Operations	Low
Critical Infrastructure	Medium

As a result of considering these additional factors, the overall ranking remained low.

3.5.11.8 Future Development Considerations

Flooding is not a major concern for the UMMS campus. For future development or redevelopment the university may want to consider the following:

- Ensure that critical infrastructure/generators are located in places on campus with minimum susceptibility for flooding impacts,
- Consider flood control/mitigation with any future campus development or redevelopment plans,
- Work with City of Worcester officials on emergency procedures should the ingress/egress routes to campus be dramatically impacted by floodwaters, and
- Evaluate green infrastructure techniques that can be implemented to minimize flood occurrences.

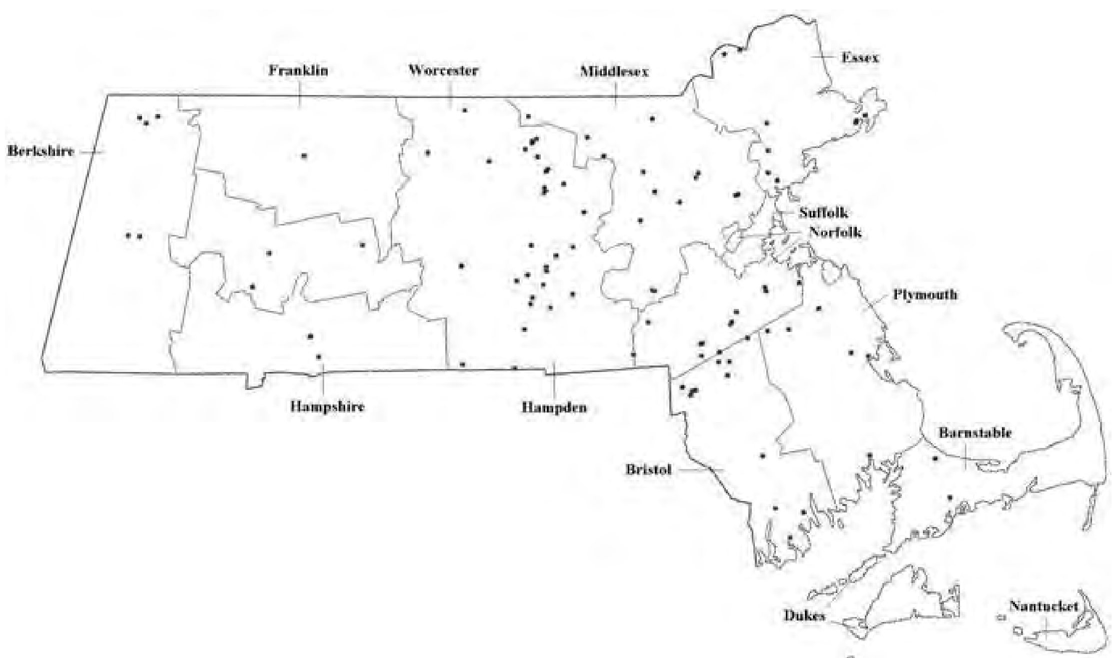
3.5.12 Dam Failure

A dam is an artificial barrier that holds water for storage or water control. The primary purpose of a dam is to retain water for water supply, power generation, flood control, or recreation. A dam failure is the uncontrolled release of water held by the dam due to deficiencies in the dam's structure. While dam failures are uncommon, the hazards associated with dam failure can range from minor to catastrophic depending on the amount of notice for impending dam failure, size of the dam, the type of dam failure, and the area surrounding the dam.

3.5.12.1 Location of Dam Failure

Worcester County has 430 dams, which makes up 30% of the dams in the Commonwealth of Massachusetts. The City of Worcester has the most dams in the Commonwealth and is responsible for 28 dams. According to the *Local Financial Impact Review: Massachusetts Dam Safety Law* report issued in 2011 by the Auditor of the Commonwealth, Worcester County had 32 dams determined to be in poor or unsafe condition (see Figure 31). Of these 32 high or significant hazard potential dams in Worcester County, four of the dams are located in Worcester: Patch Pond Dam, Quinsigamond Pond Dam, Green Hill Pond Dam, and Bell Pond Dam (Table 3-58).

Figure 31: Poor Condition Dams in Massachusetts



Source: *Local Financial Impact Review: Massachusetts Dam Safety Law* report (2011)

Table 3-58: City of Worcester Dams Rated "Critical" in the *Local Financial Impact Review: Massachusetts Dam Safety Law* Report (2011)

Dam Name	Hazard Rating	Overall Physical Condition	Year Built	Office of Dam Safety Notes
Patch Pond Dam	High	Poor	1900	Dam in disrepair, no evidence of maintenance, no O&M Manual
Quinsigamond Pond Dam	No Rating	Poor	1891	Dam in disrepair, no evidence of maintenance, no O&M Manual
Green Hill Pond Dam	High	Poor	1881	Some maintenance and standard procedures
Bell Pond Dam	Significant	Poor	1840	Dam in poor level of upkeep, very little maintenance, no O&M Manual
Information adapted from *Local Financial Impact Review: Massachusetts Dam Safety Law* report (2011)				

The Spring 2014 edition of "On the Water Front" published by the Worcester Department of Public Works and Parks notes that three dams are receiving particular attention including:

- Patch Pond Dam – located in Worcester, this dam is in the worst condition of any city-owned dam. The Worcester Department of Public Works and Parks received a grant from the Commonwealth to conduct a feasibility study to determine if dam removal is an option for Patch Pond Dam.
- Kettle Brook Reservoir Number 4 Dam – located in Paxton, this dam is part of Worcester's water supply system. The dam is in fair condition but may not handle flows from a large flood without overtopping. To correct this, a bridge over the spillway is being replaced, the height of the existing dikes is being increased, and the spillway is being repaired.
- Poor Farm Pond Dam – located in Shrewsbury as part of a former water source for irrigating crops, the pond is sediment filled and the dam is in disrepair. In November 2013, the Department of Public Works and Parks received a dam and seawall grant from the Commonwealth to remove this dam in late 2014 or early 2015.

3.5.12.2 Severity and Extent of Dam Failure

The Commonwealth of Massachusetts has four hazard classifications for dams, as described in Table 3-59 below.

Table 3-59: Dam Hazard Classification (Commonwealth of Massachusetts)

Hazard	Description
Low Hazard	Failure or improper operation may cause minimal property damage and loss of life is not expected
Significant Hazard	Failure or improper operation may cause loss of life and damage to homes, industrial facilities, commercial properties, secondary highways, secondary railroads, or cause interruption of use or service of relatively important facilities
High Hazard	Failure or improper operation will likely cause loss of life and serious damage to homes, industrial facilities, commercial properties, important public utilities, main highways, or railroads
Critical	Substandard, municipally owned dams
Source: CMRPC 2012	

The CMRPC plan states that Central Massachusetts, including Worcester is at low risk for flood threat from dams, but that dam failures could result in minor, extensive, or catastrophic damage.

3.5.12.3 Impact of Dam Failure on Life, Property and Operations

According to the State Hazard Mitigation Plan, the most common reasons for dam failure can be due to four main causes: overtopping, foundation defects, piping or seepage failure, or problems with conduits or valves. Dam failures can cause severe consequences as water rushes downstream flooding an area. Engineers refer to the area affected by the flooding water associated with the dam failure as the “inundation area.” The severity of impact to life and property depends upon the following:

- The number of people living or working in the inundation area;
- The number of structures in the inundation area; and
- The amount of time the warning is given to people downstream of the dam.

A dam failure primarily causes flooding. Secondary hazards of a dam failure can include landslides around the reservoir perimeter, riverbank erosion, and/or downstream habitat damage.

3.5.12.4 Previous Occurrences of Dam Failure Hazard

There have been no previous occurrences of a dam failure impacting the UMMS main campus. However, there have been instances of significant dam failures in Massachusetts in the past including:

- October 2005 - Whittenton Pond Dam (Taunton) was excessively stressed and a rock dam/spillway was constructed downstream of the dam as a preventative measure. The dam did not breach and no one was harmed, but approximately 2,000 people were evacuated from the area.
- March 24, 1968 – Lee Lake Dam (East Lee, MA) failure caused two fatalities, destroyed six homes, damaged 20 homes, and damaged one manufacturing plant.
- May 16, 1874 – Williamsburg Reservoir (Williamsburg, MA) broke and flooded a valley, killing 139 people and devastating farms and factories. This was the deadliest dam failure in the United States at the time.

3.5.12.5 Probability of Dam Failure Hazard

None of the dams in the vicinity of UMMS have experienced failure in the past, so the probability of future occurrence is unknown. Likelihood would increase if the following events did occur:

- Natural hazards such as an earthquake/flood,
- Sabotage, terrorism,
- Dam structures are overtopped or about to be overtopped due to floodwaters,
- Earth embankments to be breached by erosion or slope failure, and
- Spillways are blocked or seepage exists downstream.

3.5.12.6 Vulnerability to Dam Failure Hazard

The UMMS main campus is located near several dams.

Table 3-60 lists the dams located in close proximity to UMMS. The hazard classification descriptions in are available in Table 3-59.

Table 3-60: Dams Located Near UMMS

Dam Name	Hazard Classification[5]
Bell Pond Dam	Significant Hazard
Salisbury Pond Dam	Significant Hazard
Bear Brook Dam	Significant Hazard
Green Hill Pond Dam	High Hazard
Green Hill Duck Pond Dam	Not Analyzed

Many of the dams located in Worcester are over 100 years old. According to the State Hazard Mitigation Plan, the age of a dam increases the level of risk associated with failures. Criteria used to evaluate dam failure susceptibility is provided in Table 3-61.

Table 3-61: Dam Failure Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State Hazard Mitigation Plan (2013) • CMRPC (2012) • Local Financial Impact Review: Massachusetts Dam Safety Law report (2011)	• The State plan lists dam failure as having very low frequency with an extensive severity level. • The CPRPC plan lists Worcester County's vulnerability as low frequency but extensive severity. • According to the Massachusetts Dam Safety Law report, there are 32 dams in Worcester County determined to be in poor or unsafe condition; 4 of which are located in the City of Worcester

3.5.12.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a dam failure event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a dam failure event utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-62).

Table 3-62: Risk Assessment – Dam Failure Event

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Dam Failure	1	2	2	1	1.33	2.00	1.73	L

After reviewing the initial ranking of low and conducting further research, specific consideration was given to how an event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-63).

[5] MassGIS Data – Dams, February 2012

Table 3-63: Qualitative Risk Assessment – Dam Failure

	Dam Failure Hazard - Qualitative Ranking
Risk Ranking	Low
Students, Faculty & Staff	Low
Existing Buildings	Low
Future Buildings	Low
Operations	Low
Critical Infrastructure	Low

As a result of considering these additional factors, the overall ranking remained low.

3.5.12.8 Future Development Considerations

The UMMS key stakeholders on campus should continue to communicate regularly with City of Worcester officials regarding the dams located in its vicinity. Staying informed about condition, inspections and any maintenance work will be helpful to monitor for any potential impacts to the campus.

3.5.13 Wildfire

A wildfire is a fire that occurs in vegetation, including grass, brush, leaf litter, meadowland, and forests. The State of Massachusetts Hazard Mitigation Plan states that wildfires in Massachusetts can be started by natural events, arson, human activity, or in an intentional controlled manner.

3.5.13.1 Location of Wildfire

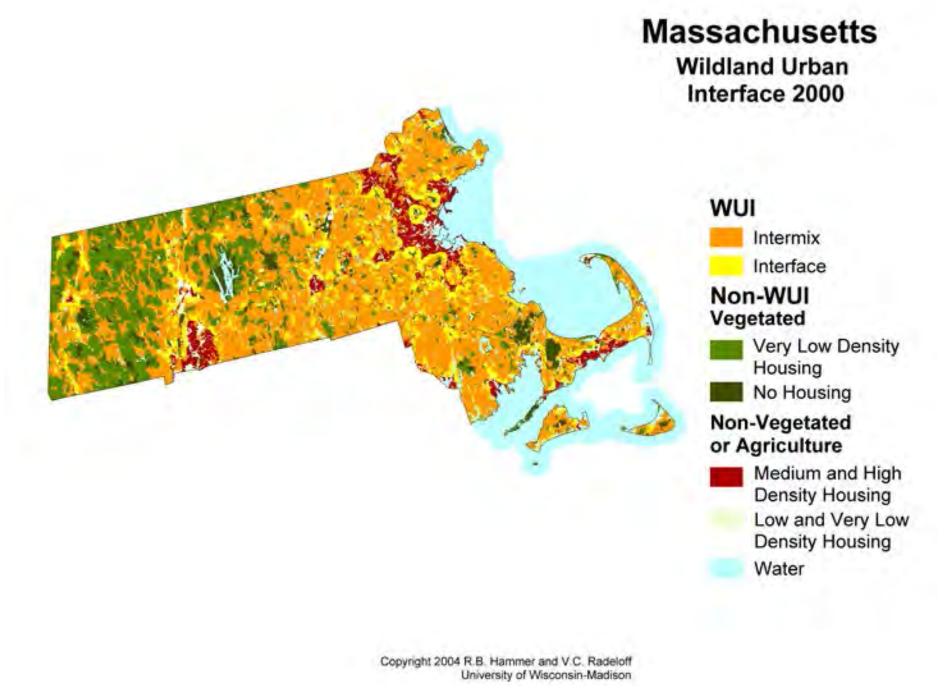
According to the Eastern Forest Environmental Threat Assessment Center (EFETAC), Massachusetts is at risk for high intensity forest fires because of the available fuel buildup in forests (i.e., thinning and prescribed burning of forested areas in Massachusetts has been inadequate in recent decades). Wildfires in Massachusetts can happen throughout the year, but the Massachusetts wildfire season typically runs from late March to early June, with April being the month with the most wildfires.

The area where urban structures meet with undeveloped wildland or vegetative fuels is called the wildland-urban interface. The wildland-urban interface is at increased risk to wildfire damage for a number of reasons, including, but not limited to the following:

- Increased likelihood of human-caused fire ignition;
- Access to these areas is difficult, making it harder to protect structures from wildfire; and
- Fire suppression can be difficult to access.

Based on census and other data available in the year 2000, the center of the City of Worcester is primarily classified as medium to high density housing (red areas in Figure 32) with smaller pockets of very low density housing (green areas in Figure 32), neither of which are considered part of the wildland-urban interface. However, the outer edges of City of Worcester are considered to be wildland-urban interface areas (yellow areas in Figure 32).

Figure 32: Massachusetts Wildland Urban Interface



Source: Radeloff, V. C. et al., *The Wildland Urban Interface in the United States.* Ecological Applications, 15:799-805. 2005 http://silvis.forest.wisc.edu/old/Library/WUI_state_download.php?state=Massachusetts&abrev=MA

3.5.13.2 Severity and Extent of Wildfire

The State of Massachusetts Hazard Mitigation Plan states the wildland-urban interface areas have the greatest potential for damage from fire. There are three main classes of wildfires, which are described in Table 3-64 below.

Table 3-64: Classes of Wildfires

Class	Description
Surface Fire	• Burns along the forest floor • Slow moving • Causes damage to or kills trees • The most common type of wildfire
Ground Fire	• Burns organic fuels below the forest floor • Usually occurs during drought conditions
Crown Fire	• Quickly moving fire, jumping along treetops • Spread rapidly by the wind
Source: Massachusetts State Hazard Mitigation Plan (2013)	

3.5.13.3 Impact of Wildfire on Life, Property, and Operations

Wildfires can result in damage to land, including forests, crops, grasslands, and brush, and personal property. Secondary impacts of wildfires include watershed damage, flooding from silt entering local watersheds, landslides in steep ravine areas caused by the removal of vegetation, and reduced air quality due to smoke, which can create a health hazard to sensitive populations such as children, the elderly, and people with respiratory and cardiovascular conditions. Wildfires do not usually cause casualties to the general public due to the fast response times to reported wildfires. However, wildfires can threaten the lives and safety of firefighters who respond to the wildfire. Economic losses can be experienced after a wildfire when harvestable timber is damaged or destroyed and/or if the wildfire results in reduced tourism to the area.

3.5.13.4 Previous Occurrences of Wildfire Hazard

UMMS staff report the main campus in Worcester has experienced smoke from wildfires in the past. These wildfires were not necessarily close, but the air quality was impacted by the smoke produced by the wildfires.

One wildfire event is listed on the NDC Storm Events Database for Worcester County since January 1, 2000. On April 19, 2012, a wildfire with unknown initial cause burned meadowlands in Dedham and an acre of land on the Leicester-Paxton boarder. A Paxton firefighter was injured when he was struck by a falling tree branch while fighting the fire.

The Geospatial Multi-Agency Coordination Wildland Fire Support website[6] reports seven wildfires occurred in Massachusetts from 2002 to 2013. Details about these wildfires are below:

- April 11, 2010 – Tekoa Mountain wildfire near Westfield, MA with unknown cause
- April 23, 2008 – Widow White Peak human caused wildfire near Lanesboro, MA
- April 19, 2008 – Oscar Range human caused wildfire near Leominster, MA
- April 16, 2005 – The Range human caused wildfire near Leominster, MA
- April 29, 2004 – Bearsden human caused wildfire near Athol Center, MA
- November 16, 2003 – 128 Fire in Dedham, MA caused by lightning
- August 14, 2002 – Devens wildfire in Lancaster, MA intentionally set for Devens Reserve Forces Training.

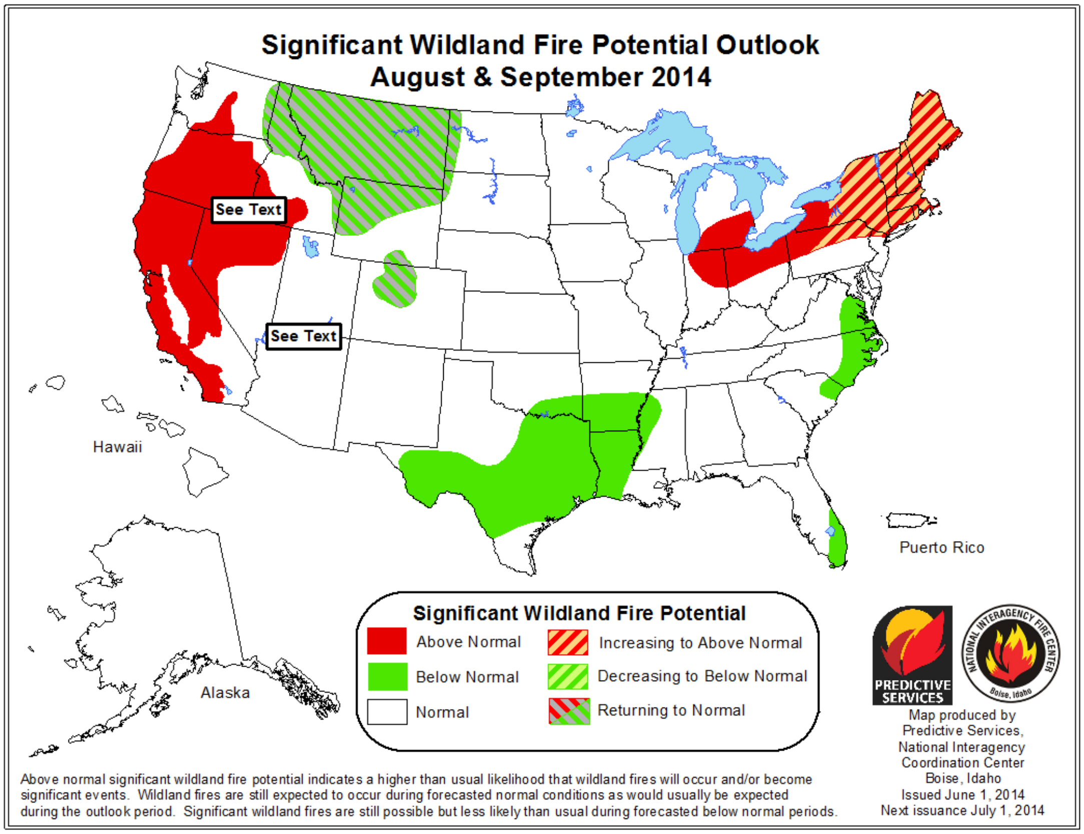
3.5.13.5 Probability of Wildfire Hazard

The Massachusetts Department of Conservation and Recreation Commissioner was quoted in a news article as stating, "In 2013 alone, more than 1,700 wildfires burned 1,400 acres in Massachusetts."[7] Most wildfires are caused by humans. The majority of wildfires are started by negligent human behavior, such as improperly extinguishing campfires or smoking in forested locations. The second leading cause of wildfires is arson.

