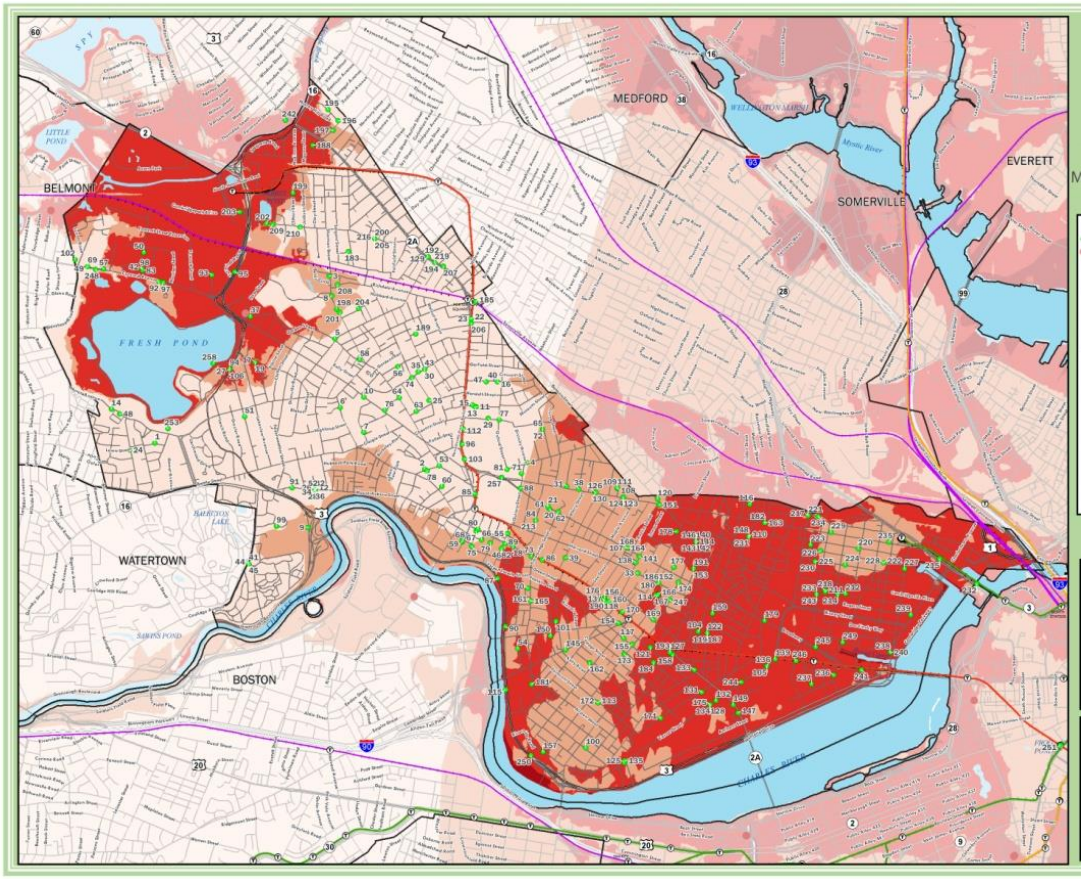
CITY OF CAMBRIDGE

HAZARD MITIGATION PLAN 2015 UPDATE



MAPC
METROPOLITAN AREA PLANNING COUNCIL

Metropolitan Area Planning Council

Final Plan

FEMA Approval Pending Adoption

March 11, 2016

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ACKNOWLEDGEMENTS AND CREDITS

This plan was prepared for the City of Cambridge by the Metropolitan Area Planning Council (MAPC) under the direction of the Massachusetts Emergency Management Agency (MEMA) and the Massachusetts Department of Conservation and Recreation (DCR). The plan was funded by the Federal Emergency Management Agency's (FEMA) Pre-Disaster Mitigation (PDM) Grant Program.

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CITY OF CAMBRIDGE HAZARD MITIGATION PLAN 2015 UPDATE

Cambridge Hazard Mitigation Plan Update Steering Committee

Lisa Peterson	Deputy City Manager
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Joseph Wilson	Police Department
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Sam Corda	Cambridge Water Department
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I. EXECUTIVE SUMMARY

Hazard Mitigation planning is a proactive effort to identify actions that can be taken to reduce the dangers to life and property from natural hazard events. In the communities of the Boston region of Massachusetts, hazard mitigation planning tends to focus most on flooding, the most likely natural hazard to impact these communities. The Federal Disaster Mitigation Act of 2000 requires all municipalities that wish to be eligible to receive FEMA funding for hazard mitigation grants, to adopt a local multi-hazard mitigation plan and update this plan in five year intervals.

PLANNING PROCESS

Planning for the Cambridge Hazard Mitigation Plan update was led by the Cambridge Local Hazard Mitigation Planning Committee, composed of staff from a number of different City Departments. This committee discussed where the impacts of natural hazards most affect the City, goals for addressing these impacts, and hazard mitigation measures that would benefit the City.

Public participation in this planning process is important for improving awareness of the potential impacts of natural hazards and to build support for the actions the City takes to mitigate them. The City hosted public meetings two times during the process with the two meetings occurring January 9, 2013 and January 10, 2013 and a third meeting that occurred March 18, 2014. The draft plan was then posted on the City's website for public review.

RISK ASSESSMENT

The Cambridge Hazard Mitigation Plan assesses the potential impacts to the City from flooding, high winds, winter storms, brush fire, and geologic hazards. Flooding, driven by hurricanes, northeasters, and other storms, clearly presents the greatest hazard to the City, most especially in locations that are low-lying or where drainage and conveyance systems can be overwhelmed during storm events with significant precipitation.

The Cambridge Local Committee identified those areas where flooding most frequently occurs, comprising 17% of the City's land area, and over 3,100 building structures worth an estimated $907,000,000.

HAZARD MITIGATION GOALS

1. Goal: Protect the health and safety of the public.
    - Encourage people to be prepared before, during and after a hazard event.
    - Identify at-risk populations and keep up to date list of locations
    - Ensure that services related to public health can function during and after a hazard, e.g., sanitation, water, debris removal, hospitals, and emergency services.

- Ensure that evacuation can happen in an organized and efficient manner.
- Minimize secondary impacts from hazards, such as the release of pollutants.

2. Goal: Protect existing properties and structures.
   - Provide resources for residents and businesses to make their buildings and properties more disaster resistant.
   - Educate the public on measures they can take to protect their property.
   - Maintain existing mitigation structures.
   - Ensure that future development / redevelopment does not make existing properties more vulnerable to hazards.
   - Ensure that critical facilities are protected from hazards.
   - Complete separation of combined sewers
3. Goal: Ensure that essential services can function during and after a hazard event.
   - Ensure that critical infrastructure is protected from natural hazards.
   - Ensure that people (key service providers and employees) can get into the city to provide services.
   - Build resiliency into the system for faster recovery, e.g., electricity distribution system.
4. Goal: Avoid chaos and confusion with good communication.
   - Have an effective communication plan.
   - Perform outreach to non-English speakers and other vulnerable populations before, during and after hazard events
   - Coordinate efforts with the private sector and institutions and with neighboring communities.
5. Goal: Work regionally to mitigate impacts from natural hazards and to respond and recover from hazard events.
   - Continue to participate in regional efforts.
   - Cooperate with other agencies, communities, and private entities.
   - Understand priorities and capabilities of other entities to allow for resource-sharing, mutual aid, and entering into memoranda of understanding (MOU).
6. Goal: Determine priorities for directing resources for hazard mitigation and response.
   - Prioritize mitigation projects.

- Continue to program mitigation projects in the 5 and 10 year CIP.
- Pursue various funding sources.
- Encourage private property-owners to implement measures to protect their own property.

7. Protect natural resources
   - Identify mitigation strategies that preserve or restore the function of natural systems.
   - Protect indigenous wetland areas, undeveloped floodplains and other natural features that provide mitigation of natural hazards.
   - Introduce green infrastructure elements, where possible, to reduce impervious surfaces and introduce natural systems.
8. Create capacity to monitor existing changes
   - Identify and understand how climate change many alter where and how the City is vulnerable to natural hazards.
   - Review and update current mitigation activities to anticipate future changes in vulnerabilities.
   - Review and update current emergency preparedness and response activities to anticipate future changes in vulnerabilities.

HAZARD MITIGATION STRATEGY

The Cambridge Local Committee identified a number of mitigation measures that would serve to reduce the City's vulnerability to natural hazard events. A primary focus of the measures was maintaining and improving the integrity of the drainage system through addressing maintenance and reconstruction issues. A secondary emphasis is on boosting the general emergency planning capabilities of the City so that both hazard mitigation and emergency management can be handled efficiently and effectively. Lastly, the City has included a set of measures that are aimed at identifying and addressing how vulnerabilities to natural hazards may change due to Climate Change.

Overall, the hazard mitigation strategy recognizes that mitigating hazards for Cambridge will be an ongoing process as our understanding of natural hazards and the steps that can be taken to mitigate their damages changes over time. The Hazard Mitigation Strategy will be incorporated into other related plans and policies.

PLAN REVIEW AND UPDATE PROCESS

Table 1 Plan Review and Update

Chapter	Reviews and Updates
III – Public Participation	The Cambridge Local Committee emphasized public participation for the update of the Hazard Mitigation Plan, discussing strategies to enhance participation opportunities at the first local committee meeting. During plan development, the plan was discussed at public meetings hosted by the Local Emergency Planning Committee and the Climate Protection Action Committee. Both meetings were publicized. The plan was also made available on the City's website for public comment.
IV – Risk Assessment	MAPC gathered the most recently available hazard and land use data and met with City staff to identify changes in local hazard areas and development trends. City staff reviewed critical infrastructure with MAPC staff in order to create an up-to-date list. MAPC also used the most recently available version of HAZUS and assessed the potential impacts of flooding using the latest data.
V - Goals	The Hazard Mitigation Goals were reviewed, updated, and endorsed by the Local Hazard Mitigation Committee.
VI – Existing Mitigation Measures	The list of existing mitigation measures was updated to reflect current mitigation activities in the City.
VII & VIII – Hazard Mitigation Strategy	Mitigation measures from the 2008 plan were reviewed and assessed as to whether they were completed, on-going, or deferred. The Local Committee determined whether to carry forward measures into the 2014 plan or delete them. The 2014 Hazard Mitigation Strategy reflects both new measures and measures carried forward from the 2008 plan. The Committee prioritized the new set of measures based on current conditions.
IX – Plan Adoption & Maintenance	This section of the plan was updated with a new on-going plan implementation review and five year update process that will assist the City in incorporating hazard mitigation issues into other City planning and regulatory review processes and better prepare the City to update the plan in 2019.

As indicated on Table 22, Cambridge has made significant progress on advancing and implementing mitigation measures from the 2008 Hazard Mitigation Plan. Many measures identified in that plan were completed, such as construction of numerous projects to address drainage issues related to Combined Sewer Overflows, and others have seen

major progress, such as having 40% of the city undergo hydraulic modeling. There are measures that still require action and that will require additional capital, equipment, and manpower. Moving forward into the next five year implementation period, there will be many more opportunities to incorporate hazard mitigation into the City's decision making processes, especially as Cambridge completes its Climate Change Vulnerability Assessment and Preparedness Plan.

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II. INTRODUCTION

PLANNING REQUIREMENTS UNDER THE FEDERAL DISASTER MITIGATION ACT

The Federal Disaster Mitigation Act, passed in 2000, requires that after November 1 2004, all municipalities that wish to continue to be eligible to receive FEMA funding for hazard mitigation grants, must adopt a local multi-hazard mitigation plan, and update this plan in five year intervals. This planning requirement does not affect disaster assistance funding.

Federal hazard mitigation planning and grant programs are administered by the Federal Emergency Management Agency (FEMA) in collaboration with the states. These programs are administered in Massachusetts by the Massachusetts Emergency Management Agency (MEMA) in partnership with the Department of Conservation and Recreation (DCR). Massachusetts has taken a regional approach and has encouraged the regional planning agencies to apply for grants to prepare plans for groups of their member communities. The Metropolitan Area Planning Council (MAPC) received a grant from FEMA under the Pre-Disaster Mitigation (PDM) Program to assist the City of Cambridge, and seven other municipalities in the Inner Core region, to update their local Hazard Mitigation Plans, which were first adopted in 2008 as part of a Metro-Boston Multi Hazard Mitigation Plan. These local Hazard Mitigation Plan updates are designed to meet the requirements of the Disaster Mitigation Act for each community.

In order to address multijurisdictional and regional issues, the participating municipalities were afforded the opportunity to meet with their neighboring communities during plan development. A public, regional meeting of the Metro Boston Multiple Hazard Community Planning Team was held April 13, 2012 to re-introduce participating communities to the hazard mitigation planning process and to identify inter-community hazard mitigation issues.

WHAT IS A HAZARD MITIGATION PLAN?

Natural hazard mitigation planning is the process of determining how to systematically reduce or eliminate the loss of life and property damage resulting from natural hazards such as floods, earthquakes, and hurricanes. Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries, and property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, programs, projects, and other activities.

PREVIOUS FEDERAL/STATE DISASTERS

The City of Cambridge has experienced 16 natural hazards that triggered federal or state disaster declarations since 1991. These are listed in Table 2. The vast majority of these events involved flooding.

Table 2. Previous Federal/State Disaster Declarations

Disaster Name (Date of Event)	Type of Federal Assistance Provided	Declared Areas in MA
Hurricane Bob (August 1991)	FEMA Public Assistance Project Grants	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
	Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk (16 projects)
No-Name Storm (October 1991)	FEMA Public Assistance Project Grants	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
	FEMA Individual Household Program	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
	Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
March Blizzard (March 1993)	FEMA Public Assistance Project Grants	Statewide
January Blizzard (January 1996)	FEMA Public Assistance Project Grants	Statewide
October Flood (October 1996)	FEMA Public Assistance Project Grants	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
	FEMA Individual Household Program	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
	Hazard Mitigation Grant Program	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
(1997)	Community Development Block Grant-HUD	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk

Table 2. Previous Federal/State Disaster Declarations

Disaster Name (Date of Event)	Type of Federal Assistance Provided	Declared Areas in MA
June Flood (June 1998)	FEMA Individual Household Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
	Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
	Community Development Block Grant-HUD	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
March Flood (March 2001)	FEMA Individual Household Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
	Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester (16 projects)
February Snowstorm (Feb 17-18, 2003)	FEMA Public Assistance Project Grants	Statewide
January Blizzard (January 22-23, 2005)	FEMA Public Assistance Project Grants	Statewide
Hurricane Katrina (August 29, 2005)	FEMA Public Assistance Project Grants	Statewide
May Rainstorm/Flood (May 12-23, 2006)	Hazard Mitigation Grant Program	Statewide
April Nor'easter (April 15-27, 2007)	Hazard Mitigation Grant Program	Statewide
Flooding (March, 2010)	FEMA Public Assistance FEMA Individuals and Households Program SBA Loan	Bristol, Essex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester
	Hazard Mitigation Grant Program	Statewide

Table 2. Previous Federal/State Disaster Declarations

Disaster Name (Date of Event)	Type of Federal Assistance Provided	Declared Areas in MA
Tropical Storm Irene (August 27-28, 2011)	FEMA Public Assistance	Statewide
Hurricane Sandy (October 27-30, 2012)	FEMA Public Assistance	Statewide

(Source: database provided by MEMA)

FEMA Funded Mitigation Projects

Over the last 20 years the City of Cambridge has not received funding from FEMA for mitigation projects under the Hazard Mitigation Grant Program (HMGP).

Community Profile

Cambridge borders Watertown, Belmont, Arlington, and Somerville and is separated from Boston by the Charles River. Cambridge was first organized as a City in 1630 and then incorporated as a city in 1846. It is located in Middlesex County and the city has a Council-Manager form of government.

The city's website is at http://www.cambridgema.gov/index.cfm.

In 2010, Cambridge had 105,162 residents and 47,291 housing units. The city's land area is 6.5 square miles. Its total area is 7.13 square miles. The city is served by State Routes 2, 2A, 16, and 38, the MBTA's Red Line and Green Line, the commuter rail, and a number of bus routes. Table 3 highlights key community data from the 2010 Census.

Cambridge is home to four colleges/universities: Harvard University (including Radcliffe College), the Massachusetts Institute of Technology (MIT), Lesley College, and Cambridge College. When discussing natural hazards, the presence of the educational institutions is an important consideration. These schools bring in thousands of college or graduate students every year and bring thousands of workers into Cambridge every day (see Table 4 for details). In addition, these institutions often conduct their own hazard planning and emergency preparedness programs.

Table 3. Cambridge Characteristics, 2010

Population = 105,162

- 4.3% are under age 5
- 9.5% are over age 65
- 8.1% speak English less than "very well" (over age 5)
- 32.0% of households have no vehicle
- 16.3% live in group quarters

Number of Housing Units = 47,291

- 65.4% are renter-occupied housing units
- 58.7% of housing units were built prior to 1940

Source: U.S. Census, 2010, American Community Survey 2006-2010

Table 4. College Students, Workers, and Buildings, 2004

	Cambridge College	Harvard Univ.	Lesley Univ.	MIT	Total
Total Acres	1	214	16	253	484
Number of Buildings	1	391	59	109	560
Staff & Faculty	210	11,256	532	8,956	20, 954
Total Students in Degree Programs	2,946	17,408	4,571	10,908	35,833
Total Students in Dormitories	0	7,167	856	5,981	14,004
Total Students in Off-Campus Affiliated Housing	0	2,065	0	130	2,195

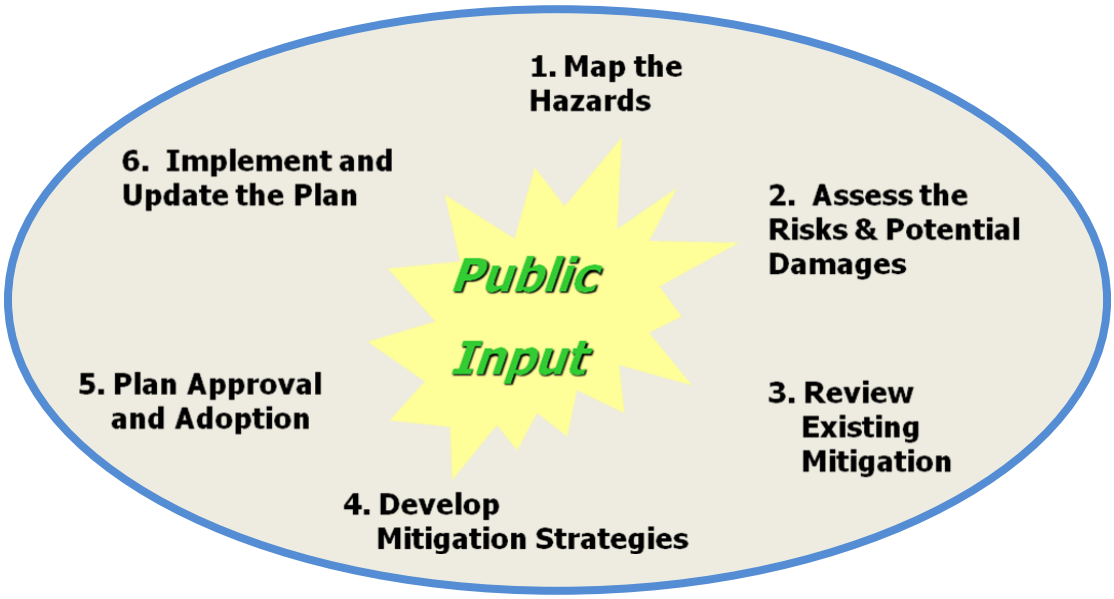
Source: 2013 Cambridge Town Gown Annual Report.