The National Interagency Fire Center (NIFC) issues monthly outlooks for the national significant willdland fire potential. According to the June 1, 2014 outlook, the significant wildland fire potential for the Northeastern United States, Including Massachusetts, is normal in June and July 2014 but in August and September 2014 the significant wildland fire potential is predicted to increase to above normal levels (see Figure 33). According to the NIFC, an above normal significant wildland fire potential indicates a higher than usual likelihood that wildland fires will occur and/or become significant events.

[6] http://wildfire.usgs.gov/geomac/index.shtml
[7] Flynn, Jack, MassLive. *With Wildfires Increasing, Massachusetts Officials Urge Caution in State Forests and Parks.* April 21, 2014.

Figure 33: Significant Wildland Fire Potential Outlook: August & September 2014 (NIFC)

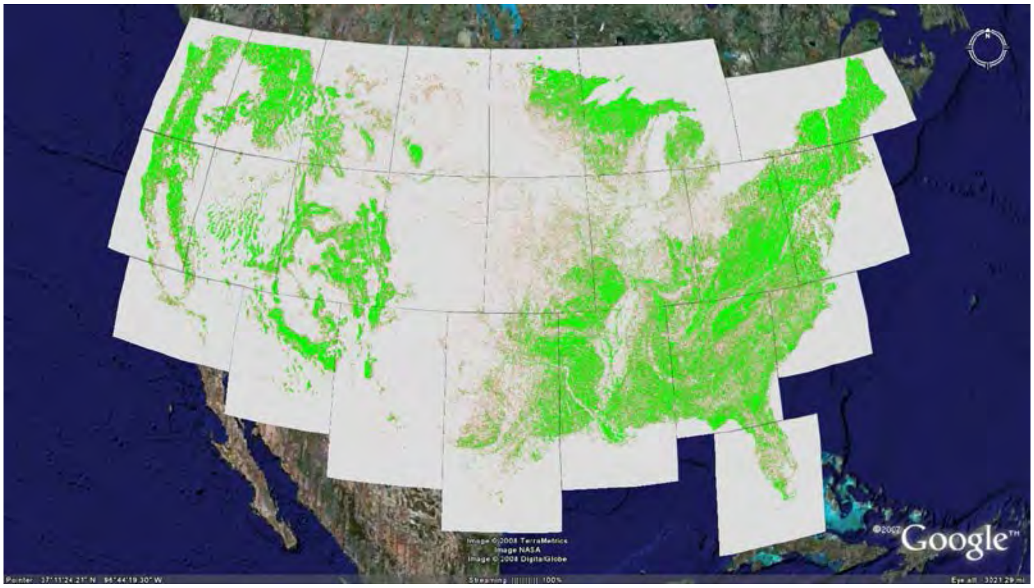


Source: http://www.predictiveservices.nifc.gov/outlooks/monthly_seasonal_outlook.pdf

3.5.13.6 Vulnerability to Wildfire Hazard

The Eastern Forest Environmental Threat Assessment Center created a Forest Area Density map (Figure 34) to determine the amount of forest that is surrounded by other forest. Coloring on the map ranges from red, indicating there is a small amount of forest in a neighborhood to green, indicating a large amount of forest in the neighborhood. The yellow intermediate colors indicate intermediate amounts of forest in the neighborhood. Areas on the figure that are colored gray indicate that that the place itself is not forest. The City of Worcester has trees, but is not densely forested. However, the City of Worcester is surrounded by forested areas.

Figure 34: Forest Area Density Map (EFETAC)



Source: http://www.forestthreats.org/research/tools/landcover-maps/fden

Table 3-65 details the susceptibility of the UMMS campus in Worcester to wildfire.

Table 3-65: Wildfire Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State Hazard Mitigation Plan (2013) • CMRPC Pre-Disaster Hazard Mitigation Plan (2012) • Anecdotal Information from UMMS • UMass Memorial Medical Center HVA (2014)	• The State Hazard Mitigation Plan indicates that Worcester is in a high wildfire risk area in Massachusetts. • The CMRC plan notes that wildfires are uncommon in the area, but smaller brush fires are relatively common. However, changing land use and weather conditions can increase the area's vulnerability. • UMMS staff report that smoke from wildfires has impacted the UMMS main campus in the past. • UMass Memorial Medical Center ranked wildfire as low vulnerability in 2014.

3.5.13.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a wildfire event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a wildfire event utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-66).

Table 3-66: Risk Assessment – Wildfire Event

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Wildfire	1	2	2	2	1.67	2.00	1.87	L

After reviewing the initial ranking of low and conducting further research, specific consideration was given to how a flood event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-67).

Table 3-67: Qualitative Risk Assessment – Wildfire

	Wildfire Hazard - Qualitative Ranking
Risk Ranking	Low
Students, Faculty & Staff	Low
Existing Buildings	Low
Future Buildings	Low
Operations	Medium
Critical Infrastructure	Low

As a result of considering these additional factors, the overall ranking remained low.

3.5.13.8 Future Development Considerations

Future development at UMMS should be constructed, updated and redeveloped with regard to the most up to date building and fire codes.

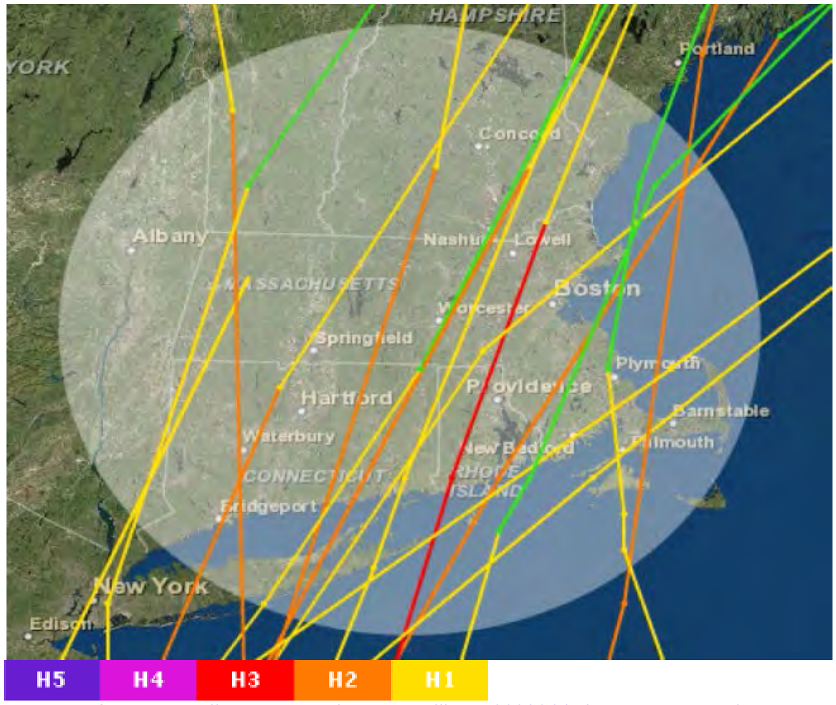
3.5.14 Hurricane

Hurricanes are characterized by a constant wind speed of 74 miles per hour (mph) or more, wind that blows in a large spiral motion around a rotating "eye" (calm center of the storm), and an expansive reach that can extend for hundreds of miles. Hurricanes can have a short duration or last for several days, impacting numerous states, counties, and towns along the coastline. The aftermath of a hurricane frequently causes additional damage due to lasting high winds, storm surge, and flooding. Storms that have wind speeds between 39 mph and 73 mph are classified as tropical storms.

3.5.14.1 Location of Hurricane

Massachusetts and the UMMS campus in Worcester are susceptible to hurricane events. Figure 35 shows the historical hurricane tracks that have impacted Massachusetts through 2012 (does not include tropical storms).

Figure 35: Historical Hurricane Tracks 1861 – 2012 (NOAA)



Source: http://csc.noaa.gov/hurricanes/#app=8380&81d2-selectedIndex=0

The State Hazard Mitigation plan notes that inland areas of Massachusetts, including Worcester, are at risk for flooding due to the heavy rain and wind associated with hurricane events.

3.5.14.2 Severity and Extent of Hurricane

For reference and tracking purposes, hurricanes are categorized by class using the Saffir-Simpson Hurricane Wind Scale (SSHWS) summarized in Table 3-68. The SSHWS uses a 1-minute sustained wind speed at a height of 33 feet over open water to categorize storm damage potential.[8] A storm with organized circulation and sustained winds below a Category 1 Hurricane threshold (winds range from 39 to 73 mph) is categorized as a tropical storm.

Table 3-68: Saffir-Simpson Hurricane Wind Scale (SSHWS)

Category	Wind Speed	Storm Surge (feet above normal sea level)	Expected Damage
1	74-95 mph	4-5 feet	Minimal: Damage is done primarily to shrubbery and trees, unanchored mobile homes are damaged, some signs are damaged, damage to structures is minimal or none.
2	96-110 mph	6-8 feet	Moderate: Some trees are toppled, some roof coverings are damaged, and mobile homes may have major damage.
3	111-130 mph	9-12 feet	Extensive: Large trees are toppled, some structural roof damage occurs, mobile homes are

[8] FEMA Coastal Construction Manual, 2011

Category	Wind Speed	Storm Surge (feet above normal sea level)	Expected Damage
			destroyed, structural damage to small homes and utility buildings is possible.
4	131-155 mph	13-18 feet	**Extreme:** Extensive damage is done to roofs, windows and doors; roof systems on small buildings completely fail; some curtain walls fail.
5	> 155 mph	> 18 feet	**Catastrophic:** Roof damage is considerable and widespread, window and door damage is severe, there are extensive glass failures, and entire buildings could fall.

It is important to note that lower category storms, including tropical storms, can inflict greater damage than higher category storms depending on where and when the storm strikes. Tropical storms have been known to produce significant damage and loss of life, mainly due to flooding.

NOAA, through the National Weather Service's Hurricane Center, issues hurricane watches and warnings, forecasts hurricane track and wind field information, and offers locally specific chances of experiencing tropical storm, strong tropical storms, and hurricane force winds out to five days. Effective in 2013, NOAA broadened the definition of hurricane and tropical storm watches and warnings to allow watches and warnings to be issued once a tropical cyclone (hurricane) or strom becomes post-tropical. During the post-tropical stage, storms can pose a significant threat to life and property, as observed with Hurricane Sandy.

3.5.14.3 Impact of Hurricane on Life, Property and Operations

The main hazards associated with hurricanes include storm surge, high winds, heavy rain, flooding, and potential tornadoes. Hurricanes can have significant impacts on human health due to storm intensity. Drowning in a storm surge is the leading cause of hurricane death. In an average 3-year period, approximately five hurricanes strike the United States coastline, killing approximately 50 to 100 people anywhere from Texas to Maine. Of these, two are typically major hurricanes classified as a Category 3 or greater. Table 3-69 lists the ten deadliest hurricanes recorded in the United States from 1980 to 2011. This table does not include the 117 fatalities associated with Hurricane Sandy that occurred in 2012[9].

[9] Source: CDC, http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6220a1.htm

Table 3-69: 10 Deadliest Hurricanes Recorded in the United States

Top 10 Deadliest Hurricanes from 1980-2011

Hurricane	*Persons*
Katrina (2005)	1833
Rita (2005)	119
Ike (2008)	112
Hugo (1989)	86
Floyd (1999)	77
Juan (1985)	63
Andrew (1992)	61
Ivan (2004)	57
Isabel (2003)	55
Gustav (2008)	53

Source: Lott et al., 2012.

The greatest impacts from hurricanes to property and infrastructure includes wind and water damage: flooding, utility failure, building damage, shoreline erosion, natural resource damage; interruptions with emergency, fire, and police services, and economic loss due to business property damage and loss of inventory. A hurricane can have devastating effects on a large area if directly in the path of a hurricane causing long term affects to the local economy and environment.

3.5.14.4 Previous Occurrences of Hurricane Hazard

Since 1954, there have been six Major Disaster Declarations in the State of Massachusetts due to a hurricane or tropical storm. Two of those six hurricanes have resulted in Worcester County receiving a designated area status from FEMA (see Table 3-70).

Table 3-70: Massachusetts Hurricane Major Disaster Declarations (1954 – May 2014)

	Disaster No.	Incident Period	Date Disaster Declared	Worcester County a Designated Area?
Hurricane Sandy	4097	10/27/2012 – 11/08/2012	12/19/2012	No
Tropical Storm Irene	4028	8/27/2011 – 8/29/2011	9/23/2011	No
Hurricane Bob	914	8/19/1991	8/26/1991	Yes
Hurricane Gloria	751	9/27/1985	10/28/1985	Yes
Hurricane Diane	43	8/20/1955	8/20/1955	Unknown
Hurricane	22	9/2/1954	9/2/1954	Unknown
Source: FEMA Major Disaster Declarations 1954 – Present				

Some of the more notable hurricane events include:

- Hurricane Sandy (2012) – In the fall of 2012, Hurricane Sandy had a major impact on the New York and New Jersey coastline. The storm broke an all-time record for storm surge height in New York harbor, caused over 100 fatalities, and has reached a cost of over $79 billion for federal aid to cover damages, recovery and mitigation measures. In Massachusetts, Sandy knocked out power to over 200,000 customers, disrupted travel and closed schools. Downed trees, power lines and flooding were also present during and after the storm.

- Hurricane Bob (1991) – Made landfall in Rhode Island on Block Island and left extensive damage throughout New England totaling over $1 billion.
- Hurricane Gloria (1985) – A storm that hit Long Island, NY and New Jersey that caused minor storm surge, erosion damage and substantial wind damage.
- Long Island Express Hurricane (1938) – This storm moved up the east coast from New York through New England and caused widespread storm surge and wind damage to buildings. It is used today as a benchmark for predicting worst-case scenario damage in the region.

Historically, when Massachusetts is impacted by a hurricane, the storm is usually a tropical storm or Category 1 to Category 3 hurricane. However, while occurrences are less frequent, Massachusetts has been impacted by Category 4 and 5 hurricanes in the past. Table 3-71 provides information about the history of hurricanes and tropical storms that have affected Massachusetts between 1851 and 2013

Table 3-71: History of Hurricanes and Tropical Storms Impacting Massachusetts 1851 – 2013

Date	Name	Category	Landfall?
October 2012	Sandy	Tropical Storm	Yes
August 2011	Irene	2	No
September 2010	Earl	4	No
August 2009	Bill	Tropical Storm	No
September 2008	Hanna	1	No
July 2006	Beryl	Tropical Storm	No
September 1999	Floyd	4	Yes
July 1996	Bertha	3	No
August 1991	Bob	3	Yes
September 1960	Donna	5	Yes
September 1959	Gracie	3	No
August 1955	Diane	3	No
October 1954	Hazel	3	No
September 1954	Edna	3	Yes
August 1954	Carol	2-3	No
1949	Unnamed	Unknown	No
1945	Unnamed	Unknown	No
September 1944	Great Atlantic Hurricane	4	Yes
September 1938	New England Hurricane of 1938	3	Yes
September 1869	September Gale of 1869	3	No
September 1815	Great September Gale of 1815	3	No
August 1635	Great Colonial Hurricane of 1635	3	No
Source: Massachusetts State Hazard Mitigation Plan (2013)			

3.5.14.5 Probability of Hurricane Hazard

According to NOAA's Adapting to Climate Change Guide and the Massachusetts State Hazard Mitigation Plan, the power and frequency of Atlantic Ocean hurricanes has increased in recent decades and the intensity of Atlantic hurricanes is likely to increase over the extended long term. Within the short term, NOAA makes predictions on a yearly basis at the start of hurricane season to forecast the number of Atlantic Ocean based hurricanes. For 2014, NOAA is forecasting a near-normal or normal hurricane season with a 70 percent likelihood of 8 to 13 named storms, of which 3 to 6 could become hurricanes. According to the State Hazard Mitigation Plan, based on past hurricane landfalls and the frequency of tropical systems to hit Massachusetts, a tropical storm is expected to impact Massachusetts is once out of 1.75 years on average.

3.5.14.6 Vulnerability to Hurricane Hazard

According to the State of Massachusetts Hazard Mitigation Plan, Massachusetts is susceptible to hurricanes (and tropical storms). Impacts to the Commonwealth in addition to a direct hit can include effects from tropical remnants such as heavy rain, localized flooding and storm surge. In Worcester County, heavy rains associated with hurricanes (and flooding events that occur as a result) present the greatest risk to the area. Table 3-72 details the susceptibility of the UMMS campus in Worcester to hurricanes.

Table 3-72: Hurricane Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• State Hazard Mitigation Plan (2013) • Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NOAA historical tropical cyclone tracks • CMRPC Pre-Disaster Hazard Mitigation Plan (2012) • Anecdotal Information from UMMS • UMass Memorial Medical Center HVA (2014)	• The state plan notes the entire state of Massachusetts is susceptible to hurricanes. • NOAA's historical tropical cyclone tracks show the paths that tropical storms/hurricanes have taken through the Commonwealth. • The state plan notes that between 1851 and 2004, approximately 32 tropical storms; five Category 1 hurricanes, two Category 2 hurricanes and three Category 3 hurricanes have made landfall. . • The state plan notes that based on past hurricane and tropical storm landfalls, the frequency of tropical systems to impact Massachusetts is an average of once out of every 1.75 years. • CMRPC Plan notes that the Central Mass region is at medium risk for Hurricane threats, and may experience serious impacts due to wind, vegetative debris, flooding, stormwater flooding and rain. • UMMS staff and students report hurricanes can be a serious issue for the campus. • UMass Memorial Medical Center identified Hurricane as a medium vulnerability in 2014

3.5.14.7 Risk Assessment Methodology, Limitations and Results

After consideration of the data available for a hurricane event and its impact to UMMS, the risk assessment for this natural hazard has been developed as a qualitative analysis. UMMS prepared a qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a hurricane event utilizing a low, medium, high and severe ranking system. The ranking given for the campus was based on background research, knowledge of the campus and facilities and past occurrences (see Table 3-73).

Table 3-73: Risk Assessment – Hurricane Event

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Ranking L,M,H,S
Hurricane	2	4	4	4	3.33	4.00	3.73	S

After reviewing the initial ranking of severe and conducting further research, specific consideration was given to how a flood event could impact students, faculty and staff, existing buildings, future buildings, operations and critical infrastructure (see Table 3-74).

Table 3-74: Qualitative Risk Assessment – Hurricane

	Hurricane Hazard - Qualitative Ranking
Risk Ranking	Severe
Students, Faculty & Staff	High
Existing Buildings	Severe
Future Buildings	Severe
Operations	High
Critical Infrastructure	Severe

As a result of considering these additional factors, the overall ranking remained severe.

3.5.14.8 Future Development Considerations

UMMS will give consideration to hurricane hazards during future development and redevelopment efforts. Additional considerations include:

- Continued enforcement of local and state regulations that address building structural criteria and flooding.
- Implement building code requirements in building rehabilitations or new construction that relate to FEMA policies and guidelines that may be included in City of Worcester regulations.
- Coordinate weather and emergency information with City of Worcester and UMass Memorial Hospital officials.
- Coordinate outreach to the public with consistent messaging, information, and instructions via public broadcast, websites, email, and social media for watches and warnings issued by the National Weather Service, hurricane evacuation routes, and homeowner guidance for hurricane preparation.
- Continue to update and revise the Emergency Response & Evacuation Policies, which includes instructions for sheltering in place for the campus population.

3.6 HUMAN HAZARDS

The hazard assessment process for human hazards takes on a different aspect than natural hazards due to the inherent unpredictability of these events. Although natural hazard events may also be unpredictable, they are related to weather patterns and seasonal changes and often correspond to specific times of the year. Alternatively, human hazards tend to be related to human behaviors that can be difficult to predict and can be either accidental or intentional in nature.

The human hazards identified and included in this section received their initial consideration from FEMA Guidance documentation, but were then expanded and customized to meet the campus' intent to have an inclusive assessment of the human hazards that could impact the campus. While there are some anecdotal data points regarding human hazard occurrences, much of the assessment was based on what could happen and how it could impact UMMS's campus population, facilities and operations. Each of the human hazards the campus is potentially susceptible to that were considered by the stakeholders is listed in Table 3-75 and further discussed in the specific human hazard assessment sections. UMMS has considered and ranked 21 human hazards, which are profiled in this section and discussed as hazards that have or could impact campus.

Table 3-75: Human Hazard Qualitative Risk Ranking Summary

	UMMS Worcester, MA Worcester County	Qualitative Campus Hazard Risk Ranking
Civil Disturbance	X	Low
Bomb Threat	X	Medium
Vandalism	X	Low
Arson	X	Medium
Assault	X	Low
Theft/Larceny	X	Medium
Fraud	X	Low
Robbery	X	Low
Burglary	X	Low
Pandemic /Epidemic	X	Medium
Explosion	X	Medium
Cyberattack/Cyberterrorism	X	High
Terrorism	X	Medium
Armed Attack/Active Shooter	X	High
Electrical Failure/Power Outage	X	Medium
Critical Infrastructure Failure	X	Medium
Information System/IT Failure	X	High
HazMat Incident (Biological/Chemical/Radiological)	X	Medium
Exposure to Select Agent	X	Medium
Fire	X	Medium
Explosion in Lab	X	Medium

3.7 HUMAN HAZARD RANKINGS

As a result of on-campus interviews and a follow up group meeting, in May 2014, the UMMS Hazard Mitigation Planning Committee ranked the human hazards that have or may impact the campus in the future according to a Hazard Ranking of Low, Medium, High or Severe. A qualitative ranking (on a scale of 0 to 5) in the categories of frequency, severity, duration and intensity was prepared after the hazards were identified and vetted. For UMMS, the hazards were then weighted regarding the probability (40% which included rankings of frequency, duration and intensity) that the hazard would impact the campus and the consequences (60% which included rankings of severity) that would be realized by the campus.

Probability

Frequency + Duration + Intensity/3 = Probability

Consequence

Severity

Total

*Probability *.4 + Consequence * .6 = Total*

Hazard rankings were assigned based on the overall probability and consequence total for each identified hazard. UMMS received an overall low, medium or high and Table 3-76 below summarizes the ranges that UMMS used for the human hazard rankings.

Table 3-76: Human Hazard Numerical Ranking Ranges

	Low	Medium	High	Severe
UMMS	1.0-2.0	2.0-3.0	3.0-3.5	3.50+

In general, hazards with a low estimated frequency, duration, severity and intensity are expected to have minimal to no impact on the campus. Hazards with a high frequency, duration, severity and intensity were given a higher mitigation priority. Higher rankings may be more likely to occur on a regular basis or within the next five years and could result in substantial impacts on campus with regard to economic damage, loss of function and operations of the campus and human injury. (Table 3-77 provides a summary of the rankings.)

Table 3-77: UMMS Human Hazard Risk Ranking Summary

Natural Hazard	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability F,D,I (40%)	Consequence S (60%)	Total	Ranking L,M,H,S
Civil Disturbance	1	1	2	1	1.00	2.00	1.60	L
Bomb Threat	1	1	3	3	1.67	3.00	2.47	M
Vandalism	1	1	2	1	1.00	2.00	1.60	L
Arson	1	2	3	3	2.00	3.00	2.60	M
Assault	1	1	2	2	1.33	2.00	1.73	L
Theft/Larceny	2	2	2	2	2.00	2.00	2.00	M
Fraud	1	1	2	1	1.00	2.00	1.60	L
Robbery	1	1	2	2	1.33	2.00	1.73	L
Burglary	1	1	2	2	1.33	2.00	1.73	L
Pandemic /Epidemic	1	2	3	3	2.00	3.00	2.60	M
Explosion	1	2	3	3	2.00	3.00	2.60	M
Cyberattack/Cyberterrorism	5	2	4	2	3.00	4.00	3.60	H
Theft					0.00	0.00	0.00	
Terrorism	1	3	2	2	2.00	2.00	2.00	M
Armed Attack/Active Shooter	1	2	4	4	2.33	4.00	3.33	H
Electrical Failure/Power Outage	2	2	3	2	2.00	3.00	2.60	M
Critical Infrastructure Failure	1	3	3	2	2.00	3.00	2.60	M
Information System/IT Failure	2	3	3	4	3.00	3.00	3.00	H
HazMat Incident (Biological/Chemical/Radiological)	1	2	3	2	1.67	3.00	2.47	M
Exposure to Select Agent	1	3	3	3	2.33	3.00	2.73	M
Fire	1	1	3	2	1.33	3.00	2.33	M
Explosion in Lab	1	1	4	3	1.67	4.00	3.07	H

3.7.1 Civil Disturbance

A civil disturbance is a protest or demonstration against some type of political or socioeconomic issue. The severity of these actions can vary from silent protests or verbal demonstrations to full-scale riots resulting in damages to property or persons. University students across the country have participated in these types of events for years as the academic setting is a place where students learn about important issues, form opinions, and many of which want to cause change. Of the highest concern is the potential for protests associated with the use of animals in research activities. The UMMS campus includes several large public venues such as the outdoor quad and the Albert Sherman Center which can be targets for these type of events.

A civil disturbance can impact the lives of those not involved to varying degrees. An active protest can impact one's ability to work or even access a place of work. A civil disturbance on a University campus could result in the disruption of operations to a building or portions of campus and result in the deployment of campus and community resources to protect innocent bystanders and break up the event if necessary. These types of events have occurred on the UMMS campus, but have not been large scale or resulted in significant harm to persons or properties. Susceptibility factors contributing to the risk assessment are provided in Table 3-78.

Table 3-78: Civil Disturbance Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• UMMS Anecdotal Information • UMass Memorial Medical Center HVA (2014)	• The campus has an open nature with four entrances. • Research animals are present on campus, which has the potential to cause civil disturbance. • Labor unions are on campus and a civil disturbance could occur as a result of labor unrest. • UMass Memorial Medical Center ranked civil disturbance as a low vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Civil Disturbance utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was low (see Table 3-79) based on the low frequency of this type of event.

Table 3-79: Risk Assessment – Civil Disturbance

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Civil Disturbance	1	1	2	1	1.00	2.00	1.60	L

3.7.2 Bomb Threat

A bomb threat is an intention to detonate an explosive device that is provided in a verbal or written form with the resolve to cause property damage or physical harm. On a University campus these threats can involve significant evasive procedures, such as campus wide notifications, building evacuations and criminal investigations. These threats are often associated with psychopathic behaviors or can be performed as a prank to disrupt campus operations. Bomb threats have occurred on the UMMS campus, but has not resulted in the detonation of actual explosive devices. The campus response to the most recent bomb threat was fragmented and reaching consensus about how to handle the situation was an issue. An option to evacuate was announced and it took two hours to send out a message about the bomb threat event to the campus community. Susceptibility factors contributing to the risk assessment are provided in Table 3-80.

Table 3-80: Bomb Threat Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• UMMS Anecdotal Information • UMass Memorial Medical Center HVA (2014)	• Bomb threats have occurred on campus in the past. • UMass Memorial Medical Center ranked bomb threat as a low vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Bomb Threat utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-81) based on the low frequency of this type of event.

Table 3-81: Risk Assessment – Bomb Threat

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Bomb Threat	1	1	3	3	1.67	3.00	2.47	M

3.7.3 Vandalism

Vandalism is the intentional destruction of property that belongs to another person or UMMS. Minor acts of vandalism have occurred on the UMMS campus but on a small scale with minimal damages. These acts have been mostly associated with car vandalism such as slashed tires in the parking lots. Susceptibility factors contributing to the risk assessment are provided in Table 3-82.

Table 3-82: Vandalism Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• UMMS Anecdotal Information	• Minor acts of vandalism such as slashed tires or car have occurred in the past with minimal damages.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Vandalism event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was low (see Table 3-83) based on the low frequency of this type of event.

Table 3-83: Risk Assessment – Vandalism

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Vandalism	1	1	2	1	1.00	2.00	1.60	L

3.7.4 Arson

Arson is the act of intentionally setting fire to property with the goal of causing damage. UMMS has experienced an arson incident in the past. The potential impacts of an arson event to university property could be significant resulting in costly property damage or even loss of life. Susceptibility factors contributing to the risk assessment are provided in Table 3-84.

Table 3-84: Arson Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• UMMS Anecdotal Information • 2010-2012 Clery Report (2013)	• The Cleary Report indicates that between 2010 and 2012 there was a case of arson on campus.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of an Arson event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-85) based on the low frequency of this type of event.

Table 3-85: Risk Assessment – Arson

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Arson	1	2	3	3	2.00	3.00	2.60	M

3.7.5 Assault

Assault is an intentional physical act of harm or threat of harm against a person. Assaults can take many forms involving illegal or impermissible touching of another. Assaults can be associated with other crimes, such as theft, or can be sexual in nature. Assaults have occurred on the UMMS campus in the past, but are mostly associated with the hospital. These events have been infrequent in nature, but have resulted in restraining orders in certain situations. Susceptibility factors contributing to the risk assessment are provided in Table 3-86.

Table 3-86: Assault Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• UMMS Anecdotal Information • 2010-2012 Clery Report (2013)	• Assaults have occurred on campus in the past, typically associated with UMass Memorial Medical Center or stalking incidents. • The Clery Report indicates that between 2010-2012 there were assaults on campus.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of an Assault event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was low (see Table 3-87) based on the past occurrences of this type of event.

Table 3-87: Risk Assessment – Assault

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Assault	1	1	2	2	1.33	2.00	1.73	L

3.7.6 Theft/Larceny

Theft is a criminal act involving the taking of property without the owner's consent. The owner could be a person, such as a fellow student or UMMS employee, or UMMS itself. Larceny is the act of taking, carrying, or leading property away from the possession of another. Acts of theft and attempted theft have occurred on UMMS property and have involved personal property, UMMS property, and UMMS information. Most of these events have also been on a small scale and have involved money or property such as laptops, cell phones, or other electronics. Theft is the most common type of crime on the UMMS campus. Susceptibility factors contributing to the risk assessment are provided in Table 3-88.

Table 3-88: Theft/Larceny Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• UMMS Anecdotal Information • 2010-2012 Clery Report (2013)	• Thefts have occurred on campus in the past, typically involving personal property, such as laptops. • Theft is the most common type of crime on campus. • According to the Clery report, there have been motor vehicle thefts on public property during 2010, 2011, and 2012.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Theft/Larceny event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-89) based on the past occurrences of this type of event.

Table 3-89: Risk Assessment – Theft/Larceny

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Theft/Larceny	2	2	2	2	2.00	2.00	2.00	M

3.7.7 Fraud

Fraud is a wrong or unlawful act of deception performed to result in personal gain, which is often financial in nature. Fraud can involve the falsification of documents or projection of untruthful information. Fraudulent acts have been performed in rare cases by UMMS employees and students, but often on a small scale. However, due to the large operating budgets of the UMMS campus, a fraudulent event performed by an employee with access to sensitive financial information or accounts could be significant and is a serious concern for the finance department. Susceptibility factors contributing to the risk assessment are provided in Table 3-90.

Table 3-90: Fraud Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• UMMS Anecdotal Information	• There have been business fraud events at UMMS in the past.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Fraud event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was low (see Table 3-91) based on the past occurrences of this type of event.

Table 3-91: Risk Assessment – Fraud

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Fraud	1	1	2	1	1.00	2.00	1.60	L

3.7.8 Robbery

Robbery is an act of violence or threat of violence associated with theft, or taking of property without the owner's consent. Often robberies involve the threat of physical harm to a person and may be associated with the use of a weapon. These acts are rare and there have been no recent robbery incidents on the UMMS campus. Susceptibility factors contributing to the risk assessment are provided in Table 3-92.

Table 3-92: Robbery Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Clery Report (2010-2012)	• According to the Clery Report, there were no robberies on campus between 2010 and 2012.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Robbery event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was low (see Table 3-93) based on the past occurrences of this type of event.

Table 3-93: Risk Assessment – Robbery

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Robbery	1	1	2	2	1.33	2.00	1.73	L

3.7.9 Burglary

Burglary is the intent of entering a building without the consent of the owner in order to commit a crime (which may include theft). The entry into the building can be completed forcibly or via an open access point. Between 2010-2012, there were burglaries on the UMMS campus and burglaries identified on "non-campus" as noted in the most recent Clery Report available from campus security. In addition, one attempted burglary occurred on the UMMS campus in 2013. Susceptibility factors contributing to the risk assessment are provided in Table 3-94.

Table 3-94: Burglary Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Clery Report (2010-2012)	• According to the Cleary Report, between 2010 and 2012, there were burglaries on campus and burglaries identified on "non-campus."

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Burglary event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was low (see Table 3-93) based on the past occurrences of this type of event.

Table 3-95: Risk Assessment – Burglary

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Burglary	1	1	2	2	1.33	2.00	1.73	L

3.7.10 Pandemic /Epidemic

A pandemic health issue is the spread of an infectious disease across large populations. This could be any infectious disease but in recent times has been most associated with influenza. A pandemic or epidemic on a campus is of particular concern do to large populations and frequent human interaction in confined classroom, research, or activity settings. To date there have been no pandemic health issues that have occurred on the UMMS campus, but it is more susceptible due to its proximity to the hospital. Susceptibility factors contributing to the risk assessment are provided in Table 3-96.

Table 3-96: Pandemic/Epidemic Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information • UMass Memorial Medical Center HVA (2014)	• UMMS is susceptible to pandemics/epidemics due to the close proximity to UMass Memorial Medical Center. • UMass Memorial Medical Center ranked pandemics/epidemics as a high vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Pandemic/Epidemic event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-97) based on the past occurrences of this type of event.

Table 3-97: Risk Assessment – Pandemic/Epidemic

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Pandemic - Epidemic	1	2	3	3	2.00	3.00	2.60	M

3.7.11 Explosion

An explosion is an extreme release of energy, which usually results in the generation of high temperatures and gas generation. Explosions can be caused by bombs or via other means specifically associated with a campus setting such as the improper use and handling of chemicals or other dangerous substances. UMMS has its own Power Plant on campus and as substations get older, there is the potential for explosion. Susceptibility factors contributing to the risk assessment are provided in Table 3-98.

Table 3-98: Explosion Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information	• UMMS has its own Power Plant on campus and as substations get older, there is the potential for explosion.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of an Explosion utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-99) based on the past occurrences of this type of event.

Table 3-99: Risk Assessment – Explosion

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Explosion	1	2	3	3	2.00	3.00	2.60	M

3.7.12 Cyberattack/Cyberterrorism

Cyberterrorism is a deliberate attack against computer systems and networks to cause large-scale disruptions and other harmful impacts. Cyberterrorism is completed via the internet and is often deployed via computer viruses as a form of terrorism. It can also be the intentional use of this media to cause harm for personal or political gain. Cyberattacks can be performed by 'hacking' into computer and network systems by an anonymous person or party. Due to the heavy use of technology on university campuses, the opportunity for cyberattacks and cyberterrorism is a constant. At UMMS, these events can occur on a daily basis with the campus population typically being unaware and unimpacted. The volumes of sensitive information stored on campus are abundant and includes student records, grades, personnel files, physician credentials and academic course information and research. Having this information secure and not susceptible to cyberattacks is important for the reputation of UMMS and for the protection of institutional knowledge and unique research. There is a large concern over cyberterrorism or a virus that could make the UMMS systems non-functional. Information Technology (IT) staff noted that a large portion of the UMMS operation is electronic and there are critical applications used by faculty, staff and students which are vulnerable. Susceptibility factors contributing to the risk assessment are provided in Table 3-100.

Table 3-100: Cyberattack/Cyberterrorism Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information • UMass Memorial Medical Center HVA (2014)	• Attempts at cyberattacks occur daily. • UMass Memorial Medical Center ranked cyberattacks as a high vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Cyberattack/Cyberterrorism utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was high (see Table 3-101) based on the past occurrences of this type of event.

Table 3-101: Risk Assessment – Cyberattack/Cyberterrorism

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Cyberattack - Cyberterrorism	5	2	4	2	3.00	4.00	3.60	H

3.7.13 Terrorism

The FBI defines terrorism as "the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof in furtherance of political or social objectives" (www.fbi.gov). The FBI further classifies terrorism as either domestic or international, depending on the origin, base, and objectives of the terrorist organization. Acts of terrorism can take several forms including bombings, weapons of mass destruction (chemical, biological, radiological, or nuclear); and cyberterrorism as discussed previously.

Terrorists often try to create fear to generate publicity for their causes. They tend to act in public venues, areas of high populations, or other places that may attract large-scale attention. UMMS has several areas which could fall into these categories and could be viewed as potential terrorist targets. From a broader perspective, the campus resides in a major community which could specifically be a potential terrorist target. There are also many sensitive areas of research that may be targets, such as animal, technological and medical research, the use of select agents, the power plant and institutional knowledge and assets. Acts of terrorism can cause large scale destruction to property, extensive loss of human life, business continuity and operational impacts, and shortages or inaccessibility to essential resources. There may be little or no warning of a terrorist event, making a planned response and the opportunity to take precautionary measures impossible. Post-event response can take weeks, months or years depending on the nature of the event. Susceptibility factors contributing to the risk assessment are provided in Table 3-102.