III. PLANNING PROCESS AND PUBLIC PARTICIPATION

MAPC employs a six step planning process based on FEMA's hazard mitigation planning guidance focusing on local needs and priorities but maintaining a regional perspective matched to the scale and nature of natural hazard events. Public participation is a central component of this process, providing critical information about the local occurrence of hazards while also serving as a means to build a base of support for hazard mitigation activities. MAPC supports participation by the general public and other plan stakeholders through Regional and Local Hazard Mitigation Planning Committees, two public meetings hosted by the City, posting of the plan to the City's website, and invitations sent to neighboring cities and towns, City boards and commissions, and other local or regional entities to review the plan and provide comment.

PLANNING PROCESS SUMMARY

The six-step planning process outlined below is based on the guidance provided by FEMA in the Local Multi-Hazard Mitigation Planning Guidance, July 1, 2008. Public participation is a central element of this process, which attempts to focus on local problem areas and identify needed mitigation measures based on where gaps occur in the existing mitigation efforts of the municipality. By working on municipal hazard mitigation plans in groups of neighboring cities and towns, MAPC is able to identify regional opportunities for collaboration and facilitate communication between communities. In plan updates, the process described below allows staff to bring the most recent hazard information into the plan, including new hazard occurrence data, changes to a municipality's existing mitigation measures, and progress made on actions identified in previous plans.



1. Map the Hazards – MAPC relies on data from a number of different federal, state, and local sources in order to map the areas with the potential to experience natural

hazards. This mapping represents a multi-hazard assessment of the municipality and is used as a set of base maps for the remainder of the planning process. A particularly important source of information is the knowledge drawn from local municipal staff on where natural hazard impacts have occurred, which is collected. These maps can be found in Appendix B.

2. Assess the Risks & Potential Damages – Working with local staff, critical facilities, infrastructure, vulnerable populations, and other features are mapped and contrasted with the hazard data from the first step to identify those that might represent particular vulnerabilities to these hazards. Land use data and development trends are also incorporated into this analysis. In addition, MAPC develops estimates of the potential impacts of certain hazard events on the community.
3. Review Existing Mitigation – Municipalities in the Boston Metropolitan Region have an active history in hazard mitigation as many have adopted flood plain zoning districts, wetlands protection programs, and other measures as well as enforcing the State building code, which has strong provisions related to hazard resistant building requirements. All current municipal mitigation measures must be documented.
4. Develop Mitigation Strategies – MAPC works with the local municipal staff to identify new mitigation measures, utilizing information gathered from the hazard identification, vulnerability assessments, and the community's existing mitigation efforts to determine where additional work is necessary to reduce the potential damages from hazard events. Additional information on the development of hazard mitigation strategies can be found in Chapter VII.
5. Plan Approval & Adoption – Once a final draft of the plan is complete it is sent to MEMA for the state level review and, following that, to FEMA for approval. Typically, once FEMA has approved the plan the agency issues a conditional approval with the condition being adoption of the plan by the municipality. More information on plan adoption can be found in Chapter IX and documentation of plan adoption can be found in Appendix D.
6. Implement & Update the Plan – Implementation is the final and most important part of any planning process. Hazard Mitigation Plans must also be updated on a five year basis making preparation for the next plan update an important on-going activity. Chapter IX includes more detailed information on plan implementation.

2008 PLAN IMPLEMENTATION AND MAINTENANCE

The 2008 Cambridge Annex to the Metro Boston Regional Multi-Hazard Mitigation Plan contained a risk assessment of identified hazards for the City and mitigation measures to address the risk and vulnerability from these hazards. Since approval of the plan by FEMA and local adoption, progress has been made on implementation of the measures.

The City has advanced a number of projects for implementation, including maintenance of 225 miles of sewer pipes, provision of back flow preventers to private landowners in targeted areas, design, and completion of numerous sewer and stormwater drainage projects around the City and advancement on the hydraulic model for Cambridge.

The City has advanced these projects in a fiscal environment that is often constrained and where municipal staff is often performing the work in multiple roles. As such, much of the coordination for projects that either directly or indirectly address mitigation measures has occurred through small groups rather than through a regular convening of a local mitigation team. In addition, the City was prepared to engage in the plan update process from the Regional Committee meeting through to the local team and public meetings.

CAMBRIDGE'S PARTICIPATION IN THE REGIONAL COMMITTEE

On February 28, 2010 a letter was sent notifying the communities of the first meeting of the Metro Boston Hazard Mitigation Planning Committee and requesting that the Chief Elected Official designate a minimum of two municipal employees and/or officials to represent the community. The following individuals were appointed to represent Cambridge on the regional committee:

Brian Gover	Local Emergency Planning Committee/ Fire Department
Gerard Mahoney	Emergency Planning and Coordination / Fire Department

The regional committee serves as an opportunity for neighboring communities to discuss hazard mitigation issues of shared concern. The Metro Boston Regional Committee met on April 13, 2010 and was attended by representatives from the neighboring municipalities of Brookline, Cambridge, Chelsea, Everett, Malden, Medford, Melrose, and Somerville. At that meeting, the communities began the process of reviewing and revising their 2008 Natural Hazard Mitigation Plans and were re-introduced to the following items:

- The Massachusetts State Hazard Mitigation Plan and the FEMA hazard mitigation planning and grant process;
- The concept of each community engaging staff and the public to update its current Natural Hazard Mitigation Plan;
- FEMA plan overview and requirements and plan eligibility;
- Review of the overall scope of work and plan revision schedule
- Question and of Discussion of local issues, inter-community and Metro Boston Region hazard mitigation issues and how to address.
- Re-introduction to identifying and mapping municipal Critical Facilities, municipal Areas of Concern, Inter-Community Areas of Concern, and Regional Shared areas of Concern.

- Municipal representatives were also briefed on the importance of trying to create a diversified presence on the local Multiple Hazard Community Planning Team in advance of local team meetings, being asked to contact major employers, business owners, schools, and non-profit organizations to participate in the process.

In addition, as the same group of MAPC staff is working on each community's plan, these issues of shared concern, and other issues that may arise between neighboring communities, are discussed in greater detail in local committee meetings and resulting actions are reflected in the identified mitigation measures, as noted in Chapter VI.

THE LOCAL HAZARD MITIGATION PLANNING TEAM

The Local Hazard Mitigation Planning Team is central to the planning process as it is the primary body tasked with developing a mitigation strategy for the community. Given this role, it is important that this committee include a diverse representation of community stakeholders and knowledgeable municipal staff.

Given the Cambridge's large number of stakeholders and staff whose participation in this process was desirable, it was decided that a local committee would be given oversight of the planning process. The committee was tasked with setting plan goals and providing information on the impacts of hazards on the City and existing mitigation measures, and helping to develop new mitigation measures that would then be made available for review. The steering committee membership can be found in the table below. The steering committee met on: October 25, 2012; November 21, 2012; June 13, 2013; and October 16, 2013.

Table 5. Cambridge Hazard Mitigation Plan Steering Committee

Name	*Representing*
Brian Gover	Local Emergency Planning Committee/ Fire Department
Gerard Mahoney	Emergency Planning and Coordination / Fire Department
Joseph Wilson	Police Department
Owen O'Riordan	Department of Public Works
John Nardone	Department of Public Works
Lisa Peterson	Manager's Office
John Bolduc	Community Development Department
Sam Corda	Cambridge Water Department
Mike Nicoloro	Inspectional Services Department
Jennifer LeTourneau	Conservation Commission
Bill Van Schalkwyk	Massachusetts Institute of Technology

Table 5. Cambridge Hazard Mitigation Plan Steering Committee

Name	*Representing*
Nick Hambridge	Harvard University
Sam Lipson	Public Health Department
Lynn Schoeff	Public Health Department
Steve Lenkauskas	Electrical Department

PUBLIC MEETINGS

Public participation in the hazard mitigation planning process is important, both for plan development and for later implementation of the plan. Residents, business owners, and other community members are an excellent source for information on the historic and potential impacts of natural hazard events and particular vulnerabilities the community may face from these hazards. Their participation in this planning process also builds understanding of the concept of hazard mitigation, potentially creating support for mitigation actions taken in the future to implement the plan. To gather this information and educate residents on hazard mitigation, the City hosted three public meetings, two during the planning process and one after a complete draft plan was available for review.

Natural hazard mitigation plans unfortunately rarely attract much public involvement in the Boston region, unless there has been a recent hazard event. One of the best strategies for overcoming this challenge is to include discussion of the hazard mitigation plan on the agenda of an existing board or commission. With this strategy, the meeting receives widespread advertising and a guaranteed audience of the board or commission members plus those who attend the meeting. These board and commission members represent an engaged audience that is informed and up to date on many of the issues that relate to hazard mitigation planning in the locality and will likely be involved in plan implementation, making them an important audience with which to build support for hazard mitigation measures. In addition, these meetings frequently receive press coverage and are televised, expanding the audience that has the opportunity to hear the presentation and provide comment by phoning or emailing local staff.

The public had an opportunity to provide input to the Cambridge hazard mitigation planning process during a meeting of the Local Emergency Planning Committee (LEPC) on January 9, 2013 held in the W.R. Grace Building in Cambridge and on January 10, 2013 at the Climate Protection Action Committee (CPAC) in the City Hall Annex. The final draft of the plan was presented at a Public Meeting held on March 18, 2014. This meeting was held in the public meeting room at the Department of Public Works.

The first two meetings were publicized as a regular meeting of the two committees. The presentation of the final draft was publicized as a standalone public meeting. The attendance list for each meeting can be found in Table 6.

Table 6. Attendance at Public Meetings

Name	Organization or Neighborhood
Public Meeting – LEPC - January 9, 2013	
Joe Wilson	Cambridge Police
James Defrancesco	Cambridge Police
Demetra Borlas	Amgen
Tamanah Anuard	Ironwood
Stefan Wawzyricki	Infinity
Tom Diamond	Pfizer
David Loh	MA Dept of Fire Services
Buchoul Yam	CPD
George Fosque	Cams. ECD
Joseph F. Gafun	MIT
Bill Van Schalkwyk	MIT
Jeff Richards	Shire
Nick Hambridge	Harvard
Gerry Mahoney	CFD
Sam Corda	Cambridge Water
Brian Gover	CFD
Bill Donovan	Whitehead Inst.
Mike Hughes	CFD
Kristin Garlund	Safety Partners
Alex Wong Bermier	Ironwood
Sarah Avgood	Safety Parties / Agios
Xi Biarth	TEI
Dave Degou	CHA
D. Carlson	MIT Pb
Bob Najjar	Draper
Jeff Trask	MIT
Norman Collings	Mount Auburn Hospital

Table 6. Attendance at Public Meetings

Name	**Organization or Neighborhood**
Eli Gifford	Harvard
Patrick J. Sullivan	Somerville Fire Department
Dana Haagensen	MA DFS
Kim Parker	Sanofi
Mary Lucot	Sanofi
Heidi Fon	Novavtis
Dick Aichelmann	Ironwood
Skip Botelho	Cambridge 911
Stacia Joyce	CFD
Laura Piecewicz	WR Grace
Kathleen Woodword	Biogen Idec
Judith Tilden	Vertex Pharma
Lou DiBerardinis	MIT
PM Bochnat	MIT
Bob Beniot	Mt Auburn Hospital
David M. Barber	MIT
Lynn Schoeff	CPHD
Heather Tece	MEMA
Public Meeting – CPAC - January 10, 2013	
Milton Bevington	Resident
Peter Crawley	Resident
Janet Curtis	Resident
Lyn Huckabee	Resident
Ted Live	Resident
Lauren Miller	Resident
David Rabkin	Resident
Marguerite Reynolds	Resident
Keren Schlomy	Resident

Table 6. Attendance at Public Meetings

Name	Organization or Neighborhood
Scott Wood	Resident
Quinton Zondervan	Resident
Malcolm Bliss	Resident
Kurt Tramposch	Resident
Paula Phipps	Resident
John Pitkin	Resident
Dorothea von Herder	Resident
Steve Lanou	MIT
Carri Boiselle	Novartis
Terrence Smith	Chamber of Commerce
Kyle Greaves	Urban Ecology Institute
Robyn Tsukayama	Harvard
Barry Hilts	Cambridge Health Alliance
Susanne Rasmussen	Community Development Department
John Bolduc	Community Development Department
Kristen von Hoffmann	School Department
Public Meeting – March 18, 2014	
Carol Weinhaus	Resident
Jim Newman	Resident
Sam Seidel	Resident/Planner
Craig Kelley	City Councilor
Brian Gover	Fire Department/LEPC
Jim Wilcox	Engineering

OTHER OPPORTUNITIES FOR PUBLIC INVOLVEMENT

Review by Community Organizations

Notice was sent to the following organizations and neighboring municipalities inviting them to review the Cambridge Hazard Mitigation Plan and submit their comments to the City:

City of Cambridge Boards and Commissions
City of Boston
City of Somerville
City of Arlington
Town of Watertown
Town of Belmont

Website

A copy of the draft Cambridge Hazard Mitigation Plan update was posted on the City's website so residents and other interested members of the public could access the draft document and submit comments or questions.

No comments were received on the plan from the public or stakeholder organizations.

Continuing Public Participation

Following the adoption of the plan update, the planning team will continue to provide residents, businesses, and other stakeholders the opportunity to learn about the hazard mitigation planning process and to contribute information that will update the city's understanding of local hazards. This will occur through a combination of in-person meetings, presentations at regular committee meetings, and provision of information on the city's website. It will also occur through day-to-day sharing of information received from the public with applicable departments, such as residents' calls to inform about flooding and feedback about changes following infrastructure improvements.

Planning Timeline Summary

April 13, 2010	Meeting of the Metro Boston Regional Mitigation Committee
October 25, 2012	Meeting of the Cambridge Local Hazard Mitigation Steering Comm.
November 21, 2012	Meeting of the Cambridge Local Hazard Mitigation Steering Comm.
January 9, 2013	First Public Meeting with Cambridge Local Emergency Planning Comm.
January 10, 2013	Second Public Meeting with Cambridge Climate Action Committee
June 13, 2013	Meeting of the Cambridge Local Hazard Mitigation Steering Comm.
October 16, 2013	Meeting of the Cambridge Local Hazard Mitigation Steering Comm.
March 18, 2014	Third Public Meeting at Department of Public Works
May 5, 2014	Draft Plan Update submitted to MEMA
April 30, 2015	Revised Draft Plan Update submitted to MEMA
September 1, 2015	Plan Review Tool received from FEMA
February 23, 2015	Revised Draft Plan Update submitted to MEMA

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IV. RISK ASSESSMENT

The risk assessment analyzes the potential natural hazards that could occur within the City of Cambridge as well as the relationship between those hazards and current land uses, potential future development, and critical infrastructure. This section also includes a vulnerability assessment that estimates the potential damages that could result from certain large scale natural hazard events.

UPDATE PROCESS

In order to update Cambridge's risk assessment, MAPC gathered the most recently available hazard and land use data and met with City staff to identify changes in local hazard areas and development trends. MAPC also used the most recently available version of HAZUS (described below).

Overview of Hazards and Impacts

The Massachusetts Hazard Mitigation Plan 2013 (state plan) provides an in-depth overview of natural hazards in Massachusetts. The state plan indicates that Massachusetts is subject to the following natural hazards (listed in order of frequency); floods, heavy rainstorms, nor'easters or winter storms, coastal erosion, hurricanes, tornadoes, wildfires, drought and earthquakes. Previous state and federal disaster declarations since 1991 are summarized in Table 2.

The following table summarizes the hazard risks for Cambridge. This evaluation takes into account the frequency of the hazard, historical records, and variations in land use. This analysis is based on the vulnerability assessment in the Commonwealth of Massachusetts State Hazard Mitigation Plan, 2013. The statewide assessment was modified to reflect local conditions in Cambridge using the definitions for hazard frequency and severity listed below Table 7.

Table 7. Hazard Risks Summary

Hazard	Frequency		Severity	
	Massachusetts	Cambridge	Massachusetts	Cambridge
Flooding	High	High	Serious	Serious
Dam failures	Very Low	Very Low	Serious	Minor
Thunder Storms	High	High	Minor	Minor
Winter storms	High	High	Minor	Minor
Hurricanes	Medium	Medium	Serious	Serious
Nor'easters	High	High	Serious	Serious
Tornadoes	Medium	Very Low	Serious	Serious

Table 7. Hazard Risks Summary

Hazard	Frequency		Severity	
Brush fires	Medium	Medium	Minor	Minor
Earthquakes	Very Low	Very Low	Extensive	Serious
Landslides	Low	Very Low	Minor	Minor
Extreme Temperatures	Medium	Medium	Minor	Minor
Drought	Low	Low	Minor	Minor

Definitions used in the Massachusetts State Hazard Mitigation Plan 2013

Frequency Categorization

Very low: events that occur less frequently than once in 100 years (Less than 1% per year)

Low: events that occur from once in 50 years to once in 100 years (1% to 2% per year)

Medium: events that occur from once in 5 years to once in 50 years (2% to 20% per year)

High: events that occur more frequently than once in 5 years (Greater than 20% per year)

Severity Categorization

Minor: Limited and scattered property damage; limited damage to public infrastructure and essential services not interrupted; limited injuries or fatalities.

Serious: Scattered major property damage; some minor infrastructure damage; essential services are briefly interrupted; some injuries and/or fatalities.

Extensive: Widespread major property damage; major public infrastructure damage (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and/or fatalities.

Catastrophic: Property and public infrastructure destroyed; essential services stopped; numerous injuries and fatalities

FLOOD RELATED HAZARDS

Flooding was the most prevalent serious natural hazard identified by local officials in Cambridge. Flooding is generally the rising or overflowing of water onto normally dry land and can be caused by hurricanes, nor'easters, severe rainstorms, and thunderstorms among other causes. Global climate change has the potential to increase the frequency and severity of rainstorms and snowstorms, which would be a continuation of trend observed over the past several decades.

Previous Occurrences and Extent of Flooding

There have been a number of major floods that have affected the Metro Boston region over the last fifty years. Significant historic flood events in Cambridge have included:

- March 1968
- The blizzard of 1978
- January 1979
- April 1987
- October 1991 ("The Perfect Storm")
- October 1996
- June 1998
- March 2001
- April 2004
- May 2006
- April 2007
- March 2010

The best available local data on the previous occurrences of flooding are from the National Climatic Data Center, which are provided by county. Cambridge is part of Middlesex County, for which historic flood events from 2005 through March30, 2014 were compiled and are summarized in Table 8.

Table 8: Middlesex County Flood Events 2005 – 2014

Date	Type	Deaths	Injuries	Property Damage
10/15/2005	Flood	0	0	125.00K
5/13/2006	Flood	0	0	5.000M
5/13/2006	Flood	0	0	0.00K
7/11/2006	Flood	0	0	2.00K
10/28/2006	Flood	0	0	5.00K
4/16/2007	Flood	0	0	25.00K
2/13/2008	Flood	0	0	0.00K
5/27/2008	Flood	0	0	3.00K
6/24/2008	Flood	0	0	10.00K

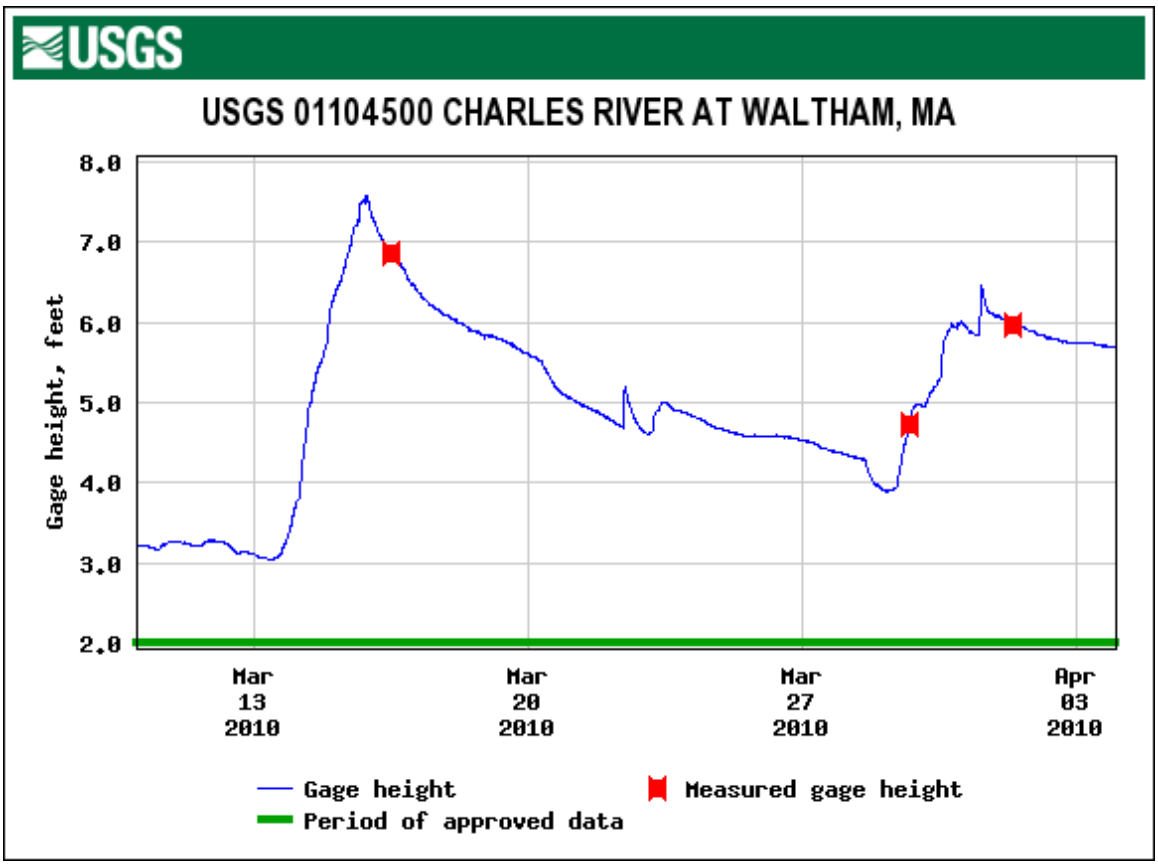
6/29/2008	Flood	0	0	5.00K
8/10/2008	Flood	0	0	15.00K
8/10/2008	Flood	0	0	40.00K
9/6/2008	Flood	0	0	15.00K
12/12/2008	Flood	0	0	20.00K
3/14/2010	Flood	0	0	26.430M
3/29/2010	Flood	0	0	8.810M
4/1/2010	Flood	0	0	0.00K
8/28/2011	Flood	0	0	5.00K
10/14/2011	Flood	0	0	0.00K
6/8/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	15.00K
7/18/2012	Flood	0	0	5.00K
10/29/2012	Flood	0	0	0.00K
6/7/2013	Flood	0	0	0.00K
7/1/2013	Flood	0	0	0.00K
7/1/2013	Flood	0	0	0.00K
7/23/2013	Flood	0	0	0.00K
9/1/2013	Flood	0	0	10.00K
3/30/2014	Flood	0	0	35.00K
3/30/2014	Flood	0	0	0.00K
3/30/2014	Flood	0	0	0.00K
TOTAL		**0**	**0**	**40,510,000**

(Source: NOAA NCDC

The most severe recent flooding occurred during the major storms of March 2010, when a total of 14.83 inches of rainfall accumulation was officially recorded by the National Weather Service (NWS). The weather pattern that caused these floods consisted of early springtime prevailing westerly winds that moved three successive storms, combined with tropical moisture from the Gulf of Mexico, across New England. Torrential rainfall caused March 2010 to be the wettest month on record. One indication of the extent of flooding is the level of flow in the Charles River during this record flood. Based on USGS gage height data, Figure 1 shows that Charles River at the gage immediately upstream in

Waltham exceeded 7 feet after the first storm, and exceeded 6 feet after the storm of March 31. The cumulative impact of multiple storms kept river levels high into April.

Figure 1. Charles River Gage Height, March 2010 Floods



Overview of City-Wide Flooding

The City of Cambridge is subject to inland flooding in the form of urban flooding. Urban flooding occurs when the rate of precipitation and/or amount of stormwater runoff overwhelms the capacity of natural or structured drainage systems causing overflows; and leads to flooding of low-lying areas such as streets, intersections, and underpasses. This type of flooding is often caused by storm events leading to large amounts of draining stormwater, which can be impeded by elements of the built environment and can be backed up when drainage conveyance systems (storm drains, pipes, etc.) and/or locations (ponds, streams, etc.) are at or above capacity.

The city straddles two watersheds, the Charles River watershed to the south and east, and the Alewife Brook (tributary to the Mystic River) watershed to the northwest. Stream piping and development have severely altered the natural flow of water in Cambridge.

Stormwater drainage from developed areas occurs primarily through the manmade system of storm drains.

Outside of inland urban flooding, Cambridge has limited exposure to riverine and coastal flooding and flooding is relatively infrequent due to the Charles River Dam, which controls water levels for the Charles River and limits tidal changes within the Charles River Basin. However, if sea levels are to rise and storm events to become more intense in the future, there is the potential for the dam to be overtopped and Cambridge to become susceptible to coastal flooding.

When flooding does occur in the city, the levels of flooding vary according to the topography of the location. Typically, the flooding results in several inches to a foot of water that ponds up in an area. In certain locations, such as underpasses, the flooding can be several feet of water due to the low elevation and as a result of stormwater flowing into the space.

Overview of Drainage System

The majority of Cambridge's flooding problems are associated with insufficient capacity in the drainage system, topography, and the City's location in the Concord-Alewife flood plains. As a result, Cambridge faces challenges in terms of mitigation planning for flooding hazards.

There are a variety of issues that affect the drainage system in the City. In some cases, the system is served by older infrastructure that has been impacted by increased development and does not have the necessary capacity to accommodate the resulting higher volume of runoff. In addition, there are many older conveyance systems that need updated to meet new standards and changes in precipitation events. Some of these issues are exacerbated by the fact that drainage from many surrounding cities and towns flow through Cambridge to the Charles River.

Information on flood hazard areas was taken from two sources. The first was the National Flood Insurance Rate Maps (FIRM). The FIRM flood zones are shown on Map 3 in Appendix B and defined below.

Flood Insurance Rate Map Zone Definitions

- Zones A1-30 and AE: Special Flood Hazard Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Base Flood Elevations are shown within these zones.
- Zone A (Also known as Unnumbered A Zones): Special Flood Hazard Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations or depths are shown.
- Zone AO: Special Flood Hazard Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average

depths are between one and three feet. Average flood depths derived from detailed hydraulic analyses are shown in this zone.

- Zone B and X (shaded): Zones where the land elevation as been determined to be above the Base Flood Elevation, but below the 500 year flood elevation. These zones are not Special Flood Hazard Areas.
- Zones C and X (unshaded): Zones where the land elevation has been determined to be above both the Base Flood Elevation and the 500 year flood elevation. These zones are not Special Flood Hazard Areas

The second source of flooding information was discussions with local officials. The Locally Identified Areas of Flooding below were identified by City staff as areas where flooding has occurred or could occur if certain infrastructure failed. These areas do not necessarily coincide with the flood zones from the FIRM maps. They may be areas that flood due to inadequate drainage systems or other local conditions rather than location within a flood zone. The numbers correspond to the numbers on Map 8, "Locally Identified Hazard Areas".

1. Fresh Pond Reservation (A, B, C) – This is the location of low lying areas adjacent to Fresh Pond that experience overland flooding during significant rainfall events. Flooding occurs primarily on undeveloped land but can block trails and walking paths around the pond.
2. Alewife Watershed - This area adjacent to Alewife Brook suffers from flooding during events in excess of the 5-10 year storm. The flooding has resulted in lanes closures on the nearby roadway. The causes of flooding in the area are multiple, including lack of capacity in the Alewife Brook, lack of flood storage capacity on land within the flood plain or adjacent to the Alewife Brook, backwater from the Mystic River and restrictions to conveyance caused by the various bridges over the Brook.
3. New Street - The area around New Street experience surface flooding during the 10-year storm events and can contribute to nearby CSO discharges.
4. Bellis Circle - Flooding in this area is generally caused by the inability of the conveyance system to carry water into the Alewife Brook since longer duration events raise the brook's water level and prohibit the pipe systems from discharging into the brook. The system can then back up and flood the low lying areas around Bellis Circle.
5. Vassal Lane/Tobin School – This area is subject to flooding during events equal to or in excess of a 10-year storm. Flooding is due to the limited capacity of the drainage system, including the MWRA's collection system. Impacts include basement flooding, CSO discharges, and surface flooding.
6. Concord Avenue and Fern Street - Flooding in this area is due to the limited capacity of the drainage system, including the MWRA's collection system. Impacts include CSO discharges and surface flooding.
7. Porter Square at Somerville Avenue - The Somerville Avenue area in the Porter

Square is an area that has traditionally suffered from poor drainage. The drainage issues are caused primarily by a poor collection and conveyance system in this area.

8. Harvard Square - The area surrounding Harvard Square has been subject to significant flooding and backups due to the poor conveyance capacity of the municipal system and the MWRA system.
9. Cambridge Cemetery –Area with pockets of low-lying land and poor drainage that experiences surface flooding during storms events with significant precipitation.
10. Agassiz Community – This area includes an existing CSO that has overflowed during intense storm events and resulted in surface flooding.
11. Myrtle Street and Magnolia Avenue - During significant rain events ponding occurs in this area. The primary reason for flooding in these areas is their relative low lying nature and the inadequacy of the conveyance system.
12. Cambridge Highlands – CSOs in this area have resulted in backups during intense storm events leading to surface flooding. The CSOs in this area have substantial limitations in capacity.
13. Area 4 - A location that has poor conveyance systems and that tends to flood in short duration intense events and flood to a significant extent during the longer duration events.
14. Hancock Street and Kinnaird Street – Low lying area that has been impacted by poor drainage which results in surface flooding.
15. Green Street at Kennedy Biscuit Lofts – Area with CSOs that have capacity limitations and that have contributed to flooding in the areas as a result of heavy precipitation.
16. Cardinal Medeiros Avenue - Corridor with poor conveyance systems that tend to surcharge and flood in short duration intense events and flood to a significant rainfall events.
17. East Cambridge – Area with CSO constraints that has led to back up issues and surface flooding. The drainage system in the area has constraints relative to the CSO system and capacity of existing pipes.
18. Corcoran Way and May Street – Area that has historically experienced flooded. During significant rain events, surface flooding has occurred as well as flooding within nearby buildings.

These 18 locations capture places where previous flooding has occurred and where the city expects future flooding to occur absent mitigation actions. When this flooding has occurred, the city and its residents have experienced issues related to transportation, building damage, utilities, and ability to reach area via emergency services. This has had an impact on mobility during hazard events and the ability to reach people with vital services.

As shown in Table 8, damages from the March 2010 floods in Middlesex County totaled $35.2 million, while total damages for all floods since 2005 totaled $40.5 million. There were no deaths or injuries reported and the flooding events associated with property damage totaled $25.7 million dollars. The vulnerability analysis conducted by MAPC estimates a range of damages from flooding of $181million to $907 million.

Based on the record of previous occurrences, floods in Cambridge are high frequency events as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% per year).

Repetitive Loss Structures

There are 2 current repetitive loss structures in Cambridge, an increase from the one (1) structure identified in the 2008 plan. As defined by the Community Rating System (CRS) of the National Flood Insurance Program (NFIP), a repetitive loss property is any property which the NFIP has paid two or more flood claims of $1,000 or more in any given 10-year period since 1978. For more information on repetitive losses see http://www.fema.gov/business/nfip/replps.shtm.

The following table shows the breakdown of structure type by number of claims and amount of losses.

Table 9. Repetitive Loss Properties Summary

	Number of Claims	Building Losses	Contents Losses	Total Losses
Single Family	0	0	0	0
2-4 Family	3	$9,484.68	$629.23	$10,113.91
Condo	0	0	0	0
Other Residential	0	0	0	0
Non-Residential	2	$75,882.82	$82,425.00	$158,307.82
TOTAL	**5**	**$85,367.5**	**$83,054.23**	**$168,421.73**

Source: Federal Emergency Management Agency, National Flood Insurance Program

Conclusions

Based on these factors, there is potential for significant flooding events but these have occurred infrequently and property damage or endangerment is not a frequent occurrence in the City. However, areas that are impacted or where property damage has occurred do not necessarily correspond to recognized flood plain areas.

Dam Failure

Dam failure can occur as a result of structural failure, independent of a hazard event, or as the result of the impacts of a hazard event such as flooding associated with storms or

an earthquake. In the event of a dam failure, the energy of the water stored behind even a small dam can cause loss of life and property damage if there are people or buildings downstream. The number of fatalities from a dam failure depends on the amount of warning provided to the population and the number of people in the area in the path of the dam's floodwaters. Dam failure in general is infrequent but has the potential for severe impacts; that said, the City of Cambridge has not experienced of dam failure or the impacts from a dam failure.. An issue for dams in Massachusetts is that many were built in the 19th century without the benefits of modern engineering or construction oversight.

A review with City staff and information available from the Division of Conservation and Recreation (DCR) was used to identify dams in Cambridge. DCR assesses the dams are using the three hazard classifications below:

- High Hazard: Dams located where failure or mis-operation will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).
- Significant Hazard: Dams located where failure or mis-operation may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities.
- Low Hazard: Dams located where failure or mis-operation may cause minimal property damage to others. Loss of life is not expected.

Although the City of Cambridge does not own or operate any dam, the Charles River Dam does impact the City. The dam, which is owned and operated by DCR, is located along the Charles River and Basin, which borders the City to the south and east (separating Cambridge and the City of Boston). The Charles River Dam is located downstream from Cambridge between the neighborhoods of Charlestown and the North End, and is classified as an urban flood control structure and has been identified as a Significant Hazard according to the DCR Hazard Potential Classification.

Another significant dam that is proximate to Cambridge is the Amelia Earhart Dam. Located in the City of Medford, this dam is associated with the Mystic River and is owned, maintained, and operated by DCR. The Amelia Earhart Dam is listed as a low hazard, but is estimated to need $5 million dollars in repairs, such as repairs to the current third pump and the possible installation of a fourth pump. The dam separates the tidal and the non-tidal parts of the Mystic River, and is currently able to pump 4,000 cubic feet per second of flow from the Mystic and Malden Rivers against high tide into Boston Harbor. The pump improvements would increase the rate that flood water can travel out of the cities and towns along the Mystic River.

Although there has never been a dam failure in Cambridge, if one did occur at the Charles River Dam, the city would not be directly impacted by flooding as the dam is located downstream from Cambridge. Likewise, a dam failure at the Amelia Earhart Dam

would not have direct flooding impacts on Cambridge, as that dam impounds the Mystic River, which does not flow through Cambridge.

The probability of future dam failure events is classified in the Massachusetts State Hazard Mitigation Plan 2013 as very low frequency, or an event that occurs less frequently than once in 100 years (less than 1% per year).

WIND RELATED HAZARDS

Wind-related hazards include hurricanes and tornadoes as well as high winds during severe rainstorms and thunderstorms. The typical wind speed in the Cambridge area ranges from around 11 miles per hour to 14 over the course of the year, but independent of storm events, gusts of up to 40 mph can occur. As with many cities and towns, falling trees that result in downed power lines and power outages are an issue in Cambridge. Information on wind related hazards can be found on Map 5 in Appendix B

Hurricanes

A hurricane is a violent wind and rainstorm with wind speeds of 74-200 miles per hour. A hurricane is strongest as it travels over the ocean and is particularly destructive to coastal property as the storm hits the land. Hurricanes generally occur between June and November. Falling trees are a significant problem because they can cause power outages when they fall on power lines or block traffic and emergency access.

Between 1858 and 2013, Massachusetts has experienced approximately 35 tropical storms, eleven Category 1 hurricanes, five Category 2 hurricanes, and one Category 3 hurricane. This equates to a frequency of approximately once every four years.

A hurricane or tropical storm track is the line that delineates the path of the eye of a hurricane or tropical storm. There has been one recorded storm track through Cambridge, a Category 1 Hurricane in 1944. The storm passed roughly through the central part of the City (just west of Harvard Square), traveling from Boston and through to Somerville and Medford. The City experiences the impacts of the wind and rain of hurricanes and tropical storms in the region regardless of whether the storm track passes through the City. The hazard mapping indicates that the 100 year wind speed is 110 miles per hour (see Appendix B).

Hurricanes typically have regional impacts beyond their immediate tracks, and numerous hurricanes have affected the communities of eastern Massachusetts (Table 10). Falling trees and branches are a significant problem because they can result in power outages when they fall on power lines or block traffic and emergency routes. Hurricanes are a city-wide hazard in Cambridge.

Table 10. Hurricane Records for Massachusetts

Hurricane Event	Date
Great New England Hurricane*	September 21, 1938
Great Atlantic Hurricane*	September 14-15, 1944
Hurricane Doug	September 11-12, 1950
Hurricane Carol*	August 31, 1954
Hurricane Edna*	September 11, 1954
Hurricane Diane	August 17-19, 1955
Hurricane Donna	September 12, 1960
Hurricane Gloria	September 27, 1985
Hurricane Bob	August 19, 1991
Hurricane Earl	September 4, 2010
Tropical Storm Irene	August 28, 2011
Hurricane Sandy	October 29-30, 2012

*Category 3. Source: National Oceanic and Atmospheric Administration (NOAA)

Hurricane intensity is measured according to the Saffir/Simpson scale, which categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure, and storm surge potential. These are combined to estimate potential damage. The following gives an overview of the wind speeds, surges, and range of damage caused by different hurricane categories:

Scale No. (Category)	Winds(mph) Storm	Surge (ft)	Potential Damage
1	74 – 95	4 - 5	Minimal
2	96 – 110	6 - 8	Moderate
3	111 – 130	9 - 12	Extensive
4	131 – 155	13 - 18	Extreme
5	> 155	>18	Catastrophic

Source: NOAA

Based on the record of previous occurrences, Hurricanes in Cambridge are a Medium frequency event as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur from once in 5 years to once in 50 years, or a 2% to 20% chance per year.

Tornados

A tornado is a violent windstorm characterized by a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground. They develop when cool air overrides a layer of warm air, causing the warm air to rise rapidly. Most vortices remain suspended in the atmosphere. Should they touch down, they become a force of destruction.