Table 3-102: Terrorism Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information • UMass Memorial Medical Center HVA (2014)	• Due to the use of select agents on campus, UMMS could be a soft target for terrorist activities. • There is a Power Plant on campus which could be a potential target. • UMass Memorial Medical Center ranked terrorism as a high vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Terrorism event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-103) based on the past occurrences of this type of event.

Table 3-103: Risk Assessment – Terrorism

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Terrorism	1	3	2	2	2.00	2.00	2.00	M

3.7.14 Armed Attack/Active Shooter

An active shooter is defined by the U.S. Department of Homeland Security as an individual actively engaged in killing or attempting to kill people in a confined and populated area; in most cases, active shooters use firearm[s] and there is no pattern or method to their selection of victims. Due to the large campus population and events that have taken place on other college and university campuses across the country, an active shooter scenario presents a substantial threat taken seriously by UMMS. The direct impacts of an active shooter situation could be serious injury or death on a large scale. UMMS actively completes active shooter training and new students are required to watch a video regarding this type of situation. No active shooter incidents have taken place at UMMS.

In 2013 there were several gun incidents on campus. These incidents were not intentional, but people not aware they could not have guns on campus. Possession of firearms on UMMS property is regulated under MGL, Chapter 269, Section 10j. The regulation states that firearms of any type, assembled or disassembled, ammunition, knives, machetes, javelins, martial arts devices, clubs, or any device which can be considered hazardous to the welfare of members of the UMMS community are strictly prohibited on campus. Susceptibility factors contributing to the risk assessment are provided in Table 3-104.

Table 3-104: Armed Attack/Active Shooter Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information • Clery Report (2010-2012) • UMass Memorial Medical Center HVA (2014)	• Guns have been present on campus in the past. • According to the Cleary Report, there were three Weapons Law arrests between 2010 and 2012. • UMass Memorial Medical Center ranked an armed attack/active shooter situation as a high vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of an Armed Attack/Active Shooter event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was high (see Table 3-105) based on the potential for an occurrence.

Table 3-105: Risk Assessment – Armed Attack/Active Shooter

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Armed Attack - Active Shooter	1	2	4	4	2.33	4.00	3.33	H

3.7.15 Electrical Failure/Power Outage

A power outage, or electrical failure, occurs when there is a short- or long-term interruption in electricity supply to one or more buildings or areas of a building. The loss of electrical power can be local or citywide, and can be limited to a particular area of a building, several buildings, or campus-wide. An electrical failure at UMMS not only impacts equipment using electricity, such as lighting, ventilation, and appliances, but also impacts information technology networks and backup systems, which rely on electricity to function. The loss of electrical power can be caused by a number of factors including:

- Disruption of electrical supply at the source
- Fire or flood within a building or impacting multiple buildings
- Mechanical failure in transmission lines or internally inside a UMMS building

The main UMMS campus has a power plant on campus and receives electrical power from an outside vendor. In addition, in April 2014, UMMS reached a 30-year agreement with First Wind, Major Energy, Greenhouse Solar, and Hecate Solar in Massachusetts to receive up to 12 megawatts of solar-generated power.

Power outages have occurred on the UMMS campus in the past. Backup generators and a cogeneration facility are available to provide emergency power. The fuel supply for backup generators and the cogeneration facility is expected to last at least 96 hours during a power outage. The power plant has 84,000 gallons of fuel, which is enough fuel for the power plant to generate electricity for approximately 30 days. While backup power supplies are available at the UMMS main campus, the electrical infrastructure is aged. Susceptibility factors contributing to the risk assessment are provided in Table 3-106.

Table 3-106: Electrical Failure/Power Outage Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information • UMass Memorial Medical Center HVA (2014)	• Power outages and blackouts have occurred in the past. • The UMMS electrical infrastructure is aged, making it more vulnerable to potential failure. • UMass Memorial Medical Center ranked electrical failure/power outage as a high vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of an Electrical Failure/Power Outage event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-107) based on the past occurrences and the likelihood for future outages.

Table 3-107: Risk Assessment – Electrical Failure/Power Outage

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Electrical Failure - Power Outage	2	2	3	2	2.00	3.00	2.60	M

3.7.16 Critical Infrastructure Failure

Critical infrastructure can be defined as a system whose destruction or damage could have crippling impact on the UMMS campus. Critical infrastructure can include: utilities, information technology systems, or certain structures on campus. Critical infrastructure failure is a serious consideration for UMMS as the campus strives to minimize any extended impacts to operations. Loss of power or communications is one of the most damaging events that can occur on a University campus as it can result in the need to close the campus and either shelter in place or evacuate. The financial implications in terms of loss of building operations and the inability to continue classes can be significant. Also impacts to sensitive, irreplaceable research that requires refrigeration, cooling and heating, such as particular experiments or animal research are enormous. Impacts to critical infrastructure can be caused by a variety of events, many of which are natural such as heavy snow storms that bring down power lines, accidental such as failure from aged infrastructure, or intentional such as terrorism attacks. Some of these have been discussed as associated with other hazards.

One unique situation at UMMS is that any type of water failure would impact the power plant and fire suppression capabilities on campus (a City water main break impacted the sprinkler system on campus in the past). In addition, the HVAC systems are not on emergency generator backup. Susceptibility factors contributing to the risk assessment are provided in Table 3-108.

Table 3-108: Critical Infrastructure Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information • UMass Memorial Medical Center HVA (2014)	• Critical infrastructure systems have been impacted on campus in the past, including a city water main break impacting the sprinkler system at UMMS and natural gas odors have been reported. • UMass Memorial Medical Center ranked water failure and natural gas failure as a high vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Critical Infrastructure failure event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-109) based on the past occurrences of this type of event.

Table 3-109: Risk Assessment – Critical Infrastructure

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Critical Infrastruct-ure	1	3	3	2	2.00	3.00	2.60	M

3.7.17 Information System/IT Failure

An information system or information technology (IT) network failure is indicated by loss of UMMS network, data center, internet, wi-fi, or e-mail. Information system/IT failures can impact the entire campus or be localized to a certain area on campus, such as one area of a building. IT staff noted that a large portion of the UMMS operation is electronic and there are critical applications used by faculty, staff and students which require the information systems and IT networks to be operating appropriately. The loss of information systems or an information technology network failure can have a dramatic impact on campus operations, including loss of access to internal files, loss of internet, inability to access research data, inability to credential nurses/doctors, and loss of email capacity. Disruptive information system failures associated with power outages and damage to the data center from leaking oil have occurred at CUMC in the past. Susceptibility factors contributing to the risk assessment are provided in Table 3-110.

Table 3-110: Information System/IT Failure Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information • UMass Memorial Medical Center HVA (2014)	• Disruptive information system failures have occurred at UMMS in the past such as oil leaking into the data center. • UMass Memorial Medical Center ranked information system/IT failure as a high vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of an Information System/IT Failure event utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was high (see Table 3-111) based on the past occurrences and likely future failures of this type of event.

Table 3-111: Risk Assessment – Information System/IT Failure

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Information System - IT Failure	2	3	3	4	3.00	3.00	3.00	H

3.7.18 Hazardous Material Incident

A hazardous material (hazmat) is any material that can result in a threat to human life or property in any quantity. Hazardous materials can be solids, liquids or gasses and can include materials that have explosive, flammable, combustible, toxic, infectious, and radioactive properties. Release of these materials could be accidental or intentional and involve varying degrees of damage depending upon the properties of the material itself, the quantity of material and use of the material. At UMMS, these materials are used for research, course/laboratory work, cleaning, and fuel and to support other operational functions. Hazardous materials can be delivered to the campus in large quantities involving additional transportation hazards and proper handling is required.

Hazardous materials incidents have a more regular frequency than many of the other human caused events at UMMS due to the widespread use of these materials in operations, laboratory work and research. Typically these events are associated with laboratory experiments, research or minor spills of hazards materials used in operations. While the majority of these incidents at UMMS have been accidental, there has been intentional misuse of materials in the past as well as unsafe lab practices or use of older chemicals. Susceptibility factors contributing to the risk assessment are provided in Table 3-112.

Table 3-112: Hazardous Material Incident Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information • UMass Memorial Medical Center HVA (2014)	• Hazardous materials are present at UMMS and incidents involving hazardous materials have occurred on campus in the past. • UMass Memorial Medical Center ranked hazardous materials incidents as a high vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Hazardous Material Incident utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-113) based on the past occurrences and likely future failures of this type of event.

Table 3-113: Risk Assessment – Hazardous Material Incident

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Hazardous Material Incident	1	2	3	2	1.67	3.00	2.47	M

3.7.19 Exposure to Select Agent

Select agents are biological materials that have the potential to severely threaten human, animal, and/or plant health or animal and plant products. Select agents are regulated by the Department of Health and Human Services (HHS) and United States Department of Agriculture (USDA) under 7 CFR Part 331, 9 CFR Part 121, and 42 CFR Part 73. Tier 1 select agents pose the highest risk of intentional misuse, present a severe threat to public health and safety, and have a high potential for mass casualties or crippling impact on the economy, critical infrastructure, or public confidence. Select agents are included on the HHS Select Agent List after considering the following:

- The agent's effect on human health after exposure to the agent;
- The agent's degree of contagiousness and the modes of transfer to humans;
- The availability and effectiveness of treatment and prevention of illness resulting from infection by the agent; and
- Any other criteria considered appropriate by the Secretary, including the needs of vulnerable populations, including children.

Select agents are included on the USDA Select Agent List after consideration of the following:

- The agent's effect on animal and plant health and on the production/marketability of animal or plant products;
- The agent's pathogenicity and transfer methods to animals or plants;
- The availability and effectiveness of treatment and prevention of illness or disease caused by the agent; and
- Any other criteria considered appropriate by the Secretary to protect animal health, plant health, animal products, or plant products.

Select agents are present at the UMMS campus and used by researchers. Because select agents are used in the labs, there is a possibility for human error resulting in inadvertent exposure to a select agent or multiple select agents. While select agents are stored in secured areas, the presence of select agents on campus increases the chances of an intentional select agent exposure to self or others. In addition, facilities staff maintain high containment labs, which also increases the likelihood of exposure to select agents. Susceptibility factors contributing to the risk assessment are provided in Table 3-114.

Table 3-114: Exposure to Select Agents Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information	• Select agents are stored and used on campus. • Facilities staff maintains high containment labs.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of an Exposure to Select Agent incident utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-115) based on the presence of select agents on campus.

Table 3-115: Risk Assessment – Exposure to Select Agent

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Exposure to Select Agent	1	3	3	3	2.33	3.00	2.73	M

3.7.20 Fire

According to FEMA, most campus-related fires occur from a lack of general knowledge about fire prevention and fire safety. Typical causes of fires at colleges and universities include: overloaded power strips, cooking, intentionally set fires, open flame, and/or malfunctioning equipment. The majority of deaths caused by fires at a college campus are related to dorm or other housing fires. While UMMS does not have residence halls or dormitories, the potential for a fire on campus still exists from sources such as cooking, open flame, mishandling of flammable chemicals, intentionally set fires, overloaded electrical circuits or power strips, or malfunctioning equipment. UMMS has experienced small laboratory fires on campus in the past and none of the fire incidents were associated with equipment failure. Most buildings on campus are equipped with sprinklers. Susceptibility factors contributing to the risk assessment are provided in Table 3-116.

Table 3-116: Fire Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information	• Small laboratory fires have occurred on campus in the past. • UMass Memorial Medical Center ranked fire as a high vulnerability in 2014.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Fire Incident utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-117) based on the past occurrences of this type of event.

Table 3-117: Risk Assessment – Fire Incident

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Fire Incident	1	1	3	2	1.33	3.00	2.33	M

3.7.21 Explosion in Lab

An explosion is an extreme release of energy which usually results in the generation of high temperatures and gas generation. Explosions in a laboratory setting can specifically be associated with the improper use and handling of chemicals or other dangerous substances. Due to the heavy research component of the UMMS campus, explosions associated with chemical uses have occurred in the laboratories in the past resulting in injury. Safety protocols and procedures and training are provided on campus to try to minimize these events. Susceptibility factors contributing to the risk assessment are provided in Table 3-118.

Table 3-118: Explosion in Lab Susceptibility

How Susceptibility Was Determined	Susceptibility Criteria
• Anecdotal information	• Explosions associated with chemical uses have occurred in UMMS laboratories in the past.

A qualitative assessment of the frequency, duration, severity, intensity, probability and consequence of a Fire Incident utilizing a low, medium, high and severe ranking system was prepared. The ranking given for UMMS was medium (see Table 3-119) based on the past occurrences of this type of event.

Table 3-119: Risk Assessment – Explosion in Lab

	Frequency 0-5	Duration 0-5	Severity 0-5	Intensity 0-5	Probability (F,D,I) 40%	Consequence (S) 60%	Total	Risk Ranking L,M,H,S
Explosion in Lab	1	1	4	3	1.33	3.00	2.33	H

4. VULNERABILITY AND IMPACT ASSESSMENT

4.1 ASSET INVENTORY

Assets that were assessed during the mitigation planning process focused on facilities/buildings, equipment and research and the role they play at UMMS. While UMMS has an extensive list of assets, not all buildings/facilities and other assets are critical to operations. In order to differentiate the more critical buildings on campus from the less critical buildings/structures, each building/structure owned by UMMS (leased properties were excluded) was ranked on a scale of one to five, with one being the most critical (essential) and five being the least critical (non-essential). The rankings were taken into consideration when mitigation goals and prioritization for mitigation actions were set.

Table 4-1 outlines the methodology that was used to assign rankings to the list of assets that was developed for each campus.

Table 4-1: Asset Ranking Methodology

Criticality Ranking	Ranking Criteria
Level 5	Buildings critical to campus operations and likely to shelter students/faculty: • Sherman Center Dining Area/Food Service • Laboratories and animal research facilities • Critical Infrastructure (including IT)
Level 4	Buildings that are less critical but serve a support function: • Records/document locations • Archives • Non-critical but important infrastructure
Level 3	Buildings that are administrative, academic or multi-use.
Level 2	Buildings used for recreational purposes such as Campus Centers.
Level 1	Buildings that are non-essential such as maintenance buildings, storage sheds, etc.

Table 4-2 summarizes the assets that were evaluated during the mitigation planning process for the UMMS campus.

Table 4-2: UMMS Assets Evaluated During Mitigation Planning Process

Existing Buildings	Date Construction Completed	Gross Square Feet
ACC (Ambulatory Care Center)	2009	258,271
(ASC) Albert Sherman Center	2012	540,842
Power Plant	1973	88,421
Medical School	1975	946,923
Teaching Hospital	1976	707,402
Lakeside Emergency Wing	2003	296,445
South Garage / Public Safety	2004	485,160

Existing Buildings	Date Construction Completed	Gross Square Feet
Benedict Building	1991	78,114
BNRI	1999	39,171
CCNI	2002	2,884
West Parking Garage	1985	733,432
Shaw Building	1951	44,700
South Street Bldg 1	1983	465,780
South Street Bldg 2	1985	217,001
Plantation (North) Garage	2013	437,284
Aaron Lazare Research Building	2001	408,160
Helipad	2006	2,471
Stoddard Building	1926	15,162
Fuller Lab	1950	6,422
Higgins Building	1952	4,050
Chang Building	1954	27,695
Reed Lab (Rose & Gordon)	1965	31,980
Hoagland-Pincus Conference Center	1967	28,077
Machine Shop	1963	3,267
Behavioral Barn	1968	8,871
Marine Animal Bldg	1960	1,734
Mattapan II	2009	102,654
Massachusetts Biologic Filling Facility	2005	158,572
Century Drive	1991	81,465
Biotech One	1986	77,201
Biotech Two	1986	88,110
Biotech Three	1991	114,038
Biotech Four	1994	93,526
Biotech Five	1999	92,100
Biotech 3 Parking Garage	1991	31,030

4.2 NON-HAZARD SPECIFIC RISK ASSESSMENT & ESTIMATING LOSSES

The purpose of assessing risks and estimating losses is to determine how the campus assets may be affected by various hazard events. Information gathered in previous steps of the process was used to help estimate losses from hazard events to people, buildings, operations and other assets. Some campus assets are more vulnerable than others due to age, location or some other factor. After assets were inventoried, additional information such as insured building value, building replacement value, insured contents value, occupancy limitations, date constructed and square feet and operational use was collected. The information was utilized to conduct loss estimates for assets according to the methodology outlined in FEMA *"Understanding Your Risks – Identifying Hazards and Estimating Losses"* (FEMA 386-2). The FEMA methodology was applied for a non-hazard specific situation and where applicable for an earthquake hazard. All other hazards followed a qualitative methodology. UMMS evaluated building vulnerability based on a loss of function and total damage calculation using the FEMA methodology.

A loss of function calculation was prepared for UMMS that included using the following information:

- List of existing buildings
- Date construction completed
- Gross square feet
- Assigned building criticality value (see Table 4-3)
- Factored square footage
- Building/total campus square footage
- Per day loss of function cost
- Estimated hazard specific loss of function days
- Loss of function cost per hazard

The calculations that were needed for the loss of function analysis are as follows:

factored square footage

*gross square feet * building criticality value = factored square footage*

building/total campus square footage

factored square footage/total gross square feet = building/total campus square footage

per day loss of function cost

resulting square footage factor/daily operating budget of the college (derived from 2013 operating budget) = per day loss of function cost

estimated hazard specific loss of function days

a minimum of 7 days was assumed

loss of function cost per hazard

per day loss of function cost/estimated hazard loss of function days = loss of function cost per hazard

Once a loss of function cost was determined, a vulnerability assessment was prepared for owned buildings on the UMMS campus. The vulnerability assessment utilized the following information:

- List of existing buildings
- Insurable replacement value
- Insurable contents value
- Loss of function cost

The calculation utilizing the information above provided a total damage dollar value.

total damage

insurable replacement value + insurable contents value + loss of function cost = total damage

Based on the total damage dollar value, each building was given a building vulnerability ranking of high, medium or low that was then transferred onto a vulnerability map.

4.3 LOSS OF FUNCTION

The methodology for discussing the Loss of Function Calculation can be found in Section 4.2. Data specific for UMMS is presented in Table 4-3. The data in this table and supporting graphic are for a non-hazard specific loss of function cost to the buildings associated with UMMS. Since the calculation is driven by both criticality ranking and building size, the UMMS team felt that in many cases, the loss of function cost was an under estimate of potential actual losses. For example, while the square footage size of the power plant is smaller, the loss of function cost for this critical facility to the campus could far exceed costs presented in Table 4-3.