Some ingredients for tornado formation include:

- Very strong winds in the mid and upper levels of the atmosphere
- Clockwise turning of the wind with height (from southeast at the surface to west aloft)
- Increasing wind speed with altitude in the lowest 10,000 feet of the atmosphere (i.e., 20 mph at the surface and 50 mph at 7,000 feet.)
- Very warm, moist air near the ground with unusually cooler air aloft
- A forcing mechanism such as a cold front or leftover weather boundary from previous shower or thunderstorm activity

Tornados can form from individual cells within severe thunderstorm squall lines. They can form from an isolated 'supercell' thunderstorm. They can be spawned by tropical cyclones or even their remnants that are passing through. Tornadoes are most common in the summer, June through August, and most form in the afternoon or evening.

Tornado damage severity is measured by the Fujita Tornado Scale, in which wind speed is not measured directly but rather estimated from the amount of damage. As of February 01, 2007, the National Weather Service began rating tornados using the Enhanced Fujita-scale (EF-scale), which allows surveyors to create more precise assessments of tornado severity. The EF-scale is summarized below:

Fujita Scale			Derived		Operational EF Scale	
F Number	Fastest ¼ mile (mph)	3-second gust (mph)	EF Number	3-second gust (mph)	EF Number	3-second gusts (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over -200

Source: Massachusetts State Hazard Mitigation Plan, 2010

On average, there are six tornadoes that touchdown somewhere in the northeast region every year. Tornadoes are most common in the summer, June through August and most form in the afternoon or evening. Tornadoes are associated with strong thunderstorms. The strongest tornado in Massachusetts history was the Worcester Tornado in 1953 (NESEC). The most recent tornado events in Massachusetts were in Springfield in 2011 and in

Revere in 2014. The Springfield tornado caused significant damage and resulted in 4 deaths in June of 2011. The Revere tornado touched down at in Chelsea just south of Route 16 (Revere Beach Parkway) and moved north into Revere's business district along Broadway, past Revere City Hall, and ended near the intersection of Routes 1 and 60. The path was approximately two miles long and 3/8 mile wide, with wind speeds up to 120 miles per hour. According to Revere Fire Chief Gene Doherty, 65 homes had "substantial damages" and 13 homes and businesses were uninhabitable.

Although there have been no recorded tornados within the limits of the City of Cambridge, since 1955 there have been 17 tornadoes in surrounding Middlesex County recorded by the Tornado History Project. Two of these were and F3 tornadoes, four were F2, and the rest were F1. These 17 tornadoes resulted in a total of one fatality and six injuries as summarized in Table 11.

Table 11. Tornado Records for Middlesex County

Date	Fujita	Fatalities	Injuries	Width	Length	Damage
10/24/1955	1	0	0	10	0.1	$500-$5000
6/19/1957	1	0	0	17	1	$5K-$50K
6/19/1957	1	0	0	100	0.5	$50-$500
7/11/1958	2	0	0	17	1.5	$50K-$500K
8/25/1958	2	0	0	50	1	$500-$5000
7/3/1961	0	0	0	10	0.5	$5K-$50K
7/18/1963	1	0	0	50	1	$5K-$50K
8/28/1965	2	0	0	10	2	$50K-$500K
7/11/1970	1	0	0	50	0.1	$5K-$50K
10/3/1970	3	1	0	60	35.4	$50K-$500K
7/1/1971	1	0	1	10	25.2	$5K-$50K
11/7/1971	1	0	0	10	0.1	$50-$500
7/21/1972	2	0	4	37	7.6	$500K-$5M
9/29/1974	3	0	1	33	0.1	$50K-$500K
7/18/1983	0	0	0	20	0.4	$50-$500
9/27/1985	1	0	0	40	0.1	$50-$500
8/7/1986	1	0	0	73	4	$50K-$500K

Given their unpredictable track, tornadoes are a potential city-wide hazard in Cambridge, although the impact of any one event is typically limited to a particular area, as was the case with the recent tornado in Revere. Areas that could be impacted are those with higher rise buildings such as Central Square and Kendall Square. There have been no recorded tornadoes in Cambridge, so there is no historical data with which to document damages. However, most structures pre-date current building codes and could be subject

to damages. Evacuation may be required on short notice. Sheltering and mass feeding efforts may be required along with debris clearance, search and rescue, and emergency fire and medical services.

Based on the record of previous occurrences since 1950, Tornado events in Cambridge are a Medium frequency event as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur from once in 5 years to once in 50 years, or a 2% to 20% chance per year.

Nor'easters

A northeast coastal storm, known as a nor'easter, is typically a large counter-clockwise wind circulation around a low-pressure center. Featuring strong northeasterly winds blowing in from the ocean over coastal areas, nor'easters are relatively common in the winter months in New England occurring one to two times a year and frequently lead to coastal flooding and erosion. The storm radius of a nor'easter can be as much as 1,000 miles and these storms feature sustained winds of 10 to 40 mph with gusts of up to 70 mph. These storms are accompanied by heavy rains or snows, depending on temperatures. All of Cambridge could be at risk from the snow and rain from a nor'easter, depending on the track and radius of the storm, but would not be subject to coastal hazards.

Previous occurrences of Nor'easters include the following which are listed in the Massachusetts State Hazard Mitigation Plan 2013:

February 1978	Blizzard of 1978
October 1991	Severe Coastal Storm ("Perfect Storm")
December 1992	Great Nor'easter of 1992
January 2005	Blizzard/ oreaster
October 2005	Coastal Storm/Nor'easter
April 2007	Severe Storms, Inland & Coastal Flooding/Nor'easter
January 2011	Winter Storm/Nor'easter
October 2011	Severe Storm/Nor'easter

Many of the historic flood events identified in the previous section were precipitated by nor'easters, including the "Perfect Storm" event in 1991. More recently, blizzards in December 2010, October 2011, and February 2013 were both large nor'easters that caused significant snowfall amounts.

Cambridge is vulnerable to both the wind and precipitation that accompanies nor'easters. High winds can cause damage to structures, fallen trees, and downed power lines leading to power outages. Intense rainfall can overwhelm drainage systems causing localized flooding of rivers and streams as well as urban stormwater ponding and localized flooding.

The entire city of Cambridge could be at risk from the wind, rain or snow impacts from a nor'easter, depending on the track and radius of the storm, but due to its inland location the city would not be subject to coastal hazards.

Based on the record of previous occurrences, nor'easters in Cambridge are high frequency events as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% per year).

Severe Thunderstorms

While less severe than the other types of storms discussed, thunderstorms can lead to localized damage and represent a hazard risk for communities. Generally defined as a storm that includes thunder, which always accompanies lightning, a thunderstorm is a storm event featuring lightning, strong winds, and rain and/or hail. Thunderstorms sometime give rise to tornados. On average, these storms are only around 15 miles in diameter and last for about 30 minutes. A severe thunderstorm can include winds of close to 60 mph and rain sufficient to produce flooding.

Cambridge is at high risk for high winds from severe thunderstorms but impacts tend to be isolated and not widespread when they do occur in the City. Thunderstorms impact the city primarily during the spring and summer months.

Eastern Massachusetts is at risk of one to two severe thunderstorms per year.
Past occurrences that are listed in the Massachusetts Hazard Mitigation Plan 2013 include:

March 1972
March-April 1982
October 1996
June 1998
March-April 2001
October 2005
May 2006
April 2007
March 2010
August 2011

Severe thunderstorms are a city-wide hazard for Cambridge. The City is vulnerable to both the wind and precipitation associated with thunderstorms. High winds can cause damage to structures, fallen trees, and downed power lines leading to power outages and obstruction of transportation corridors. Intense rainfall can overwhelm drainage systems causing localized flooding of rivers and streams as well as urban stormwater ponding and localized flooding.

Based on the record of previous occurrences, severe thunderstorms in Cambridge are high frequency events as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% per year).

WINTER STORMS

Winter storms are the most common and most familiar of the region's hazards that affect large geographic areas. The majority of blizzards and ice storms in the region cause more

inconvenience than they do serious property damage, injuries, or deaths. However, periodically, a storm will occur which is a true disaster and necessitates intense large-scale emergency response. Occasionally winter storms can also hinder the tidal exchange in tidally restricted watersheds and result in localized flooding within these areas. Ice build-up at gate structures can also damage tide gates and increase the hazard potential as a result of malfunctioning tide gates. Coastal storms also cause flooding because of tidal surges.

The Northeast Snowfall Impact Scale (NESIS) developed by Paul Koki of The Weather Channel and Louis Cellini of the National Weather Service (Koki and Cellini, 2004) characterizes and ranks high impact northeast snowstorms. These storms have large areas of 10 inch snowfall accumulations and greater. NESIS has five categories: Extreme, Crippling, Major, Significant, and Notable. NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The largest NESIS values result from storms producing heavy snowfall over large areas that include major metropolitan centers. The NESIS categories are summarized below:

Category	NESIS	Value Description
1	1—2.499	Notable
2	2.5—3.99	Significant
3	4—5.99	Major
4	6—9.99	Crippling
5	10.0+	Extreme

Source: Massachusetts State Hazard Mitigation Plan, 2013

Since 1958 Massachusetts has experienced two Category 5 Extreme snow storms, nine Category 4 (Crippling) storms, and 13 Category 3 (Major) snow storms. The most significant winter storm in recent history was the "Blizzard of 1978," which resulted in over 3 feet of snowfall and multiple day closures of roadways, businesses, and schools. Historically, severe winter storms have occurred in the following years:

Table 12. Severe Winter Storm Records for Massachusetts

Blizzard of 1978	February 1978
Blizzard	March 1993
Blizzard	January 1996
Severe Snow Storm	March 2001
Severe Snow Storm	December 2003
Severe Snow Storm	January 2004
Severe Snow Storm	January 2005
Severe Snow Storm	April, 2007
Severe Snow Storm	December 2010
Blizzard of 2013	February 2013

Source: National Oceanic and Atmospheric Administration

Because a major feature of winter storms is heavy precipitation, the same mitigation measures in place for flooding are all important for mitigating the impacts of winter storms. However, the rapid melting of snow after major storms, combined with rainfall, is a more common flooding threat.

The City of Cambridge does not keep local records of winter storms. Data for Middlesex County, which includes Cambridge, is the best available data to help understand previous occurrences and impacts of winter storm events. According to National Climate Data Center (NCDC) records, from 1996 to 2014 Middlesex County experienced 50 heavy snowfall events, resulting in no deaths or injuries and $1.45 million dollars in property damage. See Table 13 for and heavy snow events and impacts in Middlesex County.

Table 13 - Heavy Snow events and Impacts in Middlesex County 1996 –2011

Date	Type	Deaths	Injuries	Property Damage
1/2/1996	Heavy Snow	0	0	0.00K
1/7/1996	Heavy Snow	0	0	1.400M
2/16/1996	Heavy Snow	0	0	0.00K
3/2/1996	Heavy Snow	0	0	0.00K
3/7/1996	Heavy Snow	0	0	0.00K
4/7/1996	Heavy Snow	0	0	0.00K
4/9/1996	Heavy Snow	0	0	0.00K
12/6/1996	Heavy Snow	0	0	0.00K
3/31/1997	Heavy Snow	0	0	0.00K
4/1/1997	Heavy Snow	0	0	0.00K
12/23/1997	Heavy Snow	0	0	0.00K
1/15/1998	Heavy Snow	0	0	0.00K
1/14/1999	Heavy Snow	0	0	0.00K
2/25/1999	Heavy Snow	0	0	0.00K
3/6/1999	Heavy Snow	0	0	0.00K
3/15/1999	Heavy Snow	0	0	0.00K
1/13/2000	Heavy Snow	0	0	0.00K
1/25/2000	Heavy Snow	0	0	0.00K
2/18/2000	Heavy Snow	0	0	0.00K
1/20/2001	Heavy Snow	0	0	0.00K
2/5/2001	Heavy Snow	0	0	0.00K
3/5/2001	Heavy Snow	0	0	0.00K
3/9/2001	Heavy Snow	0	0	0.00K
12/8/2001	Heavy Snow	0	0	0.00K
3/16/2004	Heavy Snow	0	0	0.00K
2/24/2005	Heavy Snow	0	0	0.00K

Date	Type	Deaths	Injuries	Property Damage
12/13/2007	Heavy Snow	0	0	0.00K
12/16/2007	Heavy Snow	0	0	0.00K
1/14/2008	Heavy Snow	0	0	28.00K
2/22/2008	Heavy Snow	0	0	0.00K
12/19/2008	Heavy Snow	0	0	0.00K
12/20/2008	Heavy Snow	0	0	8.00K
12/31/2008	Heavy Snow	0	0	0.00K
1/11/2009	Heavy Snow	0	0	0.00K
1/18/2009	Heavy Snow	0	0	0.00K
3/2/2009	Heavy Snow	0	0	0.00K
12/20/2009	Heavy Snow	0	0	0.00K
1/18/2010	Heavy Snow	0	0	0.00K
2/16/2010	Heavy Snow	0	0	15.00K
1/26/2011	Heavy Snow	0	0	0.00K
12/29/2012	Heavy Snow	0	0	0.00K
2/8/2013	Heavy Snow	0	0	0.00K
3/7/2013	Heavy Snow	0	0	0.00K
3/18/2013	Heavy Snow	0	0	0.00K
12/14/2013	Heavy Snow	0	0	0.00K
12/17/2013	Heavy Snow	0	0	0.00K
1/2/2014	Heavy Snow	0	0	0.00K
2/5/2014	Heavy Snow	0	0	0.00K
2/13/2014	Heavy Snow	0	0	0.00K
Total	**50**	**0**	**0**	**1.45 M**

(Source: NOAA NCDC)

Winter Storms are a City-wide hazard in Cambridge. Map 6 in Appendix B displays areas of average annual snowfall, which is between 48-72 inches (4-6 feet) for the western portion of the City, while the eastern part of the City has an average snowfall of 36-48 inches (3-4 feet).

The impacts of winter storms are most significant on the transportation system. The Cambridge Public Works Department works to clear roads and carries out general snow removal operations, in conjunction with local snow removal contractors. The City bans on-street parking at nights during snow storm events and during snow removal to ensure that streets can be plowed and public safety vehicle access is maximized. Transit operations may also be impacted, as they were in the most recent blizzard which caused the complete closure of the MBTA system for one day and limited services on several transit lines lasting several weeks.

The City's overall vulnerability to winter storms is primarily related to restrictions to travel on roadways, temporary road closures, school closures, and potential restrictions on emergency vehicle access. Other vulnerabilities include power outages due to fallen trees and utility lines, and damage to structures due to heavy snow loads.

Based on the record of previous occurrences, winter storm events in Cambridge are high frequency events as defined by the Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% per year).

GEOLOGIC HAZARDS

Geologic hazards include earthquakes, landslides, sinkhole, subsidence, and unstable soils such as fill, peat, and clay. Although new construction under the most recent building codes generally will be built to seismic standards, there are still many structures which pre-date the most recent building code. Information on geologic hazards can be found on Map 4 in Appendix B.

Earthquakes

Damage in an earthquake stems from ground motion, surface faulting, and ground failure in which weak or unstable soils, such as those composed primarily of saturated sand or silts, liquefy. The effects of an earthquake are mitigated by distance and ground materials between the epicenter and a given location. An earthquake in New England affects a much wider area than a similar earthquake in California due to New England's solid bedrock geology (NESEC).

Earthquakes are a hazard with multiple impacts beyond the obvious building collapse. Buildings may suffer structural damage which may or may not be readily apparent. Earthquakes can cause major damage to roadways, making emergency response difficult. Water lines and gas lines can break, causing flooding and fires. Another potential vulnerability is equipment within structures. For example, a hospital may be structurally engineered to withstand an earthquake, but if the equipment inside the building is not properly secured, the operations at the hospital could be severely impacted during an earthquake. Earthquakes can also trigger landslides.

Seismologists use a magnitude scale (Richter Scale) to express the seismic energy released by each earthquake. The typical effects of earthquakes in various ranges are:

Richter Magnitude	Earthquake Effects
Less than 3.5	Generally not felt, but recorded
3.5- 5.4	Often felt, but rarely causes damage
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas up to about 100 km. across where people live.
7.0- 7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred meters across.

Source: Nevada Seismological Library (NSL), 2005

According to the State Hazard Mitigation Plan, New England experiences an average of five earthquakes per year. From 1668 to 2007, 355 earthquakes were recorded in Massachusetts (NESEC) and a sample of these is included in Table 14 below.

Table 14. Historical Earthquakes in Massachusetts or Surrounding Area, 1727-2013

Location	Date	Magnitude*
MA - Cape Ann	11/10/1727	5
MA - Cape Ann	12/29/1727	NA
MA – Cape Ann	2/10/1728	NA
MA – Cape Ann	3/30/1729	NA
MA – Cape Ann	12/9/1729	NA
MA – Cape Ann	2/20/1730	NA
MA – Cape Ann	3/9/1730	NA
MA - Boston	6/24/1741	NA
MA - Cape Ann	6/14/1744	4.7
MA - Salem	7/1/1744	NA
MA - Off Cape Ann	11/18/1755	6
MA – Off Cape Cod	11/23/1755	NA

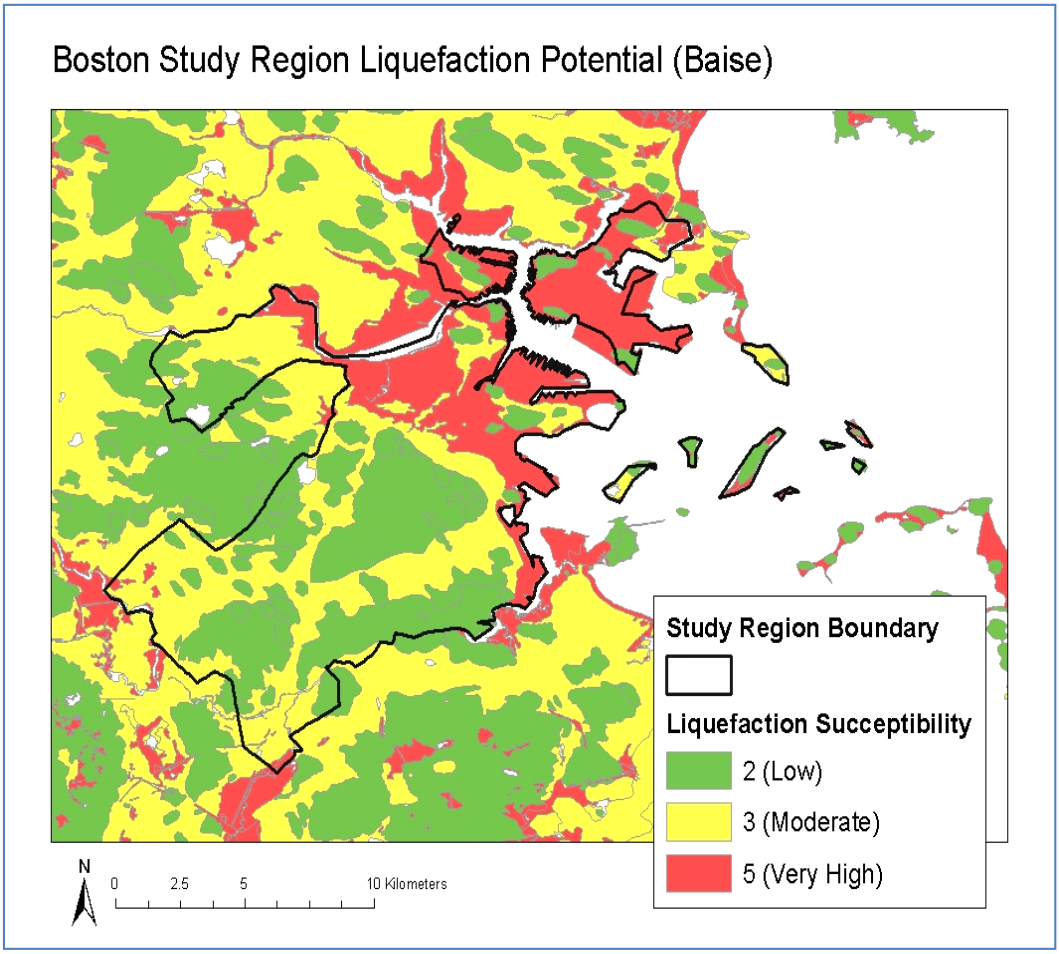
Table 14. Historical Earthquakes in Massachusetts or Surrounding Area, 1727-2013

Location	Date	Magnitude*
MA - Boston	3/12/1761	4.6
MA - Off Cape Cod	2/2/1766	NA
MA - Offshore	1/2/1785	5.4
MA – Wareham/Taunton	12/25/1800	NA
MA - Woburn	10/5/1817	4.3
MA - Marblehead	8/25/1846	4.3
MA - Brewster	8/8/1847	4.2
MA - Boxford	5/12/1880	NA
MA - Newbury	11/7/1907	NA
MA - Wareham	4/25/1924	NA
MA – Cape Ann	1/7/1925	4
MA – Nantucket	10/25/1965	NA
MA – Boston	12/27/74	2.3
VA –Mineral	8/23/11	5.8
MA - Nantucket	4/12/12	4.5
ME - Hollis	10/17/12	4.0

There have been no recorded earthquake epicenters within Cambridge.