Table 4-3: UMMS Loss of Function Cost

	Date Construction	Gross Square Feet	Building Criticality Value	Factored Square Footage	Building/Total Campus Square Footage	Per Day Loss of Function Cost	Estimated Hazard Specific Loss of Function Days	Loss of Function
Ambulatory Care Center (ACC)	2009	258,271	5	1,291,355	0.192211258	$335,420	7	$2,347,938
Albert Sherman Center (ASC)	2012	540,842	5	2,704,210	0.402507139	$702,398	7	$4,916,787
Power Plant	1973	88,421	5	442,105	0.065804955	$114,833	7	$803,834
Medical School	1975	946,923	5	4,734,615	0.704722021	$1,229,780	7	$8,608,463
Teaching Hospital	1976	707,402	5	3,537,010	0.526464947	$918,712	7	$6,430,981
Lakeside Emergency Wing	2003	296,445	5	1,482,225	0.220621233	$384,997	7	$2,694,977
South Garage / Public Safety	2004	485,160	5	2,425,800	0.361067305	$630,083	7	$4,410,583
Benedict Building	1991	78,114	5	390,570	0.058134247	$101,448	7	$710,133
BNRI	1999	39,171	3	117,513	0.017491179	$30,523	7	$213,662
CCNI	2002	2,884	3	8,652	0.001287804	$2,247	7	$15,731
West Parking Garage	1985	733,432	1	733,432	0.109167415	$190,503	7	$1,333,524
Shaw Building	1951	44,700	3	134,100	0.019960065	$34,831	7	$243,820
South Street Building 1	1983	465,780	3	1,397,340	0.207986556	$362,949	7	$2,540,640
South Street Building 2	1985	217,001	3	651,003	0.096898301	$169,093	7	$1,183,652
Plantation (North) Garage	2013	437,284	1	437,284	0.065087376	$113,581	7	$795,069
Aaron Lazare Research Building	2001	408,160	5	2,040,800	0.303762122	$530,082	7	$3,710,577
Helipad	2006	2,471	4	9,884	0.00147118	$2,567	7	$17,971
Stoddard Building	1926	15,162	3	45,486	0.006770347	$11,815	7	$82,703
Fuller Lab	1950	6,422	3	19,266	0.002867641	$5,004	7	$35,029
Higgins Building	1952	4,050	3	12,150	0.001808462	$3,156	7	$22,091
Chang Building	1954	27,695	3	83,085	0.012366756	$21,581	7	$151,065
Reed Lab (Rose & Gordon)	1965	31,980	3	95,940	0.014280154	$24,920	7	$174,438

	Date Construction	Gross Square Feet	Building Criticality Value	Factored Square Footage	Building/Total Campus Square Footage	Per Day Loss of Function Cost	Estimated Hazard Specific Loss of Function Days	Loss of Function
Hoagland-Pincus Conference Center	1967	28,077	2	56,154	0.008358221	$14,586	7	$102,099
Machine Shop	1963	3,267	1	3,267	0.000486275	$849	7	$5,940
Behavioral Barn	1968	8,871	3	26,613	0.003961202	$6,913	7	$48,388
Marine Animal Building	1960	1,734	5	8,670	0.001290483	$2,252	7	$15,764
Mattapan II	2009	102,654	5	513,270	0.076397484	$133,318	7	$933,226
Massachusetts Biologic Filling Facility	2005	158,572	5	792,860	0.118012954	$205,939	7	$1,441,576
Century Drive	1991	81,465	3	244,395	0.036376884	$63,480	7	$444,358
Biotech One	1986	77,201	3	231,603	0.034472863	$60,157	7	$421,100
Biotech Two	1986	88,110	3	264,330	0.039344101	$68,658	7	$480,604
Biotech Three	1991	114,038	3	342,114	0.050921832	$88,862	7	$622,031
Biotech Four	1994	93,526	3	280,578	0.041762529	$72,878	7	$510,146
Biotech Five	1999	92,100	3	276,300	0.041125771	$71,767	7	$502,368
Biotech 3 Parking Garage	1991	31,030	1	31,030	0.004618649	$8,060	7	$56,419

4.4 BUILDING VULNERABILITY ASSESSMENT

Using the Loss of Function cost per hazard, a Building Vulnerability Assessment was conducted that included utilizing additional information such as Insurable Replacement Value and Insurable Contents Value for buildings. A Total Damage amount was calculated and then building vulnerability rankings were assigned based on the dollar amount and reference figures that follow (see Table 4-4).

Table 4-4: UMMS Campus Buildings - Vulnerability Assessment

Existing Buildings	Insurable Replacement Value	Insurable Contents Value	Loss of Function Per Hazard	Total Damage	Building Vulnerability Ranking
ACC (Ambulatory Care Center)	$120,000,000	$180,000,000	$2,347,938	$302,347,938	Medium
(ASC) Albert Sherman Center	$340,000,000	$510,000,000	$4,916,787	$854,916,787	High
Power Plant	$105,000,000	$157,500,000	$803,834	$263,303,834	Medium
Medical School	$294,259,745	$441,389,618	$8,608,463	$744,257,826	High
Teaching Hospital	$353,701,000	$530,551,500	$6,430,981	$890,683,481	High
Lakeside Emergency Wing	$207,511,500	$311,267,250	$2,694,977	$521,473,727	High
South Garage / Public Safety	$25,000,000	$37,500,000	$4,410,583	$66,910,583	Low
Benedict Building	$25,482,035	$38,223,053	$710,133	$64,415,221	Low
BNRI	$21,882,864	$32,824,296	$213,662	$54,920,822	Low
CCNI	$850,000	$1,275,000	$15,731	$2,140,731	Low
West Parking Garage	$70,098,949	$105,148,424	$1,333,524	$176,580,896	Medium
Shaw Building	$14,358,467	$21,537,701	$243,820	$36,139,988	Low
South Street Bldg 1	$95,973,638	$143,960,457	$2,540,640	$242,474,735	Medium
South Street Bldg 2	$45,164,065	$67,746,098	$1,183,652	$114,093,814	Medium
Plantation (North) Garage	$30,000,000	$45,000,000	$795,069	$75,795,069	Low
Aaron Lazare Research Building	$194,963,995	$292,445,993	$3,710,577	$491,120,564	High
Helipad	$2,500,000	$3,750,000	$17,971	$6,267,971	Low
Stoddard Building	$2,890,248	$4,335,372	$82,703	$7,308,323	Low
Fuller Lab	$5,238,321	$7,857,482	$35,029	$13,130,832	Low
Higgins Building	$890,876	$1,336,314	$22,091	$2,249,281	Low
Chang Building	$5,297,517	$7,946,276	$151,065	$13,394,857	Low
Reed Lab (Rose & Gordon)	$10,684,852	$16,027,278	$174,438	$26,886,568	Low
Hoagland-Pincus Conference Center	$4,713,673	$7,070,510	$102,099	$11,886,282	Low
Machine Shop	$200,000	$300,000	$5,940	$505,940	Low

Existing Buildings	Insurable Replacement Value	Insurable Contents Value	Loss of Function Per Hazard	Total Damage	Building Vulnerability Ranking
Behavioral Barn	$60,000	$90,000	$48,388	$198,388	Low
Marine Animal Bldg	$50,000	$75,000	$15,764	$140,764	Low
Mattapan II	$58,944,438	$88,416,657	$933,226	$148,294,321	Medium
Massachusetts Biologic Filling Facility	$199,792,403	$299,688,605	$1,441,576	$500,922,583	High
Century Drive	$16,410,760	$24,616,140	$444,358	$41,471,258	Low
Biotech One	$19,219,111	$28,828,667	$421,100	$48,468,877	Low
Biotech Two	$44,586,183	$66,879,275	$480,604	$111,946,062	Medium
Biotech Three	$33,925,715	$50,888,573	$622,031	$85,436,318	Low
Biotech Four	$30,660,911	$45,991,367	$510,146	$77,162,424	Low
Biotech Five	$33,637,476	$50,456,214	$502,368	$84,596,058	Low
Biotech 3 Parking Garage	$2,320,500	$3,480,750	$56,419	$5,857,669	Low

Figure 36: Building Vulnerability Assessment – Worcester Campus Non-Hazard Specific

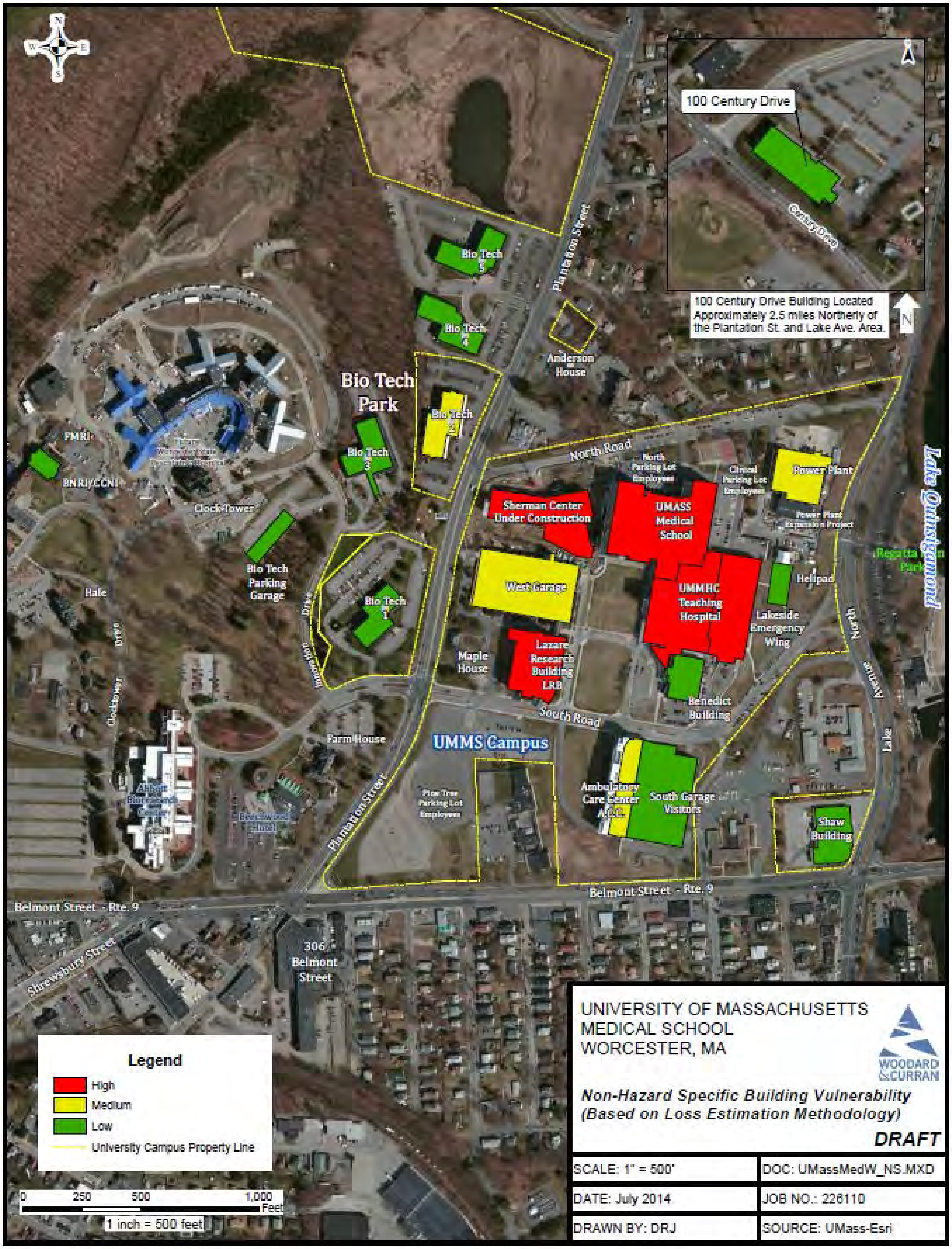


Figure 37: Building Vulnerability Assessment – Shrewsbury, South Street Non-Hazard Specific

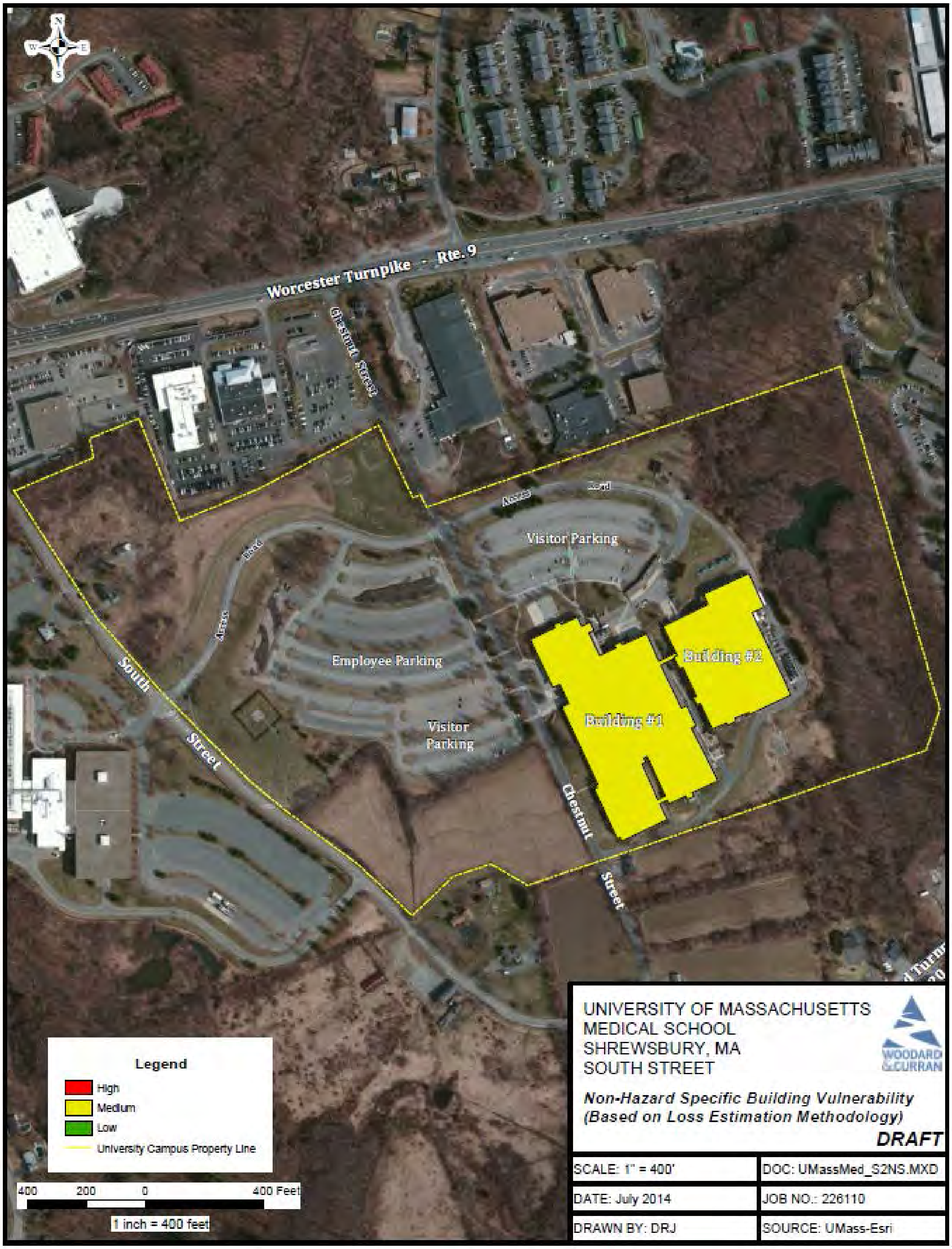


Figure 38: Building Vulnerability Assessment – Shrewsbury, Maple Avenue Non-Hazard Specific

Figure 39: Building Vulnerability Assessment – Mattapan Non-Hazard Specific

5. GOALS & OBJECTIVES

UMMS used the identification, profiling and vulnerability assessment of natural and human hazards that have or may impact the campus in the future to establish planning goals and objectives that provide the basis for the development of the proposed hazard mitigation projects. The establishment of goals and objectives was based upon a clear understanding of the hazards that have a potential to impact the UMMS community, what the risks associated with each hazard are and where vulnerabilities exist, as well as UMMS's commitment to reducing future vulnerability and mitigating risks where possible.

According to the FEMA guidance documentation, a goal serves as a general guideline that explains what a community would like to achieve and an objective defines a specific strategy or implementation step that will help reach a specific goal. A mitigation action is a specific task that UMMS can tie back to its goals and objectives and measure what has been achieved.

5.1 MITIGATION GOALS

The UMMS Hazard Mitigation Plan Goals are long-term statements of what the University hopes to achieve over time through implementation of the Plan. The five goals consider the existing resources and capabilities of UMMS, and strive to reduce vulnerabilities or mitigate hazards and their risks. All of these goals will be evaluated and revised as needed during future Plan updates. The following are the goals developed for the UMMS Hazard Mitigation Plan:

GOAL 1

- Protect existing and future assets from known hazards by implementing mitigation projects to minimize potential losses and ensure public health and safety.
    - The focus of this goal is to protect property and prevent injuries that could result from natural hazards such as winter storms, nor'easters, hurricanes, and other high wind events and human hazards such as explosion, fire, vandalism and infrastructure failure. This goal focuses on impacts to vulnerable property and structures and human safety.

GOAL 2

- Maintain a continuity of campus business operations during and after a hazard event.
    - The focus of this goal is intended to address hazards that could cause a prolonged interruption to normal campus functionality such as a loss of utilities or limited access to/from campus. This goal focuses on protection of research, critical facilities and infrastructure and enhancement of communication and education amongst the campus community.

GOAL 3

- Create and maintain a safe, secure environment for the campus population before, during and after a hazard event.
    - The focus of this goal is intended to protect students, faculty, staff and visitors from potential impacts from a hazard before, during, and after an event. This goal emphasizes the importance of community outreach, communication and scenario planning in protecting lives, safety and property.

GOAL 4

- Communicate natural and human hazard information to the campus community and improve education and outreach efforts regarding their potential impact.
    - The focus of this goal involves ongoing education and outreach to the campus community, UMass Memorial Hospital, surrounding neighborhoods, and other stakeholder groups.

GOAL 5

- Proactively protect existing and future campus assets from known hazards by incorporating mitigation activities into capital improvement and infrastructure planning.

    - The focus of this goal is intended to involve hazard mitigation planning into aspects of campus development, redevelopment, upgrades and retrofits. This goal focuses on evaluating hazards and addressing vulnerabilities from human and natural hazards as a regular part of the construction planning process.

Each goal is intended to reduce hazard vulnerabilities discussed in Section 3. Vulnerabilities to both the natural and human hazards include campus structures and property, operations, research, students, faculty, staff and visitors.

The goals and objectives developed for this plan took into consideration the hazard identification and ranking exercise that was detailed in Section 3. Any hazard event that can impact or interfere with UMMS's continuity of operations and ability to carry out its mission of educating students and conducting research was considered to be of a primary concern.

UMMS also considered the interdependencies and overlap between campus and hospital facilities and operations, and how that unique relationship factors in to both hazard vulnerabilities as well as mitigation strategies. Loss of IT capabilities, which can occur on its own due to an equipment failure or as a secondary impact of other natural hazards such as hurricanes, winter storms or heavy wind events, was identified as a major vulnerability. Consideration was also given to hazards relating to the sensitive nature of some of the materials handled on campus (controlled substances, select agents, BSL 3 lab, radioactives). Other goals and objectives were developed around the importance of continuing to engage and educate the public about natural and human hazards, their impact, how to be prepared and how residents can continue to participate in the discussion in the future.

The goals and objectives identified for UMMS are presented in Table 5-1.

Table 5-1: UMMS Goals & Objectives

Goal/Objective	Explanation
Goal 1	Protect existing and future assets from known hazards by implementing mitigation projects to minimize potential losses and ensure public health and safety.
Objective 1-A	Use appropriate techniques to mitigate against impacts from severe winter storms.
Objective 1-B	Use appropriate techniques to mitigate against impacts from high wind events such as windstorms, hurricanes and nor'easters.
Objective 1-C	Use appropriate techniques to mitigate against impacts from extreme heat at the MassBiologics campus.
Goal 2	Maintain a continuity of campus business operations during and after a hazard event.
Objective 2-A	Build redundancy in essential systems.

Goal/Objective	Explanation
Objective 2-B	Protect critical infrastructure.
Objective 2-C	Evaluate and enhance communication and education during hazard events to increase the understanding of impacts to campus.
Objective 2-D	Evaluate and enhance contingency procedures for Departments and Services that require 24/7 coverage.
Goal 3	Create and maintain a safe, secure environment for the campus population before, during and after a hazard event.
Objective 3-A	Proactively conduct scenario planning activities.
Objective 3-B	Continually develop and maintain emergency response programs.
Objective 3-C	Protect human health.
Objective 3-D	Improve campus safety and security with emphasis on open nature of campus and unrestricted building access.
Goal 4	Communicate natural and human hazard information to the campus community and improve education and outreach efforts regarding their potential impact.
Objective 4-A	Advise the campus community on health and safety precautions against potential hazards.
Objective 4-B	Work collaboratively with external campus stakeholders on hazard mitigation.
Objective 4-C	Consider and obtain feedback from the campus population on hazard planning communications.
Goal 5	Proactively protect existing and future campus assets from known hazards by incorporating mitigation activities into capital improvement and infrastructure planning.
Objective 5-A	Monitor and track campus asset conditions.
Objective 5-B	Maintain and retrofit campus assets to facilitate resilience during hazard events.
Objective 5-C	Use appropriate measures to ensure new development will not increase hazard threats.
Objective 5-D	Consider natural and human hazard risks as new buildings and infrastructure are developed.

6. MITIGATION ACTIVITIES AND ACTION PLAN

6.1 MITIGATION ACTIVITIES AND ACTION PLAN

The mitigation actions and projects noted in this section were identified based on the goals and objectives prepared during the planning process, past occurrences and UMMS's commitment to work closely with faculty, staff, students, residents and City officials to ensure public safety. The mitigation actions were intended to be inclusive of important activities to be addressed by the campus in the future and therefore contain both mitigation and preparedness activities grouped by category. Most of the action items focus on mitigating hurricanes, winter storms, ice storms and human hazards. Table 6-1 summarizes a list of mitigation projects for UMMS.

Table 6-1: UMMS Mitigation Projects

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
PLANNING						
P1	All	Develop and communicate a campus wide emergency evacuation/shut down plan that would limit access to and from campus and include additional security measures.	1A, 1B, 2C, 3D, 4C	$25,000	6 months	16
P2	Winter storm, Nor'easter, ice storm	Develop a transportation plan for getting critical staff to campus during weather events like winter storms, blizzards and ice storms.	1A, 2C, 2D, 3B, 4A	$20,000	6 months	16
P3	All	Develop a shelter in place plan for faculty and students.	1A, 1B, 2C, 2D, 3A, 3B, 3D	$15,000	3 months	13, 16
P4	All	Develop agreements with other schools who could take on residents should a hazard event occur and the school would not be able to function again in a short timeframe (a plan in already in place for faculty).	2D	$10,000	3 months	16
P5	All	Develop an emergency communication plan that articulates a clear hierarchy and interfaces with the hospital.	4A, 4B, 4C	$30,000	6 months	16
P6	All	Develop a supply chain plan for how UMMS would get critical supplies when and if needed.	2D	$15,000	3 months	13, 16
P7	All	Develop a prioritization methodology for lab samples that would get moved/relocated in the event of an emergency.	2D	$50,000	6 months	16
P8	All	Incorporate mitigation retrofits into the annual Capital Improvement Plan when possible.	5A, 5B, 5C, 5D	$10,000	annually	16
P9	All	Develop a backup/emergency lab which stays set up that could be used if needed.	2D	$100,000	12 months	16
P10	All	Develop contingency plan if underground water supply pipe were disrupted.	2A, 2B, 2D, 3C, 5A	$20,000	6 months	16

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
P11	All	Develop a plan for research community for electrical outage.	2A, 2B, 2D, 5A, 5B	$2,000	6 months	16
P12	All	Develop contingency plan for emergency trailered units to be connected at critical buildings and supported (chiller, boiler and electrical generator units)	2A, 2D	$15,000	6 months	13, 16
P13	Winter storm, Nor'easter, Ice storm, Hurricane, Tornado, Earthquake, Flooding, Extreme heat/temperature	Develop a plan for off-site locations in weather event (preventative actions).	2D, 4A, 4B	$10,000	3 months	16
P15	Assault and civil disturbance	More planning associated with bullying.	3C, 3D, 4A	$15,000	4 months	16
TRAINING						
T1	All	More training/practice with complex emergency response situations that require coordination with multiple departments, etc.	2C, 3A, 3D, 4A, 4B, 4C	$75,000	1 year	13, 16
T2	All	Training and practice of campus evacuation on a normal day and also on a day where there would be a special event.	2C, 3A, 3B 3D, 4A, 4B, 4C	$30,000	6 months	16
T3	All	Conduct a shelter in place drill/training.	2C, 3A, 3B, 3D, 4A, 4B, 4C	$15,000	3 months	13, 16
T4	All	Train faculty, students and staff on IT/fire/natural gas backup safety and best practices	2A, 2B, 2C, 3A, 3B, 4A	$5,000	1 month	16
T5	Fire, explosion	Training on use of fire extinguisher	3B	$5,000	1 month	16
T6	All	Training on use of calling 911 vs. calling campus police.	4A, 4C	$5,000	1 month	16
T7	Active shooter	Conduct an active shooter drill/training exercise.	3A, 3D, 4A, 4B, 4C	$50,000	6 months	13, 16

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
T8	Civil disturbance	More training/practice on handling civil disturbances and labor unrest.	3A, 3C, 4A	$15,000	3 months	13, 16
T9	IT failure	Conduct training on IT failure and best practices.	2A, 2B, 4A	$100,000	1 year	16
T10	All	Conduct training on natural gas use, locations and what to do in an emergency situation.	2A, 2B, 2C, 3B, 4A, 4B	$10,000	1 month	16
T11	All	Provide training to employees on information that is withheld (for example, South Street address not given out).	2A, 3C, 4A, 4B	$3,000	1 month	16
T12	Assault, terrorism, active shooter	Training on safe environments for employees who do home visitation.	3C	$5,000	1 month	16
T13	IT failure	Training for employees on Information Security Awareness, including: Email, Phishing, PHI, etc.; Training for employees associated with the risks in using social media.	2B	$100,000	1 year	16
T14	All	Tabletop exercise for mobilizing mission critical units to other places if a building were to become inoperable.	3A, 4A, 4B	$15,000	3 months	16
T15	Hazardous materials handling	More training in the use of select agents.	3C, 4A, 4B	$10,000	1 month	16
T16	All	Develop an on-line resource to provide basic training in a routine, scheduled manner.	4A	$100,000	1 year	16
T17	All	Continue practicing emergency operations.	3A, 3B, 4A	$20,000	3 months	16
T18	All	Develop a responsible conduct of research as an online resource which would serve as basic training for researchers so that they would know the basics of safety and security.	3D	$100,000	1 year	16
		POLICY/PROCEDURES				
PP1	Winter storm, Nor'easter, Ice storm, Hurricane, Tornado	Develop procedures for more timely dismissal for storms.	1A, 1B, 3C, 4A, 4C	$10,000	2 months	16
PP2	Winter storm,	Develop procedures for animal care in inclement	1A, 1B, 2A,			16

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
	Nor'easter, Ice storm, Hurricane, Tornado	weather.	2B			
PP3	Assault, bomb threat, theft.	Develop protocol to lock all floors at 5 PM.	3D	$2,000	1 month	16
PP4	ITdisruption	Security around the use of scanners (scanned materials are accessible).	2A	$5,000	1 month	16
PP5	Assault, civil disturbance, bomb threat, terrorism	More formal process to identify and report unusual behaviors.	3C, 3D	$5,000	1 month	16
PP6	Hazardous materials handling	Review of off-site spill containment procedures	4A, 4B, 4C	$2,000	1 month	16
PP7	Assault, bomb threat, theft	Develop a procedure to check unoccupied areas on some routine basis.	3C, 3D	$1,000	2 weeks	16
PP8	Winter storm, Nor-easter, Hurricane, Tornado, Earthquake	Develop Policy for essential and non-essential staff during storm and other weather events to allow some remote access to reduce traffic to school.	3C, 4A, 4C	$5,000	1 month	16
PP9	Hazardous materials handling	Implement routine chemical safety inspections.	3C, 4A, 4C	$20,000	annually	16
STUDY						
S1	All	Conduct an evacuation/egress study.	2C, 3A	$10,000	2 months	16
S2	Critical Infrastructure Failure	Complete HVAC study at South Street.	5A	$20,000	6 months	16
S3	Critical Infrastructure Failure	Study the chiller in the power plant.	5A, 2B	$25,000	6 months	16
S4	Critical Infrastructure Failure	Evaluate potential for gray water system.	5A	$25,000	6 months	16
S5	All	Complete study to evaluate a potential second egress and look at evacuation overall. Consider staggered evacuation options.	2C, 3A, 3C	$20,000	3 months	16
S6	Flood, Drought,	Mitigation study to determine water vulnerabilities from	1B, 2B, 5A,	$35,000	6 months	16

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
	Hurricane, Critical Infrastructure Failure	the City.	5B			
S7	Information System/IT Failure	Conduct inventory of where risk exists for IT equipment.	5A, 2B	$1.5M	1.5 years	16
S8	Information System/IT Failure	Examine internal controls related to data security (have huge quantities of sensitive data - newborn screening, physician credentials).	5A, 2B	$15,000	6 months	16
S9	Information System/IT Failure	Evaluate the need and development of a secondary data center (permanent co-location) for use in extended power loss scenarios.	5A	$15M	3 years	16
S10	Information System/IT Failure	Evaluate the need for individual IT closets to be on emergency power.	5A	$800,000	2 years	16
S11	Critical Infrastructure Failure	Examine the need for additional substations.	2B, 5A	$75,000	9 months	16
S12	Information System/IT Failure	Complete an inventory of all IT closets to determine which are needed and which could be consolidated/eliminated.	5A, 2B	In progress	Ongoing	16
S13	Critical Infrastructure Failure	Conduct Study of impacts of Long-Term shutdown of water and electrical systems.	2B, 5A	$40,000	6 months	16
COMMUNICATIONS						
C1	Electrical Failure/Power Outage	Public outreach/communication regarding the emergency power capabilities for the medical school. What is on emergency power? When does it kick on? How do we know the power that would be supplied is adequate?	2A, 2B, 3B, 4C	$5,000	1 month	13, 16
C2	All	Public outreach to the campus community regarding what to do in an emergency. Should we stay or go? Better communication needed. Staff likes the new emergency card - what about students?	4A, 4B, 4C	$5,000	1 month	13, 16
C3	All	Establish hazard information centers/kiosks.	4A, 4C	$5,000	1 month	16
INFRASTRUCTURE						

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
I1	Electrical Failure/Power Outage	When UMMS suffers from a power bump/outage, they can have disruptions – (UPS) uninterrupted power supply installation might be helpful.	2D, 5B	$50,000	ongoing	16
I2	Critical Infrastructure Failure	Develop a summary of aging/old/abandoned campus infrastructure and utilities and prepare a proper abandonment/decontamination plan for each asset. Ensure that when campus renovations occur, this plan is utilized.	2B, 5A, 5D	$25,000	6 months	16
I3	Critical Infrastructure Failure, Hurricane, Windstorm	Replace roof on Benedict building (did seams 5 yrs. ago).	5B, 5A	$1M	9 months	16
I4	Critical Infrastructure Failure, Hurricane, Windstorm	Replace South Street roof (minus data center section, which has already been updated).	5B, 5A	$2M	9 months	16
I5	Critical Infrastructure Failure	Replace HVAC system or at least Penthouse Unit.	5B, 5A	$30M	9 months	16
I6	Critical Infrastructure Failure	Install well for on-site water capacity and on-site treatment plant. Install a water tower.	5B, 5A, 5D	$5-$6M	2 years	16
I7	Information System/IT Failure	Develop power redundancy to support IT closets.	5D	In progress	Ongoing	16
I8	Critical Infrastructure Failure	Replace older transformers in Hospital and School that contain PCBs	5D, 5A	$9M	2 years	16
I9	Critical Infrastructure Failure	Remove asbestos piping in power plant.	5D, 5A	$1M	1 year	16
I10	Critical Infrastructure Failure	Develop backup non-potable source for water. Tanker trucks used in the past, but not reliable. Perhaps installing new onsite well (South Street data center, Power Plant)	5B, 5A, 5D	$500,000	9 months	16
I11	Critical Infrastructure Failure	Upgrade /replace electrical substations which are 40 years told.	5D, 5A	$1M	1 year	16

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
I12	Critical Infrastructure Failure	Sanitary Waste Line for Hospital needs to be replaced. Inspect cast iron lines where areas are being remodeled and replace.	5D, 5A	$3M	2 years	16
I13	Critical Infrastructure Failure	Power Plant doesn't have a true N+1 or N+ 2 chiller system. Loss of certain chillers effects redundancy.	5D, 5A	$2M	1 year	16
I14	HazMat Incident	Another designated chemical storage area is needed to get hazardous waste materials off the floor where some are currently located. Building codes are an issue.	5D, 5A, 5B	$500,000	9 months	16
I15	Critical Infrastructure Failure	Ability to have HVAC on emergency power in Hospital and LRB.	5D, 5A, 5B	$100,000	9 months	16
I16	Critical Infrastructure Failure	Install quick connects/hook-ups for emergency generator, portable chillers and boilers at critical buildings.	5D, 5A, 5B	$250,000	6 months	16
EQUIPMENT/TECHNOLOGY						
ET1	All	Upgrade the police department radio system to P-25.	3C	$500,000	6 months	16, 15
ET2	All	Add security cameras in key locations that are under monitored.	3C	$1M	6 months	16, 15
ET3	All	Implement cellular data connections for key individuals so they can work remotely.	4C	$180,000	3 months	16
ET4	All	Develop/purchase a mobile IT unit for extended power outages to cover critical areas.	4C	$150,000	3 months	16
ET5	All	Increased use of technology during weather events (Goto Meeting etc.) to work remotely.	4C, 4A	$75,000	3 months	16
ET6	Critical Infrastructure Failure, Flood, Hurricane, Winter Storm	Duplicate off-site freezer capabilities for cell lines (needs to be a staffed program).	5B	$100,000	Ongoing	16
ET7	Information System/IT Failure	UMMS has an opportunity to create a "central laboratory" notebook that could be stored in the "cloud" so that it would remain accessible during IT issues.	2B, 2C	$50,000	6 months	16

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
ET8	All	Wire alarm system to police dispatch.	3B	$50,000	3 months	16
ET9	Information System/IT Failure	Put call centers in the cloud for backup purposes.	4C, 2B	$400,000	1 year	16
ET10	Information System/IT Failure	Develop cloud replication of data.	2B	$10M-$20M	2 years	16
ET11	Information System/IT Failure	Develop internet connection to ASI if the data center is lost.	2B	$60,000	9 months	16
ET12	Information System/IT Failure, Cyberattack or Cyberterrorism	Purchase additional equipment that could reduce cyberattacks.	2B, 5B	$2M	1 year	16
ET13	Information System/IT Failure Information System/IT Failure	Relocate data center to hardened environment.	2B	$50,000	6 months	16
ET14	Information System/IT Failure	Increase IT personnel resources to better deal with cyberthreats and infrastructure.	2B, 5B	$150,000	1 year	16
ET15	Information System/IT Failure	Develop additional intranet connection to Mattapan facility (currently only one IT pipe going to that facility).	2B	$160,000	9 months	16
ET16	Information System/IT Failure	Develop a robust VDI environment to allow remote desktop connections from remote locations (outside of main campus)	2B	$2M	1 year	16
ET17	Information System/IT Failure	Central laptop system stored in cloud.	2B	$700,000	1 year	16
ET18	All	Develop a comprehensive Disaster Recovery and Business Continuity Plan to cover the School's operations.	2B	$200,000	1 year	16
ET19	Information System/IT Failure	Air testing and monitoring equipment within the existing data center.	2B	$100,000	9 months	16
ACCESS/SECURITY						

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
AS1	Theft/Larceny, Burglary, Active Shooter	Create better access control for various staff types, students, so that not everyone has general access. Better control over who needs access to what.	3D, 3C, 3D	$250,000	1 year	16
AS2	Theft/Larceny, Burglary, Active Shooter	Determine a way to effectively access control the whole school building from the hospital. Currently, cross access is easy/not limited.	3D, 3C, 3D	$50,000	1 year	16
AS3	Theft/Larceny, Burglary, Active Shooter	Develop a program for signing in and "badging "visitors upon arrival.	2D, 3C, 3D	$1M	1 year	16
AS4	Theft/Larceny, Burglary	Evaluate security and access of the loading docks during daylight hours.	2D, 3C, 3D	$100,000	6 months	16
AS5	Theft/Larceny, Burglary	Consider a regional card access service so that there is redundancy. Each site would have their own server that is simultaneously attached to a home server.	2D, 3C, 3D	$100,000	6 months	16
AS6	All	Improve signage to where stairs are located in the school building (currently not clear).	3C, 3D	$20,000	6 months	16
AS7	Theft/Larceny, Burglary, Civil Disturbance	Potentially some fencing around the UMMS entrances to create more of a barrier/more security and less of a wide open feel.	3D	$2M	1 year	16
AS8	Theft/Larceny, Burglary, Active Shooter	Develop access lists for personnel allowed in certain areas.	2D, 3D	$5,000	1 month	16
AS9	Theft/Larceny, Burglary	Do campus walkthrough to assess external lighting conditions at night.	2D, 3D	$5,000	1 month	16
AS10	Theft/Larceny, Burglary	Develop card access system for South Street facility.	2D, 3D	$15,000	3 months	16
AS11	Theft/Larceny, Burglary	Put window film on clear panels at South Street for security purposes.	3D	$7,500	3 months	16
AS12	Theft/Larceny, Burglary	Increased visibility for doorways.	3D	$10,000	6 months	16
AS13	Theft/Larceny,	Study how to provide better day protection for	2D	$25,000	6 months	16

Project No.	Hazard Addressed	Description	Objectives Addressed	Estimated Cost	Project Duration	Potential Funding Source
	Burglary	unauthorized access to labs.				
AS14	Theft/Larceny, Burglary, Terrorism	Develop badge into Power Plant elevator lobby or badge door from second floor.	2D	$40,000	6 months	16

6.2 MITIGATION PROJECT PRIORITIZATION

The identified projects and mitigation activities have been evaluated and ranked by utilizing the FEMA STAPLEE criteria. The STAPLEE criteria focuses on ensuring that projects and activities are socially acceptable to the community, technically feasible, protective of or beneficial to the environment and are backed by legal authority and consistent with current laws, consider economic benefits and costs and include environmental considerations. The information that is included for each project addresses this criteria. Current campus and community needs were also considered which means the project or activity must be acceptable to decision makers, University/campus representatives, stakeholders and the public. The goals and objectives proposed in this Plan are intended to fulfill at a minimum the following STAPLEE criteria:

Table 6-2: STAPLEE Criteria

STAPLEE CRITERIA	
Social	Improve the quality of life and reduce campus/ neighborhood impacts. • Include public support and involvement. • Consider effects on selected segments of the population. • Compatible with present and future community. • Consider cultural impacts on the community.
Technical	Develop technically feasible mitigation efforts. • Effective in reduction of long-term losses, impacts and risks. • Effective in minimizing secondary losses. • Effective in solving the problem and not only the symptoms.
Administrative	Provide resources and staffing to implement proposed actions. • Jurisdiction and capability necessary to implement an action. • Ability to accomplish activities in a timely manner. • Ability to maintain and manage the mitigation measure.
Political	Acceptable to and supported by community politicians. • Have full support of the University Administration. • Involve political leaders in the planning process. • Support and involvement of stakeholders. • Public support and involvement.
Legal	Legal authority to undertake an action. • Meet all applicable regulatory requirements. • Define the roles of University (system and campus level), local, State and Federal governments. • Provide a legal basis for mitigation actions. • Assure laws, regulations, ordinances, and resolutions are in place. • Identify liabilities for an action or lack of an action. • Consider needs for legal counsel.
Economic	Develop affordable and cost effective mitigation efforts. • Obtain budget and funding for an action. • Economic costs and benefits of a mitigation action. • Burden to the tax base or local economy.
Environmental	Improve environmental quality. • Identify and evaluate environmental impacts.