Liquefaction - One additional impact that is of particular concern in the Boston metropolitan area is liquefaction (see Figure 2 below). This is due to the prevalence of filled land. Liquefaction means that loosely packed, water-logged sediments lose strength and therefore move in large masses or lose bearing strength. Soil units susceptible to liquefaction include: non-engineered artificial fill, alluvial deposits, fluvial deposits, and flood plain deposits. Non-engineered artificial fill is what is typically known locally as filled land. An earthquake with a magnitude of 5.5 or greater can trigger liquefaction. In the Boston region, these areas of filled land are densely developed with structures that pre-date the seismic provisions of the current Massachusetts State Building Code.

Figure 2. Boston Study Region Liquefaction Potential



Source: Baise, Laurie G., Rebecca B. Higgins; and Charles M. Brankman, Tufts University

Earthquakes are a potential city-wide hazard in Cambridge, although the figure above indicates that the eastern side of Cambridge has higher susceptibility to liquefaction. The City has many older buildings that pre-date current building code which could be vulnerable in the event of a severe earthquake. Potential earthquake damages to Cambridge have been estimated using HAZUS-MH. Total damages are estimated at $597 million for a 5.0 magnitude earthquake and $8.86 billion for a 7.0 magnitude earthquake. Other potential impacts are detailed in Table 19.

According to the Boston College Weston Observatory, in most parts of New England, there is a one in ten chance that a potentially damaging earthquake will occur in a 50 year time period. The Massachusetts State Hazard Mitigation Plan classifies earthquakes as "very low" frequency events that occur less frequently than once in 100 years, or a less than 1% per year.

Landslides

According to the USGS, "The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity

acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors." Among the contributing factors are: erosion by rivers or ocean waves over steepened slopes; rock and soil slopes weakened through saturation by snowmelt or heavy rains; earthquakes create stresses that make weak slopes fail; and excess weight from accumulation of rain or snow, and stockpiling of rock or ore, from waste piles, or from man-made structures.

Landslides can result from human activities that destabilize an area or can occur as a secondary impact from another natural hazard such as flooding. In addition to structural damage to buildings and the blockage of transportation corridors, landslides can lead to sedimentation of water bodies.

There is no universally accepted measure of landslide extent but it has been represented as a measure of the destructiveness of a landslide. The table below summarizes the estimated intensity for a range of landslides. For a given landslide volume, fast moving rock falls have the highest intensity while slow moving landslides have the lowest intensity.

Estimated Volume	**Expected Landslide Velocity**		
($m^{3)}$	Fast moving landslide (Rock fall)	Rapid moving landslide (Debris flow)	Slow moving landslide (Slide)
<0.001	Slight intensity		
<0.5	Medium intensity		
>0.5	High intensity		
<500	High intensity	Slight intensity	
500-10,000	High intensity	Medium intensity	Slight intensity
10,000 – 50,000	Very high intensity	High intensity	Medium intensity
>500,000		Very high intensity	High intensity
>>500,000			Very high intensity

Source: *A Geomorphological Approach to the Estimation of Landslide Hazards and Risks in Umbria, Central Italy*, M. Cardinali et al, 2002

Landslides are potentially a city-wide hazard. The City is classified as having areas with a low risk for landslides as well areas with a moderate risk (Appendix B - Map 4). The western portion of the city has a low risk for landslides whereas the eastern portion has a moderate risk for landslides. In the past, Cambridge has not experienced impacts from landslides.

There are no documented previous occurrences of landslides in Cambridge. Should a landslide occur in the future, the type and degree of impacts would be highly localized, and the city's vulnerabilities could include damage to structures, damage to transportation and other infrastructure, and localized road closures. Injuries and casualties, while possible, would be unlikely given the low extent and impact of landslides in Cambridge.

Based on past occurrences and the Massachusetts Hazard Mitigation Plan, landslides are of Very Low frequency, events that can occur less frequently than once in 100 years (less than 1% per year).

OTHER NATURAL HAZARDS

Brush Fires

For the purposes of this plan, a brush fire is an uncontrolled fire occurring in a forested or grassland area. In the Boston Metro region these fires rarely grow to the size of a wildfire as seen more typically in the western U.S. As their name implies, these fires typically burn no more than the underbrush of a forested area. These fires present a hazard where there is the potential for them to spread into developed or inhabited areas, particularly residential areas where sufficient fuel materials might exist to allow the fire the spread into homes.

The Fire Department responds to a limited number of brush fires of varying sizes annually. Within the past year, which Is the best available local information, there were no brush fires that resulted in significant property damage.

The incidence of brush fires is distributed throughout the City with wetland areas and railroad rights-of-way having a higher risk. Two areas of City were identified as having the highest potential for brush fires based on past experiences are wetlands areas where there can be concentrations of dry vegetation. The areas are identified below and the numbers correspond to the numbers on Map 8, "Hazard Areas"

19. Bullfinch/Alewife Reservation

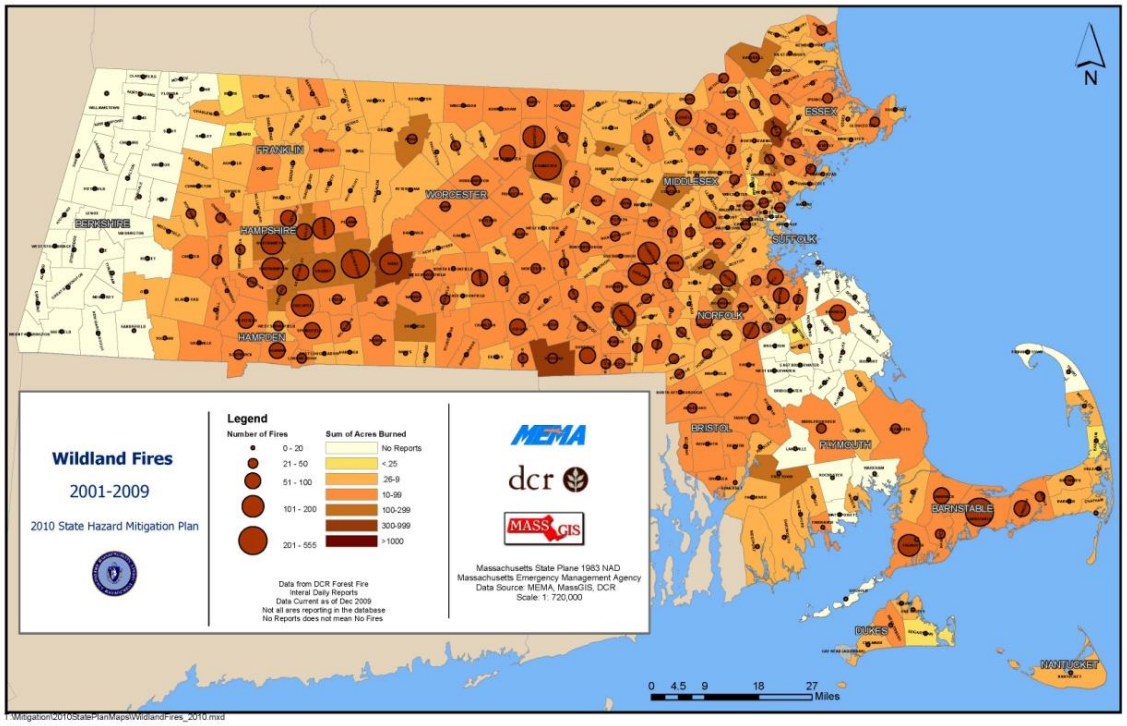
20. Marsh Post/Greenough Boulevard

Wildfires in Massachusetts are measured by the number of fires and the sum of acres burned. The most recent data available for wildfires in Massachusetts, shown in Figure 3 below, indicates that the wildfire extent in Cambridge consists of less than 9 acres burned, with fewer than 50 recordable fires from 2001to 2009.

Potential vulnerabilities to wildfires in Cambridge include injuries and loss of human life, damage to structures and other improvements, and impacts on natural resources such as marshlands along Alewife Brook. However, given the moderate extent of wildfires in the City and the immediate response times to reported wildfires in Cambridge, the likelihood of injuries and casualties is minimal. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

Based on past occurrences and the Massachusetts Hazard Mitigation Plan 2013, brushfires are of Medium frequency, events that occur from once in 5 years to once in 50 years (2% to 20% probability per year).

Figure 3. Massachusetts Wildfires 2001-2009



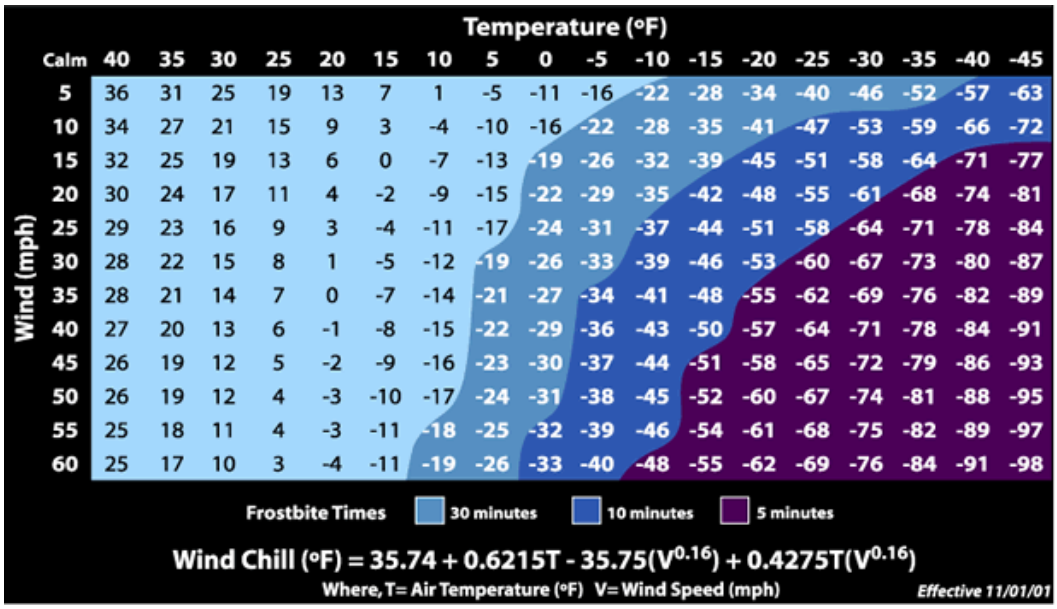
Extreme Temperatures

Extreme temperatures occur when either high temperature or low temperatures relative to average local temperatures occur. These can occur for brief periods of time and be acute, or they can occur over long periods of time where the there is prolonged period of excessively hot or cold weather.

Those that are most vulnerable to extreme heat events are children, the elderly, and those who have a physical disability. These susceptible groups may suffer from dehydration, heat exhaustion, heat cramps, and heat stokes. Extreme cold is a dangerous situation that can result in health emergencies for susceptible people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat.

For extreme cold, temperature is typically measured using Wind Chill Temperature Index, which is provided by the National Weather Service (NWS). The latest version of the index was implemented in 2001 and it meant to show how cold conditions feel on unexposed skin. The index is provided in Figure 4 below.

Figure 4. Wind Chill Temperature Index and Frostbit Risk



Wind (mph) \ Temperature (°F)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5		36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10		34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15		32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20		30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25		29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30		28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35		28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40		27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45		26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50		26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55		25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60		25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

While a heat wave for Massachusetts is defined as three or more consecutive days above 90°F, another measure used for identifying extreme heat events is through a Heat Advisory from the NWS. These advisories are issued with the heat index (Figure 5 below) is forecast to exceed 100 degree Fahrenheit (F) for 2 or more hours; an excessive heat advisory is issued if forecast predicts the temperature to rise above105 degree F.

Figure 5. Heat Index Chart

Relative Humidity (%) \ Temperature (°F)	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										

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke or Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

These events can be exacerbated in more densely settled locations and areas with a high proportion of impervious surfaces, which can lead to a 'heat island' effect that results in higher localized temperatures. Hot summer days can also worsen air pollution, especially in urban areas. In areas of the Northeast that currently face problems with smog, inhabitants are likely to experience more days that fail to meet air quality standards.

Heat waves and lower air quality can threaten the health of vulnerable populations, including the very young, the elderly, and people with certain medical conditions, such as heart disease. In Cambridge, slightly more than 10,000 residents are under the age of 15 and another approximately 10,000 are 65 years of age or older. Both populations can be found throughout the city. Additionally, Cambridge is a densely settled municipality that is mostly urbanized, so city as a whole experiences vulnerability to extreme temperatures.

Previous Occurrences-Excessive Heat

The City does not collect data on excessive heat occurrences. The best available data is from the National Climatic Data Center (NCDC) for Middlesex County, which includes Cambridge. The NCDC records indicate that July 6, 2010 the temperature in eastern Massachusetts ranged from 100 to 106 degrees Fahrenheit. There were no reported deaths, injuries or property damage resulting from excessive heat. (NOAA: NCDC)

Previous Occurrences- Extreme Cold

Cambridge does not collect data for extreme cold occurrences. The best available data is from the National Climatic Data Center (NCDC) for adjacent Suffolk County, which indicates that an extreme cold event occurred on February 3, 2007.

Probability of Future Occurrences

Based on the record of previous occurrences, extreme temperatures are a Medium frequency event as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur from once in 5 years to once in 50 years, or a 2% to 20% chance per year.

Drought

Drought is a temporary irregularity in precipitation and differs from aridity since the latter is restricted to low rainfall regions and is a permanent feature of climate. Drought is a period characterized by long durations of below normal precipitation. Drought conditions occur in virtually all climatic zones yet its characteristics vary significantly from one region to another, since it is relative to the normal precipitation in that region. Drought can affect agriculture, water supply, aquatic ecology, wildlife, and plant life.

In Massachusetts, droughts are caused by the prevalence of dry northern continental air and a decrease in coastal- and tropical-cyclone activity. During the 1960's, a cool drought occurred because dry air from the north caused lower temperatures in the spring

and summer of 1962-65. The northerly winds drove frontal systems to sea along the Southeast Coast and prevented the Northeastern States from receiving moisture (U.S. Geological Survey). This is considered the drought of record in Massachusetts.

Average annual precipitation in Massachusetts is 44 inches per year, with approximately 3 to 4 inch average amounts for each month of the year. Regional monthly precipitation ranges from zero to 17 inches. Statewide annual precipitation ranges from 30 to 61 inches. Thus, in the driest calendar year (1965), the statewide precipitation total of 30 inches was 68 percent of average.

Although Massachusetts is relatively small, it has a number of distinct regions that experience significantly different weather patterns and react differently to the amounts of precipitation they receive. The DCR precipitation index divides the state into six regions: Western, Central, Connecticut River Valley, Northeast, Southeast, and Cape and Islands. Cambridge is located in the Northeast Region. In Cambridge drought is a potential town-wide hazard.

Five levels of drought have been developed to characterize drought severity: Normal, Advisory, Watch, Warning, and Emergency. These drought levels are based on the conditions of natural resources and are intended to provide information on the current status of water resources. The levels provide a basic framework from which to take actions to assess, communicate, and respond to drought conditions. They begin with a normal situation where data are routinely collected and distributed, move to heightened vigilance with increased data collection during an advisory, to increased assessment and proactive education during a watch. Water restrictions might be appropriate at the watch or warning stage, depending on the capacity of each individual water supply system. A warning level indicates a severe situation and the possibility that a drought emergency may be necessary. A drought emergency is one in which mandatory water restrictions or use of emergency supplies is necessary. Drought levels are used to coordinate both state agency and local response to drought situations.

As dry conditions can have a range of different impacts, a number of drought indices are available to assess these various impacts. Massachusetts 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. Drought level is determined monthly based on the number of indices which have reached a given drought level. Drought levels are declared on a regional basis for each of six regions in Massachusetts. County by county or watershed-specific determinations may also be made.

A determination of drought level is based on seven indices:

1. Standardized Precipitation Index (SPI) reflects soil moisture and precipitation.
2. Crop Moisture Index: (CMI) reflects soil moisture conditions for agriculture.
3. Keetch Byram Drought Index (KBDI) is designed for fire potential assessment.
4. Precipitation Index is a comparison of measured precipitation amounts to historic normal precipitation.

5. The Groundwater Level Index is based on the number of consecutive month's groundwater levels are below normal (lowest 25% of period of record).
6. The Stream flow Index is based on the number of consecutive months that stream flow levels are below normal (lowest 25% of period of record).
7. The Reservoir Index is based on the water levels of small, medium and large index reservoirs across the state, relative to normal conditions for each month.

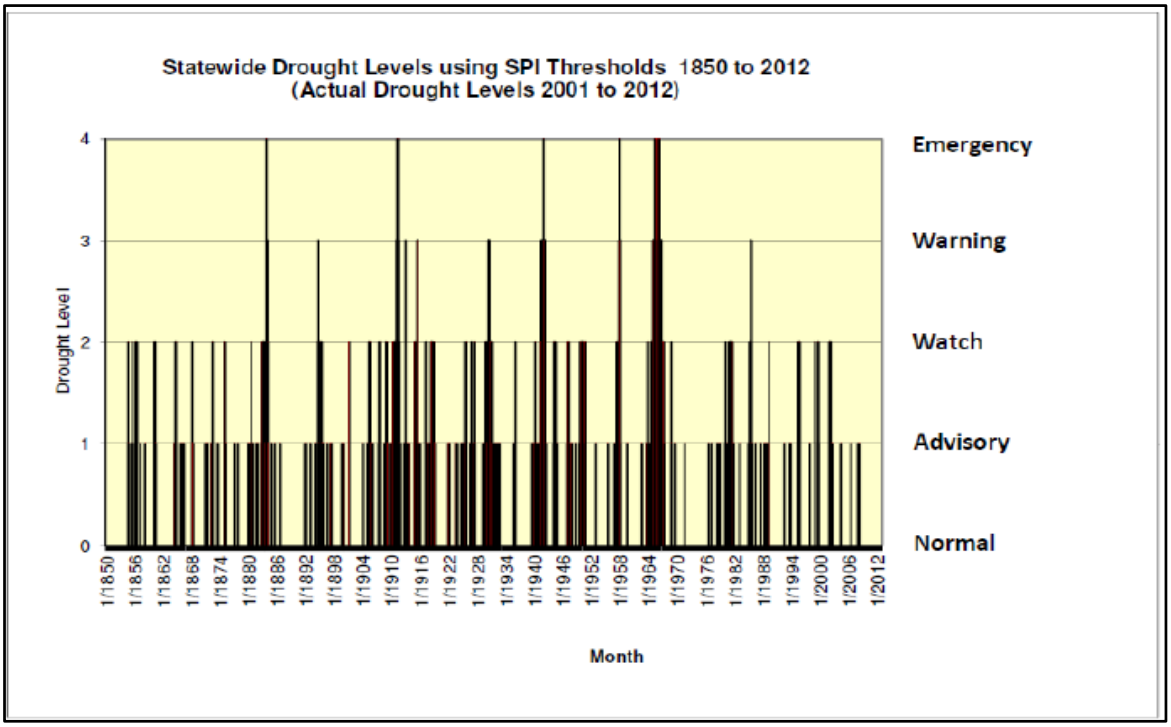
Determinations regarding the end of a drought or reduction of the drought level focus on two key drought indicators: precipitation and groundwater levels. These two factors have the greatest long-term impact on stream flow, water supply, reservoir levels, soil moisture and potential for forest fires.

Previous Occurrences

Cambridge does not collect data relative to drought events. Because drought tends to be a regional natural hazard, this plan references state data as the best available data for drought. The statewide scale is a composite of six regions of the state. Regional composite precipitation values are based on monthly values from six stations, and three stations in the smaller regions (Cape Cod/Islands and West).

Figure 6 depicts the incidents of drought levels' occurrence in Massachusetts from 1850 to 2012 using the Standardized Precipitation Index (SPI) parameter alone. On a monthly

Figure 6 - Statewide Drought Levels using SPI Thresholds 1850 – 2012



Source: Mass. State Drought Management Plan 2013)

basis, the state would have been in a Drought Watch to Emergency condition 11 percent of the time between 1850 and 2012. Table 15 summarizes the chronology of major droughts since the 1920's

Table 15 - Chronology of major droughts in Massachusetts

Date	Area affected	Recurrence interval (years)	Remarks
1929-32	Statewide	10 to >50	Water-supply sources altered in 13 communities. Multistate.
	Statewide	15 to >50	More severe in eastern and extreme western Massachusetts. Multistate.
1957-59	Statewide	5 to 25	Record low water levels in observation wells, northeastern Massachusetts.
1961-69	Statewide	35 to >50	Water-supply shortages common. Record drought. Multistate.
1980-83	Statewide	10 to 30	Most severe in Ipswich and Taunton River basins; minimal effect in Nashua River basin. Multistate.
1985-88	Housatonic River basin	25	Duration and severity unknown. Streamflow showed mixed trends elsewhere.

Drought Emergency

Drought emergencies have been reached infrequently, with 5 events occurring in the period between 1850 and 2012: in 1883, 1911, 1941, 1957, and 1965-1966. The 1965-1966 drought period is viewed as the most severe drought to have occurred in modern times in Massachusetts because of its long duration. On a monthly basis over the 162-year period of record, there is a one percent chance of being in a drought Emergency.

Drought Warning

Drought Warning levels not associated with drought Emergencies have occurred four times, in 1894, 1915, 1930, and 1985. On a monthly basis over the 162-year period of record, there is a two percent chance of being in a drought Warning level.

Drought Watch

Drought Watches not associated with higher levels of drought generally have occurred in three to four years per decade between 1850 and 1950. In the 1980s, there was a lengthy drought Watch level of precipitation between 1980 and 1981, followed by a drought Warning in 1985. A frequency of drought Watches at a rate of three years per decade resumed in the 1990s (1995, 1998, 1999). In the 2000s, Drought Watches occurred in 2001 and 2002. The overall frequency of being in a drought Watch is 8 percent on a monthly basis over the 162-year period of record.

Cambridge Drought Vulnerability

Cambridge's potential vulnerability to a severe long term drought would be a reduction in the availability of water from the City's local water supplies. The City owns and operates a separate water system, with storage reservoirs on Hobbs Brook and Stony Brook in the towns of Lexington, Lincoln, Waltham, and Weston. In a severe multi-year drought the yields from these reservoirs would be sharply reduced. However, the City is also a member of the Massachusetts Water Resources Authority, and has access to MWRA's regional water supply in the event of an emergency. The only occasion this back-up water supply was activated due to drought was during the 1960's drought, which is considered to be the drought of record in New England. In addition to providing relief during a drought, MWRA was temporarily used by Cambridge during construction of a new Water Treatment Plant in 2001. MWRA water was also used in 2006 during a water main break near Kendall Square. Since the last plan, Cambridge has drawn on MWRA water on the following occasions:

- During 2014 Cambridge was partially supplied by the MWRA while the Cities capacity was limited by two construction projects, one an MWRA project that took our raw water supply off line and another a Cambridge Sewer Separation project that limited our pumping capacity to the City.
- During 2015 there was periodic MWRA water use as an Emergency Response drill and to supplement the Cambridge during several potential electrical system demand response events (~8 MG).
- During 2016 Cambridge will be using MWRA periodically due to limited CWD capacity due to a City construction project. The use is less than a million gallons a day.

Given the resilience of the MWRA system due to the very large amount of storage in the Quabbin and Wachusett Reservoirs, severe impacts of drought on the City are unlikely.

Probability of Future Occurrences

The state has experienced Emergency Droughts five times between 1850 and 2012. Even given that regional drought conditions may occur at a different interval than state data indicates, droughts remain primarily regional and state phenomena in Massachusetts.

Emergency Drought conditions over the 162 period of record in Massachusetts are a Low Frequency natural hazard event that can occur from once in 50 years to once in 100 years (1% to 2% chance per year), as defined by the Massachusetts State Hazard Mitigation Plan, 2013.

LAND USE AND DEVELOPMENT TRENDS

Existing Land Use

The most recent land use statistics available from the state are from aerial photography done in 2005. Table 16 shows the acreage and percentage of land in 10 categories. If the three residential categories are aggregated, residential uses make up over 37% of the area of the City (1.654 acres). Commercial and industrial uses comprise over 20% of land use in of Cambridge, and undeveloped land and wetlands account for just over 14%.

Table 16. 2005 Land Use

Land Use Type	Acres	Percent
High Density Residential	1585.59	34.95%
Medium Density Residential	63.12	1.39%
Low Density Residential	5.92	1.31%
Non-Residential, Developed	1176.87	25.94%
Commercial	594.53	13.12%
Industrial	340.47	7.51%
Transportation	114.90	2.53%
Agriculture	4.14	0.09%
Undeveloped	158.09	3.48%
Undeveloped Wetland	492.78	10.86%
Total	***4,536.42***	***100%***

Source: MassDEP 2205 Land Use

Economic Elements

Cambridge has economic centers located in multiple areas of the City. Significant centers of economic development include Kendall Square, Harvard Square, Central Square, and Porter Square. These areas are complimented by commercial corridors along Massachusetts Avenue and in the Concord Alewife section of the City. There are also many smaller commercial centers and corridors located in various neighborhoods through the Cambridge.

These centers and corridors consist of historic structures and businesses as well as more recent developments that include retail, office, and residential uses.

Historic, Cultural, and Natural Resource Areas

There are several locations and areas of historical and cultural importance to Cambridge, some of which are listed on the State and National historic registers and many which are included in local historic districts. In addition, the City has designated Neighborhood Conservation Districts to protect and preserve areas and buildings that important in Cambridge's history. Included are the:

- Old Cambridge Historic District
- Fort Washington Historic District
- Avon Hill Neighborhood Conservation District
- Harvard Square Conservation District
- Mid Cambridge Neighborhood Conservation District
- Half Crown -Marsh Neighborhood Conservation District

The districts are primarily located in the central portion of the City, in and to the east and west of Harvard Square.

The City has a limited number of larger open spaces and conserved lands, especially along the existing waterways, and is actively adding more natural elements to its built environment. The open space system in the City comes mostly from land reclaimed from other uses and these public parks and plazas are complimented by privately owned open spaces that typically offer some level of public access. The city values it current set of street trees and is working to plant more trees each year. The City is also participating in efforts to address water quality issues related to the Mystic River and Alewife Brook through open space preservation and enhancement. More information about open space planning can be found in the City's 2009-2016 Open Space and Recreation Plan.

Development Trends

Under current zoning, the City of Cambridge is largely built out. Much of the land area is occupied by existing residential neighborhoods, commercial corridor and districts, open space and recreational spaces, and conservation land and undevelopable wetlands. The development that is occurring in the City is largely infill development and redevelopment.

<u>Development Since the 2008 Hazard Mitigation Plan</u>

Development trends throughout the metropolitan region are tracked by MAPC's Development Database, which provides an inventory of new development over the last decade. The database tracks both completed developments and those currently under construction. The database includes 69 developments in the City of Cambridge completed since 2008, and an additional 25 developments that were under construction but not yet completed when this plan update was drafted. These are listed in Table 17 below.

The database also includes several attributes of the new development, including site acreage, housing units, and commercial space. The 86 developments completed from 2008 to 2015 are sited on a total of 151 acres and include a total of 4,625 housing units, and 5, 111,548 square feet of commercial space. With the addition of 23 other projects still under construction in 2015, a total of 109 new developments in Cambridge since 2008 are sited on 206 acres and include a total of 5,655 housing units and 7,665,932 square feet of commercial space.

Table 17
New Developments in Cambridge 2008-2015

DEVELOPMENT NAME	ACRES	HOUSING UNITS	COMM SF
Developments Completed 2008-2015			
East Street Phase 1, #1-25 (Smith)	5.7	341	2,400
Kendall St., #250 (condos/CRP)	0.5	144	9,290
Brookline St, #21 (ManRay)	0.4	49	-
Massachusetts Ave., #1131 (Hotel Veritas)	0.1	-	-
Havard University: Dorm, 870-888 Memorial Drive	2.3	18	-
Harvey St., #95	0.2	8	-
Wheeler St., #37 (Baker Bldg.)	1.2	72	-
North Point Bldg S (Guilford/S&S)	1.0	99	-
North Point Bldg T (Guilford/S&S)	1.0	230	-
Water St., #22 (Mac-Grey)	2.4	392	-
First Street, #1 Phase 2 (Leggett McCall)	1.7	82	2,859
East Kendall St., #650 (office/CRP)	1.1	-	217,398
First Street, #265 (Kendall Sq. Electric Generating Plant)	3.9	-	11,800
Third Street, #303 (Intell Housing)	3.3	482	9,553
Harvard St., 125-127 (Printshop)	0.2	26	-
Albany St., #235 (MIT Grad Dorm #2/New Ashdown House)	3.3	-	-
Hamilton St., #72	0.3	11	-
Prospect St., #239-241 (Pann)	0.3	8	-
Pearl St., #173 (Blessed Sacrament)	0.7	42	-
River St., 280-290	0.6	17	-
Concord Ave., #479 (Shelter Inc.)	0.1	14	-
Massachusetts Ave., #1979 (Long Funeral Home)	0.1	15	-
Yerxa Rd. #45 (St Johns Phase 1A)	2.2	19	-
Discovery Park, #200/300	2.6	-	235,000
Kendall St., #450 (CRP)	0.3	-	53,000
Oxford St., #24 (Harvard NW Lab)	3.0	-	410,000
Mt. Auburn St., #330 (Mt Auburn Hosp. Acute Care Bldg.)	2.8	-	189,900
Binney St., #225 (Alexandria/Biogen)	1.8	-	302,680
Charles St., #126	0.1	8	-

Table 17
New Developments in Cambridge 2008-2015

DEVELOPMENT NAME	ACRES	HOUSING UNITS	COMM SF
Second St., #150 (Skanska)	1.4	-	108,600
Binney St., #75-125 (Alexandria)	2.4	-	347,692
First St., #159	0.7	115	3,800
Binney St., #71 (Mormon Church)	0.7	-	28,662
Main St., #100 (MIT Sloan School)	6.2	-	209,000
Amherst St., #75 (MIT Media Lab)	6.8	-	162,665
Main St., #500 (MIT Koch Cancer Research Bldg.)	2.8	-	308,756
Cambridge St., #1066 (Antiques Mall)	0.4	19	1,998
Windsor St., #424	0.2	19	-
Broadway, #277	0.2	9	1,953
Main St., #823 (Nightstage)	0.1	9	-
Putnam Ave., #625	0.6	40	-
Temple St., #7-11 (YWCA)	0.8	40	-
Broadway, #449 (City Main Library)	11.8	-	102,210
Massachusetts Ave., #1063 - 1077 (Bowl & Board)	0.2	20	6,928
Mt. Auburn St., #114 (Conductors Building)	0.5	-	83,200
Harvard University: Harvard Law School, 1587 Massachusetts Ave.	2.9	-	234,000
Massachusetts Ave., # 1663 (Lesley College)	0.4	-	2,790
New St., #87	0.7	54	-
Fresh Pond Pkwy., #355	1.0	-	11,450
Coolidge Hill Rd., #178 (Shady Hill Gym)	1.3	-	75,363
Huron Ave., #688 (City Youth Center/VFW)	0.7	-	31,000
Massachusetts Ave., #2419 (Rounder Records)	0.6	37	-
Alewife Brook Parkway, #220 (Hotel Tria)	1.6	-	57,759
Fawcett St. #70-80	4.9	429	-
1 Education St.	3.2	-	295,000
75 Ames St. / Cambridge Center/ Broad Institute Addition	1.5	-	250,000
88 Ames Street	0.2	280	16,000
223 Concord Turnpike / Vox on Two	4.6	227	-
Cambridgepark Dr. #165 Phase 1/2	2.7	244	-
Cambridge Center #17 (Biogen)	1.1	-	188,000
Concord Ave #563-603	0.7	61	7,184
Bolton St. #61-69	0.5	20	-
Brattle Circle	0.4	7	-
Massachusetts Ave. #622 (Holmes Bldg)	0.8	21	-
Pacific St. #100	0.2	11	-
Rindge Ave. #120-124 (St Johns Phases 1B and 2)	2.2	44	-
Walden St #181	0.7	10	-
Western Ave. #5 (Old Police Station)	0.3	-	59,676

Table 17
New Developments in Cambridge 2008-2015

DEVELOPMENT NAME	ACRES	HOUSING UNITS	COMM SF
Cottage Park Ave. #22-27	0.6	16	-
10 Glassworks Ave. (Maple Leaf Bldg.)	5.7	104	-
Hampshire St. #168 (KFC)	0.2	11	1,700
Harvey St. #119-135 (Cambridge Lumber)	1.3	20	-
Main St. #610 (MITIMCO/Phase 1/Pfizer)	1.0	-	188,317
Massachusetts Ave. #1797-1801 (Art Institute)	0.6	-	74,500
Norris St. #40 (N. Cambridge Catholic HS)	0.6	25	1,796
20 Child St. / North Point Bldg N	2.0	355	8,257
Massachusetts Ave. #181 (Novartis)	3.8	-	572,663
Cambridge Center Google Bridge	1.0	-	42,000
240 Sidney St.	1.2	96	-
270 Third St.	0.4	91	8,506
42 - 54 Bay State Rd.	13.5	10	-
219 Monsignor O'Brien Highway	0.3	-	-
18 White St.	0.1	8	-
32 Quincy St.	4.2	-	176,243
Chroma Cambridge	-	96	-
140 Cambridgepark Drive	2.9	-	-
Total Developments Completed 2008-2015	**151.5**	**4,625**	**5,111,548**
Developments Under Construction 2015			
Binney St., #100 (Alexandria)	1.3	-	387,700
Binney St., #50/60 (Alexandria)	1.5	-	484,568
Main St., #610 (MITIMCO/Phase 2)	4.8	-	238,264
Massachusetts Ave., #1924 (Kaya Hotel)	0.3	-	24,162
Cambridgepark Dr., #160-180	2.8	398	-
300 Massachusetts Ave (University Park Millennium Bldg)	1.2	-	218,501
33 Cottage Park Ave.	3.0	67	-
Harvard University: 79 JFK St. - Kennedy School Expansion	2.9	-	76,862
15 - 33 Richdale Ave.	1.0	46	-
Cambridgepark Dr. #130	2.3	220	-
1868 Massachusetts Ave.	0.3	27	2,514
Massachusetts Ave. , #1971 (Miso Block Redevelopment)	0.3	20	3,925
100 Putnam Ave. / MLK, JR. School	3.9	-	169,221
192 Raymond St	0.1	8	-
610 Main Street North	-	-	280,000
5 Temple Street	-	-	-
10 Acorn Park (600 Discovery Park)	26.5	-	82,340
Vassar Street, #60 (MIT Nano Lab, Building 12)	-	-	216,500
Cambridgepark Dr., #165 Phased	2.7	244	-

Table 17
New Developments in Cambridge 2008-2015

DEVELOPMENT NAME	ACRES	HOUSING UNITS	COMM SF
20 Acorn Park (500 Discovery Park)		-	132,000
10 Acorn Park (600 Discovery Park)		-	82
30 Acorn Park (400 Discovery Park)		-	96,000
40 Acorn Park (Garage B)	1.3	-	141,745
TOTAL DEVELOPMENTS UNDER CONSTRUCTION	**55.0**	**1,030**	**2,554,384**
TOTAL ALL DEVELOPMENTS 2008-2015	**206.5**	**5,655**	***7,665,932***

In order to characterize any change in the city's vulnerability related to these 109 new developments, the sites were overlaid with the FEMA flood hazard map. The analysis shows that 12 of the 109 new development sites are located on land parcels that are at least partially in a flood zone. Of these 12 sites, 8 parcels are located in "X" zones ("500 year floodplain") and 4 parcels are in "AE" zones ("100 year floodplains). However, any development within floodplain areas must comply with Cambridge's Flood Plain ordinance, which requires compensatory flood storage.

Potential Future Development

MAPC consulted with City staff to determine areas that are likely to be developed in the future, defined for the purposes of this plan as a ten year time horizon. In some cases the types of future development are known, but in many cases the areas have been identified as a location that has been planned for and shown likelihood for future growth.

The potential future development areas are shown on Map 2, "Developable Land" and are described below. The letter for each site corresponds to the letters on Map 2.

A. Kendall Square - The 27-acre area is owned by MIT and leased to Forest City Enterprises. Most of the project has been built with the last two buildings under construction. The area includes roughly 2.3 million square feet of residences (almost 700 units), biotechnology uses, a dormitory, and a hotel. This 9.8-acre area, which lies along the Board Canal, is being developed as a Planned Unit Development (PUD) and is currently owned by Lyme Properties. The area will include roughly 1.5 million square feet of a variety of uses, including biotechnology, research and development and residences. The area was a brownfield.

B. Main Street/Massachusetts Avenue – Area also known as Osborne Triangle that is the location for new development and redevelopment that is proposed to include a mixture of residential, neighborhood business, office, and institutional uses. This area serves as a link between Kendall Square and Central Square.

C. North Point - Jones Lange LaSalle is the developer for North Point. Construction will be phased over 15 to 20 years. Five million square feet is planned, with roughly 2 million square feet of residences (over 2,000 units), 3 million square feet of commercial uses, and 10 acres of open space. The area totals 43.7 acres.