STAPLEE CRITERIA	
	• Compliance with all environmental laws and regulations. • Benefit the environment from a mitigation action.

Implementation of projects and mitigation activities were prioritized by a qualitative ranking of high, medium or low. STAPLEE criteria was applied to the extent possible to all of the projects and mitigation activities that have been identified in the campus plan and priorities were evaluated on need, cost-effectiveness, number of hazards addressed, number of objectives met and funding eligibility.

UMMS utilized a qualitative assessment (high, medium, low) for prioritizing projects and mitigation activities for this plan.

- High Priority – Denotes a project or mitigation activity that meets multiple plan objectives, addresses multiple hazards, has benefits that outweigh potential costs, has funding secured or is able to be funded through the university budget and may be eligible for grant funding. Projects of high priority have the potential to be completed within the next 5 years.
- Medium Priority – Denotes a project or mitigation activity that meets some goals and objectives, addresses some hazards, has benefits that outweigh potential costs, funding is not in place but could be through university allocation or grant funding.
- Low Priority – Denotes a project that meets at least one goal/objective, addresses at least on hazard, costs may outweigh the benefits, funding has not been secured and grant eligibility is unclear and the timeframe for completion is probably long term.

Plan implementation will focus on the projects and mitigation activities that have the highest level priority associated with them. Over time and as the plan is implemented, priorities may change due to new funding sources or information or future hazard events. During the annual review of this document, the Hazard Mitigation Plan Planning Committee, will review the list of projects and mitigation activities to make sure that the prioritization ranking for each one is still the most appropriate.

Table 6-3 indicates the project number, responsible party and whether or not the project meets each individual STAPLEE criteria at a high, medium or low level. After taking this information into consideration, each project is given a qualitative high, medium or low ranking.

Table 6-3: STAPLEE Project Priority Rankings

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
PLANNING									
P1	Develop and communicate a campus wide emergency evacuation/shut down plan that would limit access to and from campus and include additional security measures.	Public Safety	Medium	High	High	Low	Low	Medium	Medium
P2	Develop a transportation plan for getting critical staff to campus during weather events like winter storms, blizzards and ice storms.	Public Safety	Medium	Medium	High	Low	Low	Medium	Medium
P3	Develop a shelter in place plan for faculty and students.	EH&S	Medium	High	High	Low	Low	Low	Medium
P4	Develop agreements with other schools who could take on residents should a hazard event occur and the school would not be able to function again in a short timeframe (a plan in already in place for faculty).	Public Safety	Low	High	High	Low	Medium	High	Medium
P5	Develop an emergency communication plan that articulates a clear hierarchy and interfaces with the hospital.	Public Safety	Medium	High	High	Low	Low	Medium	Medium
P6	Develop a supply chain plan for how UMMS would get critical supplies when and if needed.	Public Safety	Medium	High	High	Low	Low	Medium	Medium
P7	Develop a prioritization methodology for lab samples that would get moved/relocated in the event of an emergency.	Research	Low	High	High	Low	Low	Low	Low

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
P8	Incorporate mitigation retrofits into the annual Capital Improvement Plan when possible.	Facilities	Low	High	High	Low	Low	Medium	Medium
P9	Develop a backup/emergency lab, which stays set up that could be used if needed.	Facilities/EH&S	Medium	Medium	Medium	Low	Low	Medium	Low
P10	Develop contingency plan if underground water supply pipe were disrupted.	Facilities	Medium	High	High	Low	Low	Medium	Medium
P11	Develop a plan for research community for electrical outage.	Research	Medium	High	High	Low	Low	High	Medium
P12	Develop contingency plan for emergency trailered units to be connected at critical buildings and supported (chiller, boiler and electrical generator units)	Facilities	Medium	High	High	Low	Low	High	Medium
P13	Develop a plan for off-site locations in weather event (preventative actions).	Facilities	Low	Medium	Medium	Low	Low	Medium	Medium
P14	More planning associated with bullying.	HR	Low	High	High	Low	Medium	Low	Low
			TRAINING						
T1	More training/practice with complex emergency response situations that require coordination with multiple departments, etc.	Public Safety/EH&S	Medium	Medium	High	Low	Low	Low	Medium
T2	Training and practice of campus evacuation on a normal day and also on a day where there would be a special event.	Public Safety	Medium	High	High	Low	Low	Low	Medium

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
T3	Conduct a shelter in place drill/training.	Public Safety	Medium	High	High	Low	Low	Low	Low
T4	Train faculty, students and staff on IT/fire/natural gas backup safety and best practices	Public Safety	High	High	High	Low	Low	Low	Low
T5	Training on use of fire extinguisher	Public Safety	High	High	High	High	High	Medium	High
T6	Training on use of calling 911 vs. calling campus police.	Public Safety	High	High	High	High	High	Medium	High
T7	Conduct an active shooter drill/training exercise.	EH&S	High	High	High	High	High	Medium	High
T8	More training/practice on handling civil disturbances and labor unrest.	Public Safety	High	High	High	High	High	Medium	High
T9	Conduct training on IT failure and best practices.	IT	High	High	High	High	High	Medium	High
T10	Conduct training on natural gas use, locations and what to do in an emergency situation.	Facilities	Medium	Medium	High	Low	Low	Low	Medium
T11	Provide training to employees on information that is withheld (for example, South Street address not given out).	Public Safety	High	High	High	Low	Medium	Low	Medium
T12	Training on safe environments for employees who do home visitation.	Public Safety	High	Medium	Medium	Low	Medium	Low	Medium
T13	Training for employees on Information Security Awareness, including: Email, Phishing, PHI, etc.; Training for employees associated with the risks	IT	High	High	High	Low	Low	Medium	Medium

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
	in using social media.								
T14	Tabletop exercise for mobilizing mission critical units to other places if a building were to become inoperable.	Facilities	High	High	High	Low	Low	Low	Low
T15	More training in the use of select agents.	EH&S	High	High	High	Low	Low	Low	Medium
T16	Develop an on-line resource to provide basic training in a routine, scheduled manner.	IT	High	High	High	Low	Low	Low	Medium
T17	Continue practicing emergency operations.	Public Safety	High	High	High	Low	Low	Medium	Medium
T18	Develop a responsible conduct of research as an online resource which would serve as basic training for researchers so that they would know the basics of safety and security.	IT	High	High	Medium	Low	Medium	Low	Medium
POLICY/PROCEDURES									
PP1	Develop procedures for more timely dismissal for storms.	Public Safety	High	High	High	Low	Low	Low	High
PP2	Develop procedures for animal care in inclement weather.	Research	High	High	High	Low	Low	Low	High
PP3	Develop protocol to lock all floors at 5 PM.	Public Safety	High	Medium	High	Low	Low	Low	Low
PP4	Security around the use of scanners (scanned materials are accessible).	IT	Medium	Medium	High	Low	Low	Low	Medium

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
PP5	More formal process to identify and report unusual behaviors.	Public Safety	Medium	High	Medium	Low	Low	Low	Low
PP6	Review of off-site spill containment procedures	EH&S	High	Medium	Medium	Medium	Low	Low	Low
PP7	Develop a procedure to check unoccupied areas on some routine basis.	Public Safety	High	Medium	High	Low	Low	Low	Medium
PP8	Develop Policy for essential and non-essential staff during storm and other weather events to allow some remote access to reduce traffic to school.	Public Safety	Medium	High	Medium	Low	Low	Low	Medium
PP9	Implement routine chemical safety inspections.	EH&S	High	High	High	Medium	Low	Low	Medium
STUDY									
S1	Conduct an evacuation/egress study.	Public Safety	High	High	High	Low	Low	Low	High
S2	Complete HVAC study at South Street.	Facilities	Medium	Medium	High	Low	Low	Low	Low
S3	Study the chiller in the power plant as there may not be enough oxygen in this area and someone could potentially walk into a hazardous situation. Better placement of oxygen meters in the tunnel regarding available air is needed.	Facilities	Medium	High	High	High	Medium	Medium	High
S4	Evaluate potential for gray water system.	Facilities	Medium	Medium	Medium	Low	Low	Low	Low

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
S5	Complete study to evaluate a potential second egress and look at evacuation overall. Consider staggered evacuation options.	Public Safety	High	High	High	Low	Low	Low	High
S6	Mitigation study to determine water vulnerabilities from the City.	Facilities	Medium	Medium	Medium	Low	Low	Medium	Medium
S7	Conduct inventory of where risk exists for IT equipment.	IT	High	Medium	High	Low	Low	High	High
S8	Examine internal controls related to data security (have huge quantities of sensitive data - newborn screening, physician credentials).	IT	High	High	High	Low	Low	High	High
S9	Evaluate the need and development of a secondary data center (permanent co-location) for use in extended power loss scenarios.	IT	High	High	High	Low	Low	High	High
S10	Evaluate the need for individual IT closets to be on emergency power.	IT	High	Medium	High	Low	Low	Medium	Medium
S11	Examine the need for additional substations.	Facilities	Medium	Medium	Medium	Low	Low	Low	Medium
S12	Complete an inventory of all IT closets to determine which are needed and which could be consolidated/eliminated.	IT	High	High	Medium	Low	Low	Low	Medium
S13	Conduct Study of impacts of Long-Term shutdown of water and electrical systems.	Facilities	Medium	Medium	Medium	Low	Low	Low	Low
COMMUNICATIONS									
C1	Public outreach/communication regarding the emergency power capabilities for the medical	Facilities	High	High	High	Low	Low	Low	Medium

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
	school. What is on emergency power? When does it kick on? How do we know the power that would be supplied is adequate?								
C2	Public outreach to the campus community regarding what to do in an emergency. Should we stay or go? Better communication needed. Staff likes the new emergency card - what about students?	Public Safety/EH&S	High	High	High	Low	Low	Low	Medium
C3	Establish hazard information centers/kiosks.	IT	Medium	Medium	High	Low	Low	Low	Low
INFRASTRUCTURE									
I1	When UMMS suffers from a power bump/outage, they can have disruptions – (UPS) uninterrupted power supply installation might be helpful.	Facilities	Medium	Medium	Medium	Low	Low	Low	Low
I2	Develop a summary of aging/old/abandoned campus infrastructure and utilities and prepare a proper abandonment/decontamination plan for each asset. Ensure that when campus renovations occur, this plan is utilized.	Facilities	High	Medium	High	Medium	Low	Medium	Medium
I3	Replace roof on Benedict building (did seams 5 yrs. ago).	Facilities	Medium	Medium	Medium	Low	Low	Low	Low
I4	Replace South Street roof (minus data center section, which has already been updated).	Facilities	Medium	Medium	Medium	Low	Low	Low	Low
I5	Replace HVAC system or at least Penthouse Unit.	Facilities	Medium	Medium	Medium	Low	Low	Low	Low

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
I6	Install well for on-site water capacity and on-site treatment plant. Install a water tower.	Facilities	Medium	Medium	Medium	Low	Low	Low	Medium
I7	Develop power redundancy to support IT closets.	IT/Facilities	Medium	Medium	High	Low	Low	Low	Ongoing
I8	Replace older transformers in Hospital and School that contain PCBs	Facilities	Low	Medium	Medium	Medium	Medium	Medium	Medium
I9	Remove asbestos piping in power plant.	Facilities	Low	Medium	Medium	Medium	Medium	Medium	Medium
I10	Develop backup non-potable source for water. Tanker trucks used in the past, but not reliable. Perhaps installing new onsite well (South Street data center, Power Plant)	Facilities	Low	Medium	Medium	Medium	Medium	Medium	Medium
I11	Upgrade /replace electrical substations which are 40 years hold.	Facilities	Low	Medium	Medium	Low	Low	Low	Low
I12	Sanitary Waste Line for Hospital needs to be replaced. Inspect cast iron lines where areas are being remodeled and replace.	Facilities	Medium	Medium	Medium	Low	Low	Low	Low
I13	Power Plant doesn't have a true N+1 or N+ 2 chiller system. Loss of certain chillers effects redundancy.	Facilities	Medium	Medium	Medium	Low	Low	Low	Low
I14	Another designated chemical storage area is needed to get hazardous waste materials off the floor where some are currently located. Building codes are an issue.	EH&S	High	Medium	Medium	Low	Low	Medium	Medium

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
I15	Ability to have HVAC on emergency power in Hospital and LRB.	Facilities	Low	Medium	Medium	Medium	Low	Low	Low
I16	Install quick connects/hook-ups for emergency generator, portable chillers and boilers at critical buildings.	Facilities	High	High	High	Low	Low	Medium	High
	EQUIPMENT/TECHNOLOGY								
ET1	Upgrade the police department radio system to P-25.	Public Safety	High	High	High	Low	Medium	Medium	High
ET2	Add security cameras in key locations that are under monitored.	Public Safety	Medium	Medium	High	Low	Low	Low	Medium
ET3	Implement cellular data connections for key individuals so they can work remotely.	IT	Medium	Medium	Medium	Low	Low	Medium	Medium
ET4	Develop/purchase a mobile IT unit for extended power outages to cover critical areas.	IT	Medium	Medium	Medium	Low	Low	Low	Low
ET5	Increased use of technology during weather events (Goto Meeting etc.) to work remotely.	IT	High	High	High	Low	Low	Medium	Low
ET6	Duplicate off-site freezer capabilities for cell lines (needs to be a staffed program).	Research	Medium	Medium	Medium	Low	Low	High	High
ET7	UMMS has an opportunity to create a "central laboratory" notebook that could be stored in the "cloud" so that it would remain accessible during IT issues.	Research	High	High	High	Low	Low	Low	Low
ET8	Wire alarm system to police dispatch.	Public Safety	Medium	Medium	Medium	Low	Low	Medium	Medium

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
ET9	Put call centers in the cloud for backup purposes.	IT	Medium	Medium	Medium	Low	Low	Low	Low
ET10	Develop cloud replication of data.	IT	High	High	High	Low	Low	Medium	High
ET11	Develop internet connection to ASI if the data center is lost.	IT	Medium	Medium	Medium	Low	Low	Low	Medium
ET12	Purchase additional equipment that could reduce cyberattacks.	IT	Medium	Medium	High	Low	Low	Medium	Medium
ET13	Relocate data center to hardened environment.	IT	Medium	Medium	Medium	Low	Low	Low	Low
ET14	Increase IT personnel resources to better deal with cyberthreats and infrastructure.	IT	Medium	Medium	Medium	Low	Low	Medium	Low
ET15	Develop additional intranet connection to Mattapan facility (currently only one IT pipe going to that facility).	IT	Medium	Medium	Medium	Low	Low	Low	Low
ET16	Develop a robust VDI environment to allow remote desktop connections from remote locations (outside of main campus)	IT	Medium	Medium	Medium	Low	Low	Low	Medium
ET17	Central laptop system stored in cloud.	IT	Medium	Medium	Medium	Low	Low	Low	Medium
ET18	Develop a comprehensive Disaster Recovery and Business Continuity Plan to cover the School's operations. Consulting services	EH&S	Medium	High	High	Low	Low	Medium	High

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
ET19	Air testing and monitoring equipment within the existing data center.	EH&S	Medium	Medium	Medium	Low	Low	Low	Medium
ACCESS & SECURITY									
AS1	Create better access control for various staff types, students, so that not everyone has general access. Better control over who needs access to what.	Public Safety	Medium	Medium	Medium	Low	Low	Low	Low
AS2	Determine a way to effectively access control the whole school building from the hospital. Currently, cross access is easy/not limited.	Public Safety	Medium	High	Medium	Low	Low	Low	Medium
AS3	Develop a program for signing in and "badging" visitors upon arrival.	Public Safety	Medium	Medium	Medium	Low	Low	Low	Low
AS4	Evaluate security and access of the loading docks during daylight hours.	Public Safety	Medium	Medium	High	Low	Low	Low	Medium
AS5	Consider a regional card access service so that there is redundancy. Each site would have their own server that is simultaneously attached to a home server.	Public Safety	Medium	Medium	High	Low	Low	Medium	High
AS6	Improve signage to where stairs are located in the school building (currently not clear).	Public Safety	High	High	Medium	Medium	Low	Low	Low
AS7	Potentially add some fencing around the UMMS entrances to create more of a barrier/more security and less of a wide-open feel.	Facilities	Low	Medium	Medium	Low	Low	Low	Low
AS8	Consider a regional card access service so that there is redundancy. Each site would have their	Public	Medium	High	Medium	Low	Low	Low	High

Project No.	Project	Responsible Party	Cost Effectiveness of Activity	Socially Acceptable	Technically Feasible	Protect/Benefit Environment	Legal	Economic Benefit	Project Priority
	own server that is simultaneously attached to a home server.	Safety/IT							
AS9	Develop access lists for personnel allowed in certain areas.	Public Safety	High	High	High	Low	Low	Low	Low
AS10	Do campus walkthrough to assess external lighting conditions at night.	Public Safety	Medium	Medium	Medium	Low	Low	Low	Medium
AS11	Develop card access system for South Street facility.	Public Safety/IT	Medium	Medium	Medium	Low	Low	Low	Low
AS12	Put window film on clear panels at South Street for security purposes.	Public Safety	Medium	Medium	High	Low	Low	Low	Low
AS13	Increased visibility for doorways.	Public Safety	Medium	Medium	High	Low	Low	Low	Low
AS14	Provide better day protection for unauthorized access to labs.	Public Safety	Medium	High	Medium	Low	Low	Low	Low
AS15	Develop badge into Power Plant elevator lobby or badge door from second floor.	Public Safety/IT	Medium	Medium	Medium	Low	Low	Medium	Medium

6.3 POTENTIAL FUNDING SOURCES

As noted in the Massachusetts State Hazard Mitigation Plan, there may be various funding sources available for UMMS to potentially pursue as the campus considers implementing action items from this planning effort. Table 6-4 details various federal, state and local agencies and programs that may be available.