D. Concord-Alewife Area - The planning process for this underdeveloped area is at early stages. The city has formulated a vision and new zoning was recently adopted. The vision entails mixed uses throughout the area including housing; allowing development rights to be transferred away from Cambridge Highlands to the area around Alewife Station, and the use of overlay districts to address open space and stormwater issues including the use of Low Impact Development techniques. Much of the 180-acre area is in the 500 year floodplain. Additional approaches to addressing flooding concerns are discussed under potential mitigation for flooding, later.

E. Discovery Park - This area will be redeveloped for commercial uses. The project proposed for this site would increase the amount of office and research space from 416,000 square feet to 820,000 square feet. The project also entails removing parking areas along the Little River Area and providing flood storage capacity.

F. Whittemore Avenue - Harvey Street – Area located on the eastern edge of the Concord-Alewife development district with potential for future redevelopment. Current location of light industrial and technology uses.

VULNERABILITY ASSESSMENT

The purpose of the vulnerability assessment is to estimate the extent of potential damages from natural hazards of varying types and intensities.

Future Development in Hazard Areas

Table 18 shows the relationship of these parcels to two of the mapped hazards. This information is provided so that planners can ensure that development proposals comply with flood plain zoning and that careful attention is paid to drainage issues.

Table 18. Relationship of Potential Development to Hazard Areas

Area	Landslide risk	Flood Zone	Brush Fire
North Point	Moderate Susceptibility	No	No
Kendall Square	Moderate Susceptibility	3.2% in AE	No
Main Street/Massachusetts Avenue	Moderate Susceptibility	No	No
Concord-Alewife Area	Low	31.8% in AE	No
Discovery Park	Low	98.5% in AE	Yes
Whitmore Avenue - Harvey Street	Low	42.8493% in AE	No

Critical Infrastructure in Hazard Areas

Critical infrastructure includes facilities that are important for disaster response and evacuation (such as emergency operations centers, fire stations, water pump stations, etc.) and facilities where additional assistance might be needed during an emergency (such as nursing homes, elderly housing, day care centers, etc.). These facilities are listed in Table 19 and are shown on all of the maps in Appendix B.

The purpose of mapping the natural hazards and critical infrastructure is to present an overview of hazards in the community and how they relate to critical infrastructure, to better understand which facilities may be vulnerable to particular natural hazards.

Explanation of Columns in Table 19

Column 1: ID #: The first column in Table 14 is an ID number which appears on the maps that are part of this plan. See Appendix B.

Column 2: Name: The second column is the name of the site. If no name appears in this column, this information was not provided to MAPC by the community.

Column 3: Type: The third column indicates what type of site it is.

Column 4: Landslide Risk: The fourth column indicates the degree of landslide risk for that site. This information came from NESEC. The landslide information shows areas with either a low susceptibility or a moderate susceptibility to landslides based on mapping of geological formations. This mapping is highly general in nature. For more information on how landslide susceptibility was mapped, refer to http://pubs.usgs.gov/pp/p1183/pp1183.html.

Column 5: FEMA Flood Zone: The fifth column addresses the risk of flooding. A "No" entry in this column means that the site is not within any of the mapped risk zones on the Flood Insurance Rate Maps (FIRM maps). If there is an entry in this column, it indicates the type of flood zone as follows:

Zone A (1% annual chance) - Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs (base flood elevations) or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone AE and A1-A30 (1% annual chance) **-** Zones AE and A1-A30 are the flood insurance rate zones that correspond to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zones X500 (.2% annual chance) **-** Zone X500 is the flood insurance rate zone that correspond to the 500-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs (base flood elevations) or depths are shown within this zone.

Zone VE (1% annual chance) **-** Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply

Column 6: Locally-Identified Flood Area: The locally identified areas of flooding were identified by City staff as areas where flooding occurs. These areas do not necessarily coincide with the flood zones from the FIRM maps. They may be areas that flood due to inadequate drainage systems or other local conditions rather than location within a flood zone. The numbers correspond to the numbers on Map 8, "Hazard Areas".

Column 7: Hurricane Surge Category: The seventh column indicates whether or not the site is located within a hurricane surge area and the category of hurricane estimated to be necessary to cause inundation of the area. The following explanation of hurricane surge areas was taken from the US Army Corps of Engineers web site:

> "Hurricane storm surge is an abnormal rise in sea level accompanying a hurricane or other intense storm. Along a coastline a hurricane will cause waves on top of the surge. Hurricane Surge is estimated with the use of a computer model called SLOSH. SLOSH stands for Sea Lake and Overland Surge from Hurricanes. The SLOSH models are created and run by the National Hurricane Center.
>
> The SLOSH model results are merged with ground elevation data to determine areas that will be subject to flooding from various categories of hurricanes. Hurricane categories are defined by the Saffir-Simpson Scale." See http://www.sam.usace.army.mil/hesdata/General/hestasks.htm

According to the Saffir-Simpson Scale, the least damaging storm is a Category 1 (winds of 74-95 miles per hour) and the most damaging storm is a Category 5 (winds greater than 155 miles per hour).

Column 8: Brushfire Risk (Not shown): The fourth column indicates whether the site falls within an area identified by municipal staff as posing a brushfire risk. This column in not included in the Cambridge Plan as no CIs were located in an area identified as having a brushfire risk.

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
1	MBTA	Emergency Communication Equipment	Low Susceptibility	No	No	High	0
2	Lesley University Washburn Hall	Place of Assembly	Low Susceptibility	No	No	High	0
3	Cambridge Montessori School	School	Low Susceptibility	No	Bellis Circle	High	4
4	Harvard University James Hall	Emergency Communication Equipment	Low Susceptibility	No	No	High	0
5	Cambridge Montessori School	School	Low Susceptibility	No	No	High	0
6	Buckingham Middle School	School	Low Susceptibility	No	No	High	0
7	Buckingham Elementary School	School	Low Susceptibility	No	No	High	0
8	Cambridge Montessori School	School	Low Susceptibility	No	No	High	2
9	Buckingham Browne and Nichols High School	School	Low Susceptibility	No	No	High	2
10	Saint Peter's Elementary School	School	Low Susceptibility	No	No	High	0
11	Porter Square MBTA Station	Transportation Facility	Low Susceptibility	No	No	High	0
12	Mt Auburn Hospital Clark Building	Hospital	Low Susceptibility	No	No	High	0
13	Lesley University - Doble Building	Communication Tower	Low Susceptibility	No	No	High	0

[1] This brushfire risk column in not included in the Cambridge Plan as no CIs were located in an area identified as having a brushfire risk.

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
14	Residential High Rise	Emergency Communication Equipment	Low Susceptibility	No	No	High	0
15	Lesley University	Communication Tower	Low Susceptibility	No	No	High	0
16	Agassiz Community Center	Child Care	Low Susceptibility	No	Agassiz Community	High	0
17	Vassal Lane Upper School	School	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	Vassal Lane/Tobin School	High	2
18	Boston Archdiocesan Choir School	School	Moderate Susceptibility	No	No	Low	0
19	Tobin Montessori School	School	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	Vassal Lane/Tobin School	High	2
20	CRLS Auto Shop	School	Moderate Susceptibility	No	No	Low	0
21	Cambridge Rindge and Latin High School (CRLS)	School	Moderate Susceptibility	No	No	Low	0
22	Lesley University	Emergency Communication Equipment	Low Susceptibility	No	No	High	0
23	Lesley University - University Hall	Communication Tower	Low Susceptibility	No	No	High	0
24	Haggerty School	School	Low Susceptibility	No	Corcoran Way and May Street	High	0
25	Harvard University Cabot Hall, Cabot	Place of	Low	No	No	High	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
	House	Assembly	Susceptibility				
26	Mt Auburn Hospital South Building	Hospital	Low Susceptibility	No	No	High	0
27	Cambridge Water Dept	Emergency Operation Center	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	2
28	Mt Auburn Hospital Stanton Bldg	Hospital	Low Susceptibility	No	No	High	0
29	Lesley University White Hall	Place of Assembly	Low Susceptibility	No	No	High	0
30	Graham and Parks Alternative School	School	Low Susceptibility	No	No	High	0
31	Cambridge Ellis School	Child Care	Moderate Susceptibility	No	No	Low	0
32	Mt Auburn Hospital Nuclear Medicine Bldg	Hospital	Low Susceptibility	No	No	High	0
33	Harvard Place	Elderly Housing	Moderate Susceptibility	No	No	Low	0
34	Mt Auburn Hospital Medical Office Building	Hospital	Low Susceptibility	No	No	High	0
35	45 Linnaean St	Elderly Housing	Low Susceptibility	No	No	High	0
36	Mt Auburn Hospital Needham Building	Hospital	Low Susceptibility	No	No	High	0
37	Children's Village	Child Care	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	Concord Avenue and Fern Street	High	1

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
38	Harvard Vanguard Medical Associates	Medical	Moderate Susceptibility	No	No	Low	0
39	Cambridge Rehabilitation and Nursing Center	Medical	Moderate Susceptibility	No	No	Low	0
40	Baldwin School	School	Low Susceptibility	No	Agassiz Community	High	0
41	Cambridge Cemetery Garage	Municipal Building	Low Susceptibility	No	Cambridge Cemetery	High	0
42	Cambridge Police Station Reporting for North/West Cambridge	Municipal Building	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	1
43	Dragonfly After School Program	Child Care	Low Susceptibility	No	No	High	0
44	Cambridge Cemetery Fuel Pumps	Municipal Building	Low Susceptibility	No	Cambridge Cemetery	High	0
45	Cambridge Cemetery Office	Municipal Building	Low Susceptibility	No	Cambridge Cemetery	High	0
46	Radcliffe Child Care Center	Child Care	Low Susceptibility	No	No	Low	0
47	Sacramento Street Preschool/Aggasiz Kindergarten Afterschool	Child Care	Low Susceptibility	No	No	High	0
48	West Cambridge Recreation Youth Center	Municipal Building	Low Susceptibility	No	No	High	0
49	Evergreen Day School	Child Care	Low Susceptibility	No	No	High	0
50	Fire Apparatus	Municipal	Low	0.2 PCT	No	High	1

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
	Repair Garage	Building	Susceptibility	ANNUAL CHANCE FLOOD HAZARD			
51	Fire Station Engine 9	Fire Station	Low Susceptibility	No	No	High	0
52	Mt Auburn Hospital Wyman Building	Hospital	Low Susceptibility	No	No	High	0
53	Newtowne Parent Coop	Child Care	Low Susceptibility	No	No	High	0
54	Harvard University Steam Plant	Emergency Operation Center	Moderate Susceptibility	No	No	Low	2
55	Harvard University Adams House	Place of Assembly	Low Susceptibility	No	No	Low	0
56	Harvard University Botanic Children's Center	Child Care	Low Susceptibility	No	No	High	0
57	Fayerweather Street School	School	Low Susceptibility	No	No	High	0
58	Fire Station Engine 8	Fire Station	Low Susceptibility	No	No	High	0
59	Harvard University Eliot House	Place of Assembly	Low Susceptibility	No	No	High	2
60	Harvard University Gutman Library	Power Substation	Low Susceptibility	No	No	High	0
61	Cambridge Health Alliance Family Health - Teen Health Center	Medical	Moderate Susceptibility	No	No	Low	0
62	Main Public Library	Municipal Building	Moderate Susceptibility	No	No	Low	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
63	Harvard University Hilles Library	Power Substation	Low Susceptibility	No	No	High	0
64	Harvard University Currier House	Place of Assembly	Low Susceptibility	No	No	High	0
65	Harvard University Harvard Yard Child Care Center	Child Care	Moderate Susceptibility	No	No	High	0
66	Harvard University Holyoke Place	Power Substation	Low Susceptibility	No	No	High	4
67	Harvard University Malkin Athletic Center	Place of Assembly	Low Susceptibility	No	No	High	0
68	Harvard University Kirkland House	Place of Assembly	Low Susceptibility	No	No	High	2
69	Sancta Maria Nursing Facility	Medical	Low Susceptibility	No	No	High	0
70	Harvard University Mather House	Place of Assembly	Moderate Susceptibility	No	No	Low	0
71	Harvard University Memorial Hall	Place of Assembly	Low Susceptibility	No	No	High	0
72	Harvard University Oxford Street Daycare Co-op	Child Care	Moderate Susceptibility	No	No	High	0
73	Putnam Sq Apartments	Elderly Housing	Moderate Susceptibility	No	No	Low	0
74	Harvard University Moors Hall	Place of Assembly	Low Susceptibility	No	No	High	0
75	Harvard University Leverett House	Place of Assembly	Low Susceptibility	No	No	High	2
76	Harvard University Quadrangle Athletic Center	Place of Assembly	Low Susceptibility	No	No	High	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
77	Harvard University Northwest Building	Power Substation	Low Susceptibility	No	No	High	0
78	Harvard University Radcliffe Gymnasium	Place of Assembly	Low Susceptibility	No	No	High	0
79	Harvard University Rosovsky Hall	Place of Assembly	Low Susceptibility	No	No	High	2
80	Harvard University Holyoke Center	Emergency Operation Center	Low Susceptibility	No	No	High	0
81	Harvard University Science Center	Power Substation	Low Susceptibility	No	No	High	0
82	Harvard University Radcliffe Child Care Centers, Inc.	Child Care	Low Susceptibility	No	No	Low	0
83	Bay State Pools	Hazardous Material Site	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	1
84	Harvard University (Outsourced to Verizon Building)	Communication Tower	Moderate Susceptibility	No	No	Low	0
85	Harvard University Massachusetts Hall	Emergency Operation Center	Low Susceptibility	No	No	High	0
86	Harvard University Police Station	Police Station	Moderate Susceptibility	No	No	Low	0
87	Harvard University Dunster House	Place of Assembly	Moderate Susceptibility	No	No	Low	2
88	Fire Station Engine 1	Fire Station	Low Susceptibility	No	No	High	0
89	St Pauls Residence	Assisted Living	Low	No	No	Low	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
			Susceptibility				
90	Harvard University Peabody Terrace Children's Center	Child Care	Moderate Susceptibility	No	No	Low	2
91	Cambridge Homes Assisted Living	Medical	Low Susceptibility	No	No	High	0
92	Neville Place Assisted Living	Medical	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	2
93	Nstar Electric Company (Station 828)	Power Substation	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	1
94	Fresh Pond Reservoir - Cambridge Water Dept	Utilities - Water	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	2
95	Nstar Electric Company (Station 509)	Power Substation	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	2
96	Harvard University Pound Hall	Medical Facility	Low Susceptibility	No	No	High	0
97	Neville Center at Fresh Pond	Medical	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	4
98	Professional	Medical	Low	0.2 PCT ANNUAL	No	High	1

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
	Ambulance Co.	Facility	Susceptibility	CHANCE FLOOD HAZARD			
99	Shady Hill School	School	Low Susceptibility	No	No	High	0
100	Cambridgeport Children's Center - Tot Lot	Child Care	Moderate Susceptibility	No	No	Low	0
101	Cambridge Community Center	Child Care	Moderate Susceptibility	No	No	Low	2
102	Fresh Pond Golf Course Maintenance Building	Hazardous Material Site	Low Susceptibility	No	No	High	0
103	MWRA Meter 52 (joint managed MWRA/CWD)	Utilities - Water	Low Susceptibility	No	No	High	0
104	Margaret Fuller House	Child Care	Moderate Susceptibility	No	Harvard Street (Canard) and Hancock Street	Low	2
105	Technology Children's Center	Child Care	Moderate Susceptibility	No	No	Low	2
106	Cambridge Water Dept	Water Treatment Plant	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	2
107	Dr. Martin Luther King Preschool	Child Care	Moderate Susceptibility	No	No	Low	0
108	Cambridge Hospital (Birthing Center)	Hospital	Moderate Susceptibility	No	No	Low	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
109	Cambridge Hospital (Macht Building)	Hospital	Moderate Susceptibility	No	No	Low	0
110	CAAS Head Start - Frisoli Center	Child Care	Moderate Susceptibility	No	No	Low	2
111	Cambridge Hospital (Office)	Hospital	Moderate Susceptibility	No	No	Low	0
112	Harvard University Wasserstein Hall	Place of Assembly	Low Susceptibility	No	No	High	0
113	Johnson Apts	Elderly Housing	Moderate Susceptibility	No	No	Low	0
114	Kennedy Apts	Elderly Housing	Moderate Susceptibility	No	No	Low	4
115	Malik Academy / Al Bustan Preschool	Child Care	Moderate Susceptibility	No	No	Low	2
116	Roosevelt Towers midrise	Elderly Housing	Moderate Susceptibility	No	No	Low	4
117	Manning Apts	Elderly Housing	Moderate Susceptibility	No	No	Low	0
118	Cambridge Family YMCA - A Child's Place	Child Care	Moderate Susceptibility	No	No	Low	0
119	Cambridge Health Alliance Family Health - Windsor St	Medical	Moderate Susceptibility	No	Harvard Street (Canard) and Hancock Street	Low	2
120	Cambridge Health Alliance Family Health - Inman Square	Medical	Moderate Susceptibility	No	No	Low	0
121	Multi-Service/Community	Place of Assembly	Moderate Susceptibility	No	No	Low	2

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
	Learning Center						
122	Cambridge Health Alliance Administration Offices	Medical	Moderate Susceptibility	No	Harvard Street (Canard) and Hancock Street	Low	2
123	Cambridge Hospital (Main Building)	Hospital	Moderate Susceptibility	No	No	Low	0
124	Cambridge Hospital (Cahill Building)	Hospital	Moderate Susceptibility	No	No	Low	0
125	MIT Information Services Technology (W92)	Emergency Communication Equipment	Moderate Susceptibility	No	No	Low	4
126	Spaulding Rehabilitation Hospital	Medical	Moderate Susceptibility	No	No	Low	0
127	Our Place - Salvation Army	Child Care	Moderate Susceptibility	No	No	Low	2
128	MIT Johnson Athletic Center (W34)	Place of Assembly	Moderate Susceptibility	No	No	Low	2
129	Pine Village Preschool	Child Care	Low Susceptibility	No	No	High	0
130	Youville Assisted Living	Medical	Moderate Susceptibility	No	No	Low	0
131	MIT Nuclear Reactor	Power Generating Plant	Moderate Susceptibility	No	No	Low	2
132	MIT Rockwell Cage (W33)	Place of Assembly	Moderate Susceptibility	No	No	Low	2
133	MIT EHS and SEMO Office (N52)	Emergency Operation Center	Moderate Susceptibility	No	No	Low	2

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
134	MIT Zesiger Sports and Fitness (W35)	Place of Assembly	Moderate Susceptibility	No	No	Low	2
135	MIT Police Station (W89)	Police Station	Moderate Susceptibility	No	No	Low	4
136	MIT Stata Center (32)	Place of Assembly	Moderate Susceptibility	No	No	Low	2
137	Cambridge Senior Center	Medical	Moderate Susceptibility	No	No	Low	0
138	City Hall (Coffon Building)	Municipal Building	Moderate Susceptibility	No	No	Low	0
139	MIT Koch Building (76)	Place of Assembly	Moderate Susceptibility	No	No	Low	2
140	DPW Administration Building	Municipal Building	Moderate Susceptibility	No	No	Low	2
141	City Hall Annex	Municipal Building	Moderate Susceptibility	No	No	Low	0
142	DPW Fuel Pumps	Municipal Building	Moderate Susceptibility	No	No	Low	2
143	DPW Carpentry Shop	Municipal Building	Moderate Susceptibility	No	No	Low	2
144	DPW Main Garage	Municipal Building	Moderate Susceptibility	No	No	Low	2
145	Fire Station Engine 6	Fire Station	Moderate Susceptibility	No	No	Low	0
146	DPW Emergency Operations Center (Backup)	Emergency Operation Center	Moderate Susceptibility	No	No	Low	2
147	MIT Kresge Auditorium (W16)	Place of Assembly	Moderate Susceptibility	No	No	Low	2
148	Frisoli Youth Recreation Center	Municipal Building	Moderate Susceptibility	No	No	Low	2