Table 6-4: Potential Funding Sources

Funding Source Number	Agency	Program	Description	More Information
	FEDERAL			
1	National Science Foundation (NSF), Directorate for Engineering, Division of Civil and Mechanical Systems, Hazard Reduction Program	Hazard Reduction Program	Funding for research and related educational activities on hazards.	http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13358
2	NSF -Directorate for Social, Behavioral Economic Science, Division of Social Behavioral and Economic Research Decision, Risk, and Management	Decision, Risk, and Management Science Program	Funding for research and related educational and activities on risk, perception, communication, and management (primarily, technological hazards).	http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5423
3	Department of Commerce (DOC), Economic Development Administration	Disaster Mitigation Planning and Technical Assistance	Technical and planning assistance grants for capacity building and mitigation project activities focusing on creating disaster resistant jobs and workplaces.	http://www.eda.gov/disasterrecovery.htm
4	US Department of Agriculture (USDA) - National Resources Conservation (NRCS) Watersheds and Wetlands Division	Watershed Surveys and Planning	Surveys and Planning Studies for appraising water and related resources, and service formulating alternative plans for conservation use and development. Grants and advisory/counseling services to assist with planning and implementation improvement.	http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/landscape/wsp/?cid=stelprdb1042175
5	FEMA	National Flood Insurance Program	Formula grants to States to assist FEMA communities to comply with NFIP floodplain management requirements (Community Assistance Program).	http://www.fema.gov/national-flood-insurance-program
6	FEMA; DOI-USGS USGS	National Earthquake Hazards Reduction	Training, planning and technical Program assistance under grants to States or local jurisdictions.	http://www.fema.gov/national-earthquake-hazards-reduction-program
7	DOD-USACE	Beneficial Uses of Dredged	Direct assistance for projects that protect, restore, and create aquatic and ecologically related habitats,	http://water.epa.gov/type/oceb/oceandumping/dredgedmaterial/beneficial_use

Funding Source Number	Agency	Program	Description	More Information
		Materials	including wetlands, in connection with dredging an authorized Federal navigation project.	.cfm
8	USDA-NRCS	Emergency Watershed Protection (EWP)	Provides technical and financial assistance Program for relief from imminent hazards in small watersheds, and to reduce vulnerability of life and property in small watershed areas damaged by severe natural hazard events.	http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/
9	DOD - USACE	Section 205 of 1948 Flood Control Act	Resources for small flood damage reduction projects.	http://www.nww.usace.army.mil/Portals/28/docs/assistanceprograms/sec205.pdf
10	Department of the Interior/National Park Service	Federal Land Transfer / Federal Land to Parks Program	Identifies federal real property available for open space transfer to states and local governments for development of parks and recreation.	http://www.nps.gov/ncrc/programs/flp/index.htm
11	USDOT FHWA	Bridge Replacement and Rehabilitation	Funding for eligible bridges on any public road.	http://www.fhwa.dot.gov/bridge/hbrrp.cfm
12	USDOT FHWA	Recreational Trails	Funding for trails used by motorized and nonmotorized recreational vehicles	https://www.fhwa.dot.gov/environment/recreational_trails/
13	US Department of Education	Emergency Management for Higher Education *(this program was last funded in 2010)*	The Emergency Management for Higher Education (EMHE) grant program supports institutions of higher education (IHE) projects designed to develop, or review and improve, and fully integrate campus-based all-hazards emergency management planning efforts.	http://www2.ed.gov/programs/emergencyhighed/funding.html
14	US Economic Development Administration (EDA)	Disaster Relief Opportunity – Economic Adjustment Assistance	The EAA program provides recipients with flexible tools to develop and implement regionally based long term economic development strategies in response to major Federally declared disasters. The EAA program provides a wide range of technical, disaster recovery, economic recovery planning, and public works	http://www.grants.gov/search-grants.html?eligibilities%3D06%7CPublic%20and%20State%20controlled%20institutions%20of%20higher%20education

Funding Source Number	Agency	Program	Description	More Information
			assistance. It responds adaptively to pressing economic recovery issues and is well-suited to help address challenges faced by regions affected by natural disasters.	
	STATE			
15	FEMA, MEMA	Hazard Mitigation Grant Program	Allows for the completion of post-disaster mitigation projects that will reduce and/or eliminate losses due to natural hazards. Private non-profit entities are eligible to apply.	http://www.mass.gov/eopss/agencies/mema/hazard-mitigation/grants/hazard-mitigation-grant-program-hmgp.html
	OTHER			
16	UMass Campus/System	Various	• Annual Operating Budgets • Staff Time • UMass System Bond Financing • UMass Building Authority • DCAM	

6.4 CAPABILITIES ASSESSMENT

UMMS has policies, procedures and action plans in place as well as qualified staff available that can be utilized for implementation of this Hazard Mitigation Plan which addresses both natural and human hazards. The capability assessment focuses on identifying where the campus already has mechanisms and staff in place that can either be used directly or modified to support mitigation activities.

6.5 ADMINISTRATIVE CAPABILITY

The UMass System is governed by a single Board of Trustees which is composed of 19 voting member and 3 non-voting members. The President of the University (office located in Boston) oversees the five campus system. At each campus (UMass Amherst, UMass Boston, UMass Dartmouth, UMass Lowell and UMass Medical School) there is a Chancellor.

The development of the UMMS Hazard Mitigation Plan was led by Charleen Sotolongo, the Senior Director of Environmental Health & Safety and Emergency Management. Other UMMS departments that either have been or may need to be involved with mitigation activities in the future include:

- Chancellor's Office
- Information Systems
- Facilities
- Office of Communications
- Office of Community and Government Relations
- Public Safety
- Purchasing
- Human Resources
- Health Services
- Environmental Health and Safety

Within these departments, various levels of staff perform regular job duties as well as special projects when assigned. Table 6-5 provides more detail about UMMS's administrative and technical capabilities to implement hazard mitigation activities.

Table 6-5: Administrative and Technical Capabilities

Department	Campus Offices Within Department	Function	Staff Types Available
Chancellor's Office	• Chancellor's Office/Staff	Responsibility for oversight of UMMS and future strategic direction.	Chief of Staff, Executive Assistant, Chancellor
Information Systems	• Information Systems Security	The Information Services (IS) Department provides information resources and technology support to UMMS. IS consists of five service including bioinformatics and genomics; curriculum development; and distance learning initiatives. IS supports and develops technology for finance and budget administration, program management and strategic planning.	Various
Facilities	• Facilities	Ensures that university facilities and grounds support the teaching, research and student success missions.	Directors for Project Management, Administration, Planning & Information, Utilities
Office of Communications	• Customer Service	Serves as clearing house for scheduling events on campus, creating signs for campus events, organizing campus moves, etc.	Vice Chancellor Communications, News Media Producer, Writers, Videographers
Office of Community & Government Relations	• OCGR	The OCGR serves as a liaison between the University and local neighbors with the goal of creating and nurturing positive relationships in the community and at all levels of government.	Chancellor, Community Outreach & Diversity Manager, Administrative Staff
Human Resources	• Human Resources	Focuses on development of existing faculty and staff, and the continued integration of new and talented contributors to ensure that UMMS is powered by a motivated, talented, and diverse workforce.	• Business & Operations/Customer Service • Training & Organizational Development • HR Operations • Benefits, Recruitment • HRIS • Labor Relations
Public Safety	• Uniformed Police/Campus Security	Focus is to create and maintain a safe and secure environment for the	• Director, Major and Captain • Technology & Special

Department	Campus Offices Within Department	Function	Staff Types Available
	• Crime Prevention	university community.	Projects • Parking & Operations • Detective • Security Officer • Police Officer • Dispatcher
University Health Services	• University Health Services	Provides onsite healthcare and mental health services to the UMMS campus community.	• Nurse Practitioners • Consulting Physicians • Psychologists • Social workers • Registered Nurses • Laboratory Technicians • Health Educators
Purchasing	• Purchasing	Aids in the process of acquiring goods and services.	• Director, Senior Buyer, Procard Coordinator
Environmental Health & Safety	• EH&S	Provides a safe environment for UMMS including assuring faculty is in compliance with local, state and federal safety standards. EH&S monitors use of hazardous materials, safe work practices and a safe environments.	• Director, Program Coordinators, Administrative

6.6 PLAN & PROGRAM CAPABILITY

The following documents were either reviewed as a part of this mitigation planning process or identified as having relevance to implementation of mitigation activities for the UMMS campus (see Table 6-6).

Table 6-6: Documents Reviewed During Mitigation Planning Process

Name of Plan	National, State, Regional or Local Plan/Program	Relevance to Hazard Mitigation Planning Effort
Commonwealth of Massachusetts – State Hazard Mitigation Plan, 2013	State	Current Hazard Mitigation Plan for Massachusetts that discusses vulnerabilities throughout the state to natural (and some human) hazards and associated mitigation activities.
Central Massachusetts Region-Wide Pre-Disaster Mitigation Plan, 2012	Regional	Regional Hazard Mitigation Plan for the central Massachusetts area, including the City of Worcester.
City of Worcester Emergency Management Website http://www.worcesterma.gov/emergency-communications/emergency-management	Local	Website provides historical information about natural and man-made hazards with the potential to impact the City of Worcester.
National Oceanic and Atmospheric Administration (NOAA) Comparative Climatic Data For the United States Through 2012	National	Report provides tables of climatic conditions in all 50 states, Puerto Rico, and Pacific Islands, including a data station in Worcester, Massachusetts.
City of Worcester Climate Action Plan, 2006	Local	Plan provides ways to reduce Worcester's energy use and greenhouse gas emissions and provides climate change data for the City of Worcester.
On the Water Front: News and Information about Your Water and Sewer Utilities, Volume 19, Number 1, Spring 2014	Local	Report provides water quality information and details about dams in the City of Worcester.
Massachusetts Drought Management Plan, May 2013	State	Plan provides information about how Massachusetts prepares for and responds to drought scenarios.
Massachusetts Local Financial Impact Review: Massachusetts Dam Safety Law, 2011	State	Current report providing information about high hazard dams in the Commonwealth of Massachusetts.

6.7 FISCAL CAPABILITY

Annually, an operating budget is prepared for the University System and approved by the Board of Trustees. The operating budget presents projected revenue and expenditures for all five campuses as well as the President's Office.

The UMass System is in the middle of implementing its 2012 – 2016 Five Year Capital Plan update. In general, due to the age of the facilities that make up the UMass System, it is a challenge to maintain and upgrade all of the capital assets including infrastructure, buildings and grounds. According to the Capital Pan, there is no single source of funding that has the capacity to address all of the work that needs to be done, so the University relies on a combination of revenue sources to fund future capital improvement investment. The four main revenue sources are:

- State support either through general obligation bond funds or economic stimulus and supplemental legislative appropriations,
- Financing through the University of Massachusetts Building Authority,
- Financing through the Massachusetts Health and Educational Facilities Authority, and
- Other legally available sources, operating funds and external funding such as private giving and grants.

The Capital Plan also notes that between 2008 – 2010, a number of developments occurred that will continue to help the University and its five campuses improve and invest in infrastructure. The events that directly and indirectly relate to UMMS include:

- The Commonwealth passed a $2 billion Higher Education Bond Bill that included over $1 billion for University projects,
- The Commonwealth passed a $1 billion Life Sciences Investment Bill that could provide up to $240 million of capital support to the University,
- The UMASS Building Authority borrowed $550 million in October 2009 to initiate projects at all of the University's campuses, and
- The UMASS Building Authority borrowed $547 million in November 2010 to initiate a third round of projects across the University.

The UMass FY2012-2016 Capital Plan updates details over $500 million in spending at UMMS during this timeframe (see Table 6-7).

Table 6-7: UMass Capital Plan – FY2012-FY2016 UMMS Details

Program Type	Amount Allocated
New Construction	$369,000,000
Other Capital Projects	$25,000,000
Deferred Maintenance	$45,740,000
Information Technology	$8,000,000
Equipment	$5,000,000
Renovation	$46,491,000

In general, larger capital projects for the entire UMass System such as buildings and athletic facilities are funded through the UMass Building Authority. DCAM generally may fund smaller projects that tend to be more operational in nature such as building maintenance, energy projects, emergency generators and other energy related/efficiency projects. Depending on the nature of the project, utilizing staff time and assigning specific people may be another way to advance certain mitigation projects.

6.8 REGULATORY ENVIRONMENT

Additional legal and regulatory policies are in place that pertain to UMMS and may have an impact on the implementation of mitigation activities. These policies are listed in Table 6-8.

Table 6-8: Legal and Regulatory Policies

Regulation/Policy	Purpose
City of Worcester Zoning Ordinance	UMMS is located in a Mixed Use Zone. The City of Worcester Zoning Ordinance regulates use and characteristics of land and buildings in the City of Worcester.

7. PLAN IMPLEMENTATION, MAINTENANCE & ADOPTION

The implementation of the Hazard Mitigation Plan will be overseen by Charleen Sotolongo, UMMS's Senior Director, Environmental Health & Safety/Radiation Safety. Ms. Sotolongo will be responsible for engaging the Hazard Mitigation Planning Team on a regular basis to discuss how various action items might be implemented and to ensure that they are prioritized in the highest order of importance. She will also be responsible for ongoing stakeholder engagement, both on and off campus, and participation in other local and regional Hazard Mitigation Planning efforts (e.g. City of Worcester).

The meetings will be documented and summarized including the status of any mitigation project actions, risk assessments or needed plan revisions.

7.1 PLAN MAINTENANCE & REVISION

Informal Hazard Mitigation Plan monitoring activities will be ongoing on a regular basis. UMMS will formally review the Hazard Mitigation Plan annually, or upon the occurrence of a substantial hazard event at any of the campuses. An annual plan review meeting with the Hazard Mitigation Planning team will be held by the Senior Director, Environmental Health & Safety/Radiation Safety. During this meeting, the Planning Team will evaluate the progress of the Plan, document any mitigation activities that have taken place on campus since the last review, and discuss any recommended or needed changes to the Plan.

In preparation for the annual meetings of the Hazard Mitigation Planning Team, the Senior Director, Environmental Health & Safety/Radiation Safety will prepare a status report to document the campus' progress in implementing the Mitigation Plan. Status reports should describe:

- Projects that have been scoped for FEMA grant applications;
- Projects that have been submitted for FEMA funding programs;
- Grant applications that have been either approved or denied FEMA funding;
- Projects funded internally or by other grant programs;
- Projects that have been initiated or are under construction; and/or
- Completed projects.

The public will be informed about the annual review of the plan by the UMMS Public Relations Office in accordance with the campus' public relations protocols. The public will be offered the opportunity to provide input and comment through the Senior Director, Environmental Health & Safety/Radiation Safety. The public will also have an opportunity to comment on the plan during the 5-year plan update meeting. After the annual review meeting, UMass will issue a progress report and post it on the UMMS website.

UMMS recognizes the importance of continued public outreach and public participation in this planning effort. Once the plan is finalized, a link to the UMMS Hazard Mitigation Plan will be posted to the campus' website (www.umassmed.edu). A press release will be issued by the Public Relations Office, and the effort may be discussed at various meetings where the Senior Director, Environmental Health & Safety/Radiation Safety and Hazard Mitigation Planning Team members can promote the Plan and continue to make the campus and neighboring community aware and encourage participation. Hard copies of the plan will be made available on campus through the Senior Director, Environmental Health & Safety/Radiation Safety.

7.2 REVISING THE PLAN

UMMS will review and update the plan every five years. Following a meeting of the Hazard Mitigation Planning Team in September 2019, the UMMS Senior Director, Environmental Health & Safety/Radiation Safety will convene the campus Hazard Mitigation Planning Team and set forth a schedule for reviewing the plan. The review and update will include:

- Updating the plan to reflect any changes in development or in the campus communities;
- A discussion on new/changed regulatory requirements;
- A discussion of recent hazard events;
- A re-evaluation of the hazard ranking and any changes in campus priorities;
- An update of any loss estimates,
- A discussion of any new studies and technologies;
- Revisiting potential projects; and
- A discussion of projects that have been completed.

The Hazard Mitigation Planning Team will review any State or Federal changes made to UMMS plans, funding, and policies, and will also utilize any updated Census Data that is available. The Hazard Mitigation Planning Team will also review existing goals and objectives and update them along with newer action items as needed. The findings of this research and analysis will be compiled into an updated UMMS Plan and ultimately, will be issued to MEMA and FEMA for review.

7.3 INTEGRATION INTO OTHER PLANNING MECHANISMS

UMMS has a number of local plans that were previously discussed in Section 6.4.2 that are related either directly or indirectly to this Hazard Mitigation Plan. To the extent possible, requirements, actions or principles of these documents have been integrated into the Hazard Mitigation Plan. Mitigation planning can be integrated conversely into those documents by making it a regular topic that is discussed through any new or updated document and during the associated planning effort. The Senior Director, Environmental Health & Safety/Radiation Safety will work with other appropriate members of the campus community to advocate for hazard mitigation. Specific activities may include:

- Integrate the Hazard Mitigation Plan goals and objectives into any new, amended or updated planning/policy document to the extent possible,
- Formalize and publicize a recognition of hazard mitigation planning and mitigation activities as a part of local and joint emergency management plans, efforts and operations,
- Address sea level rise, climate change and hazard mitigation planning in any future versions of the campus emergency response and disaster recovery plans, etc.,
- Seek out opportunities to participate in other local Hazard Mitigation planning efforts, projects or initiatives to share local knowledge and also learn about other activities occurring in the region,

- Further integrate mitigation planning into the Capital Improvement/Master Planning process by actively and regularly seeking alternative funding sources that have been highlighted in this plan.

7.4 ADOPTION

In order to be approved by MEMA and FEMA, this Plan must be formally adopted by UMMS. Documentation that the Hazard Mitigation Plan has been formally adopted by the University and each campus is provided below.

The UMMS Hazard Mitigation Plan was thoroughly reviewed by the Hazard Mitigation Planning Team. The UMMS Hazard Mitigation Planning Team formally endorsed the Hazard Mitigation Plan ____ and recommended it for adoption by UMMS senior campus officials. The UMMS Plan was formally adopted by ______ on ______. UMMS issued a press release announcing plan endorsement on ____ and posted the plan on the UMMS web site.

7.5 APPROVAL

A copy of the formal approval letter for this Plan is provided in Appendix I.

[To be included once the Plan has been approved by MEMA and FEMA]

APPENDIX A: APPENDIX TITLE

APPENDIX B: APPENDIX TITLE

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