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
149	MIT Stratton Student Center (W20)	Place of Assembly	Moderate Susceptibility	No	No	Low	2
150	Moore Youth recreation Center	Municipal Building	Moderate Susceptibility	No	No	Low	2
151	Fire Station Engine 5	Fire Station	Moderate Susceptibility	No	No	Low	0
152	Area IV Youth Recreation Center	Municipal Building	Moderate Susceptibility	No	No	Low	0
153	Cambridgeport School	School	Moderate Susceptibility	No	No	Low	2
154	Future site of Cambridge Housing Authority, Community Learning Center and Multi-Service Center	Municipal Building	Moderate Susceptibility	No	No	Low	0
155	Central Square Multi-Level Above Ground Parking Garage	Municipal Building	Moderate Susceptibility	No	No	Low	0
156	City Hall (Lombardi Building)	Municipal Building	Moderate Susceptibility	No	No	Low	0
157	Morse School	School	Moderate Susceptibility	No	No	Low	2
158	Fire Station Engine 2	Fire Station	Moderate Susceptibility	No	No	Low	2
159	Fletcher-Maynard Academy	School	Moderate Susceptibility	No	Harvard Street (Canard) and Hancock Street	Low	2
160	City Hall (Primary)	Municipal	Moderate	No	No	Low	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
		Building	Susceptibility				
161	Dr. Martin Luther King Jr. School (Presently under construction)	School	Moderate Susceptibility	No	No	Low	0
162	Amigos School	School	Moderate Susceptibility	No	No	Low	0
163	King-Open School	School	Moderate Susceptibility	No	No	Low	2
164	(CRLS) High School Extension Program	School	Moderate Susceptibility	No	No	Low	0
165	Dr Martin Luther King, Jr. School (Presently under construction)	School	Moderate Susceptibility	No	No	Low	0
166	Prospect Hill Academy High School	School	Moderate Susceptibility	No	No	Low	4
167	Prospect Hill Academy Middle School	School	Moderate Susceptibility	No	No	Low	4
168	Dr Martin Luther King. Jr School	School	Moderate Susceptibility	No	No	Low	0
169	Henry Buckner School	School	Moderate Susceptibility	No	No	Low	0
170	Cambridge YWCA	Shelter	Moderate Susceptibility	No	No	Low	0
171	240 Albany St Shelter	Shelter	Moderate Susceptibility	No	No	Low	2
172	Johnson Apts	Emergency Communication Equipment	Moderate Susceptibility	No	No	Low	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
173	Farr Academy	School	Moderate Susceptibility	No	No	Low	0
174	MWRA Meter 145 (joint managed MWRA/CWD)	Utilities - Water	Moderate Susceptibility	No	No	Low	0
175	MIT Building W34	Emergency Communication Equipment	Moderate Susceptibility	No	No	Low	2
176	Afterworks	Child Care	Moderate Susceptibility	No	No	Low	0
177	Alef-Bet Child Care Center	Child Care	Moderate Susceptibility	No	No	Low	0
178	Nstar Electric Company	Power Substation	Moderate Susceptibility	No	No	Low	2
179	Bright Horizons Childrens Center-OKS	Child Care	Moderate Susceptibility	No	No	Low	2
180	Area IV Youth Center	Child Care	Moderate Susceptibility	No	No	Low	0
181	Nstar Electric Company (Station 831)	Power Substation	Moderate Susceptibility	No	No	Low	2
182	Cambridge Street Upper School	School	Moderate Susceptibility	No	No	Low	2
183	Benjamin Banneker School	School	Low Susceptibility	No	No	High	0
184	Bright Horizons Children's Center @ University Park	Child Care	Moderate Susceptibility	No	Area 4	Low	2
185	MWRA Meter 146 (joint managed MWRA/CWD)	Utilities - Water	Low Susceptibility	No	Porter Square at Somerville Ave	High	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
186	Associated Early Care and Education/Children's of Cambridge	Child Care	Moderate Susceptibility	No	No	Low	0
187	CAAS Head Start - Windsor Center	Child Care	Moderate Susceptibility	No	Harvard Street (Canard) and Hancock Street	Low	2
188	Nstar Gas Company	Utilities - Gas	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	1
189	Cambridge Nursery School	Child Care	Low Susceptibility	No	No	High	0
190	Cambridge YMCA	Shelter	Moderate Susceptibility	No	No	Low	0
191	CAPI	Child Care	Moderate Susceptibility	No	No	Low	2
192	Cambridge Health Alliance Family Health - Porter Square	Medical	Low Susceptibility	No	No	High	0
193	Salvation Army	Shelter	Moderate Susceptibility	No	No	Low	2
194	North Cambridge Senior Center	Medical	Low Susceptibility	No	No	High	0
195	International School of Boston	School	Low Susceptibility	No	No	High	0
196	Matignon High School	School	Low Susceptibility	No	No	High	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
197	Burns Apartments	Elderly Housing	Low Susceptibility	No	No	High	2
198	DPW Snow Salt Storage Shed	Municipal Building	Low Susceptibility	No	No	High	2
199	Weaver Apts	Assisted Living	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	2
200	Peabody School	School	Low Susceptibility	No	No	High	0
201	Cadbury Commons Assisted Living	Medical	Low Susceptibility	No	No	High	4
202	Fresh Pond Apartments	Emergency Communication Equipment	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	2
203	Sunrise Learning Academy	Child Care	Low Susceptibility	AE	No	High	1
204	Cambridge Friends School	School	Low Susceptibility	No	No	High	0
205	Rindge Ave Upper School	School	Low Susceptibility	No	No	High	0
206	Aggasiz Preschool, Inc.	Child Care	Low Susceptibility	No	No	High	0
207	Fire Station Engine 4	Fire Station	Low Susceptibility	No	No	High	0
208	North Cambridge Children's Center	Child Care	Low Susceptibility	No	No	High	2
209	Rindge Towers	Emergency Communication Equipment	Low Susceptibility	No	No	High	4

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
210	Head Start / Jefferson Park	Child Care	Low Susceptibility	No	No	High	0
211	AT&T	Communication Tower	Moderate Susceptibility	No	East Cambridge	Low	2
212	Verizon	Communication Tower	Moderate Susceptibility	No	East Cambridge	Low	2
213	Verizon	Communication Tower	Moderate Susceptibility	No	No	Low	0
214	Verizon	Communication Tower	Moderate Susceptibility	No	East Cambridge	Low	2
215	Residential High Rise	Emergency Communication Equipment	Moderate Susceptibility	No	No	Low	2
216	Gately Youth Recreation Center	Municipal Building	Low Susceptibility	No	No	High	0
217	Miller River Apartments	Emergency Communication Equipment	Moderate Susceptibility	No	No	Low	2
218	Community Charter School of Cambridge	School	Moderate Susceptibility	No	East Cambridge	Low	2
219	Russell Apts	Elderly Housing	Low Susceptibility	No	No	High	0
220	Putnam School	Elderly Housing	Moderate Susceptibility	No	East Cambridge	Low	0
221	Millers River Apts	Elderly Housing	Moderate Susceptibility	No	No	Low	2
222	Middlesex County Jail	Emergency Communication Equipment	Moderate Susceptibility	No	East Cambridge	Low	0
223	Truman Apts	Elderly Housing	Moderate Susceptibility	No	East Cambridge	Low	2

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
224	East End House Inc.	Child Care	Moderate Susceptibility	No	East Cambridge	Low	0
225	Kennedy-Longfellow School	School	Moderate Susceptibility	No	East Cambridge	Low	2
226	Public School Administration Building	Municipal Building	Moderate Susceptibility	No	East Cambridge	Low	0
227	East Cambridge Multi-Level Above Ground Parking Garage	Municipal Building	Moderate Susceptibility	No	East Cambridge	Low	1
228	Middlesex County Jail	Correctional Facility	Moderate Susceptibility	No	East Cambridge	Low	0
229	Two Little Owls School House	Child Care	Moderate Susceptibility	No	East Cambridge	Low	0
230	Putnam Ave Upper School	School	Moderate Susceptibility	No	East Cambridge	Low	2
231	Frisoli Youth Center	Child Care	Moderate Susceptibility	No	No	Low	2
232	MWRA Prison Point Chemical / Pump Building	Utilities - Water	Moderate Susceptibility	AE	No	Low	0
233	Emergency Communications Center (Backup)	Emergency Operation Center	Moderate Susceptibility	No	East Cambridge	Low	2
234	Cambridge Health Alliance Family Health - East Cambridge	Medical	Moderate Susceptibility	No	No	Low	0
235	Fire Station Engine 3	Fire Station	Moderate Susceptibility	No	East Cambridge	Low	0
236	Technology Children's Center -	Child Care	Moderate Susceptibility	No	No	Low	2

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
	Eastgate						
237	MIT Medical (E23)	Medical Facility	Moderate Susceptibility	No	No	Low	2
238	Gen On Energy	Hazardous Material Site	Moderate Susceptibility	No	No	Low	2
239	Bright Horizons @ One Rogers Street	Child Care	Moderate Susceptibility	No	East Cambridge	Low	2
240	Gen On Energy	Power Generating Plant	Moderate Susceptibility	No	No	Low	2
241	MIT Sloan School (E62)	Place of Assembly	Moderate Susceptibility	No	No	Low	2
242	Cambridge Police Vehicle Maintenance Garage	Municipal Building	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	Alewife Watershed	High	2
243	Cambridge Police Headquarters	Police Station	Moderate Susceptibility	No	East Cambridge	Low	2
244	MIT Central Utility Plant (42)	Public Works Facility	Moderate Susceptibility	No	No	Low	2
245	TSC Tot Child Care Center	Child Care	Moderate Susceptibility	No	No	Low	2
246	MIT Facilities Operations/Repair and Maintenance (E19)	Public Works Facility	Moderate Susceptibility	No	No	Low	2
247	116 Norfolk St	Elderly Housing	Moderate Susceptibility	No	No	Low	0
248	Belmont Hill	Emergency Communication Equipment	Low Susceptibility	No	No	High	0

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
249	Nstar Gas Company	Utilities - Gas	Moderate Susceptibility	No	No	Low	2
250	MWRA Cottage Farm Chemical/Pump Building	Utilities - Water	Moderate Susceptibility	No	No	Low	2
251	MBTA	Emergency Communication Equipment	Moderate Susceptibility	No	No	Low	0
252	Cambridge Water Dept	Dam	Low Susceptibility	No	No	High	0
253	Cambridge Water Dept	Utilities - Water	Low Susceptibility	No	No	High	0
254	Cambridge Water Dept	Utilities - Water	Low Susceptibility	No	No	High	0
255	Cambridge Water Dept	Dam	Low Susceptibility	No	No	High	0
256	Cambridge Water Dept	Utilities - Water	Low Susceptibility	A	No	High	0
257	DPW - Harvard Tunnel Ground Water Pumping Station	Water Pumping Station	Low Susceptibility	No	No	High	0
258	Cambridge Water Dept	Utilities - Water	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	No	High	1
259	Alewife MBTA Station	Transportation Facility	Low Susceptibility	0.2 PCT ANNUAL CHANCE FLOOD HAZARD	Alewife Watershed	High	1

Table 19. Relationship of Critical Infrastructure to Hazard Areas[1]

ID	NAME	Type	Landslide Risk	FEMA Flood Zone	Locally-Identified Flood Area	Annual Snow Fall	Hurricane Surge Category
260	Harvard Square MBTA Station	Transportation Facility	Low Susceptibility	No	Harvard Square	High	0
261	Central Square MBTA Station	Transportation Facility	Moderate Susceptibility	No	No	Low	0
262	Kendall Square MBTA Station	Transportation Facility	Moderate Susceptibility	No	No	Low	2
263	Lechmere MBTA Station	Transportation Facility	Moderate Susceptibility	No	East Cambridge	Low	0

Damage Assessments

An estimation of damages was performed for hurricanes, earthquakes, and flooding. The methodology used for hurricanes and earthquakes was the HAZUS-MH software. The methodology for flooding was developed specifically to address the issue in many of the communities where flooding was not solely related to location within a floodplain.

Introduction to HAZUS-MH

HAZUS- MH (multiple-hazards) is a computer program developed by FEMA to estimate losses due to a variety of natural hazards. The following overview of HAZUS-MH is taken from the FEMA website. For more information on the HAZUS-MH software, go to http://www.fema.gov/plan/prevent/hazus/index.shtm

> "HAZUS-MH is a nationally applicable standardized methodology and software program that contains models for estimating potential losses from earthquakes, floods, and hurricane winds. HAZUS-MH was developed by the Federal Emergency Management Agency (FEMA) under contract with the National Institute of Building Sciences (NIBS). Loss estimates produced by HAZUS-MH are based on current scientific and engineering knowledge of the effects of hurricane winds, floods, and earthquakes. Estimating losses is essential to decision-making at all levels of government, providing a basis for developing and evaluating mitigation plans and policies as well as emergency preparedness, response and recovery planning.
>
> HAZUS-MH uses state-of-the-art geographic information system (GIS) software to map and display hazard data and the results of damage and economic loss estimates for buildings and infrastructure. It also allows users to estimate the impacts of hurricane winds, floods, and earthquakes on populations."

There are three modules included with the HAZUS-MH software: hurricane wind, flooding, and earthquakes. There are also three levels at which HAZUS-MH can be run. Level 1 uses national baseline data and is the quickest way to begin the risk assessment process. The analysis that follows was completed using Level 1 data.

Level 1 relies upon default data on building types, utilities, transportation, etc. from national databases as well as census data. While the databases include a wealth of information on the City of Cambridge, it does not capture all relevant information. In fact, the HAZUS training manual notes that the default data is "subject to a great deal of uncertainty."

However, for the purposes of this plan, the analysis is useful. This plan is attempting to only generally indicate the possible extent of damages due to certain types of natural disasters and to allow for a comparison between different types of disasters. Therefore, this analysis should be considered to be a starting point for understanding potential

damages from the hazards. If interested, communities can build a more accurate database and further test disaster scenarios.

Estimated Damages from Hurricanes

The HAZUS software was used to model potential damages to the community from a 100 year and 500 year hurricane event; storms that are .01% and .005% likely to happen in a given year and roughly equivalent to a Category 2 and Category 4 hurricane. The damages caused by these hypothetical storms were modeled as if the storm track passed directly through the City, bringing the strongest winds and greatest damage potential.

Though there are no recorded instances of a hurricane equivalent to a 500 year storm passing through Massachusetts, this model was included. The model was used in order to present a reasonable "worst case scenario" that would help planners and emergency personnel evaluate the impacts of storms that might be more likely in the future, as we enter into a period of more intense and frequent storms.

Table 20. Estimated Damages from Hurricanes

	100 Year	500 Year
Building Characteristics		
Estimated total number of buildings	18,571	18,571
Estimated total building replacement value (Year 2006 $) (Millions of Dollars)	10,659	10,659
Building Damages		
# of buildings sustaining minor damage	2,081	5,799
# of buildings sustaining moderate damage	591	3,727
# of buildings sustaining severe damage	24	494
# of buildings destroyed	2	76
Population Needs		
# of households displaced	380	2,626
# of people seeking public shelter	96	668
Debris		
Building debris generated (tons)	23,151.57	93,204.9
Tree debris generated (tons)	3,459.43	10,356.1
# of truckloads to clear building debris	922	3750
Value of Damages (Thousands of dollars)		
Total property damage	127,495.59	789,150.28
Total losses due to business interruption	20,149.60	124,429.45

Estimated Damages from Earthquakes

The HAZUS earthquake module allows users to define an earthquake magnitude and model the potential damages caused by that earthquake as if its epicenter had been at the geographic center of the study area. For the purposes of this plan, two earthquakes were selected: magnitude 5.0 and a magnitude 7.0. Historically, major earthquakes are rare in New England, though a magnitude 5 event occurred in 1963.

Table 21. Estimated Damages from Earthquakes

	Magnitude 5.0	**Magnitude 7.0**
Building Characteristics		
Estimated total number of buildings	18,571	18,571
Estimated total building replacement value (Year 2006 $)(Millions of dollars)	10,659	10,659
Building Damages		
# of buildings sustaining slight damage	3,029	1,266
# of buildings sustaining moderate damage	1,202	4,762
# of buildings sustaining extensive damage	231	4,998
# of buildings completely damaged	32	7,376
Population Needs		
# of households displaced	581	24,877
# of people seeking public shelter	355	15,259
Debris		
Building debris generated (tons)	0.100 million	3.350 million
# of truckloads to clear building debris	4,120	134,080
Value of Damages (Millions of dollars)		
Total property damage	597.09	8,864.99
Total losses due to business interruption	69.76	1,835.89

Estimated Damages from Flooding

MAPC did not use HAZUS-MH to estimate flood damages in Cambridge. In addition to technical difficulties with the software, the riverine module is not a reliable indicator of flooding in areas where inadequate drainage systems contribute to flooding even when those structures are not within a mapped flood zone. In lieu of using HAZUS, MAPC developed a methodology to give a rough approximation of flood damages.

Cambridge is 7.13 square miles or 4,563.2 acres. Approximately 774 acres have been identified by local officials as areas of flooding. This amounts to 17% of the land area in the City. The number of structures in each flood area was estimated by applying the percentage of the total land area to the number of structures (18,571) in Cambridge; the same number of structures used by HAZUS for the hurricane and earthquake calculations. HAZUS uses a value of approximately $573,959 per structure for the building replacement value. This was used to calculate the total building replacement value in each of the flood areas. The calculations were done for a low estimate of 10% building damages and a high estimate of 50% as suggested in the FEMA September 2002 publication, "State and Local Mitigation Planning how-to guides" (Page 4-13). The range of estimates for flood damages is *$$181,453,055 (low) - $907,265,277 (high)*. These calculations are not based solely on location within the floodplain or a particular type of storm (i.e. 100 year flood).

Table 22. Estimated Damages from Flooding

ID	Flood Hazard Area	Approximate Area (acres)	% of Total Land Area	Estimated Number of Structures	Replacement Value	Low Estimate of Damages	High Estimate of Damages
1a	Fresh Pond Reservation	8.88	0.20	36	$20,816,846	$2,081,685	$10,408,423
1b	Fresh Pond Reservation	4.87	0.11	20	$11,419,095	$1,141,909	$5,709,547
1c	Fresh Pond Reservation	13.79	0.30	56	$32,316,602	$3,231,660	$16,158,301
2	Alewife Watershed	214.38	4.71	876	$502,547,029	$50,254,703	$251,273,514
3	New Street	11.76	0.26	48	$27,557,844	$2,755,784	$13,778,922
4	Bellis Circle	11.21	0.25	46	$26,282,433	$2,628,243	$13,141,216
5	Vassal Lane/Tobin School	13.77	0.30	56	$32,271,738	$3,227,174	$16,135,869
6	Concord Avenue and Fern Street	9.10	0.20	37	$21,323,388	$2,132,339	$10,661,694
7	Porter Square at Somerville Ave	18.17	0.40	74	$42,600,623	$4,260,062	$21,300,311
8	Harvard Square	9.07	0.20	37	$21,261,157	$2,126,116	$10,630,578
9	Cambridge Cemetery	75.23	1.65	307	$176,357,120	$17,635,712	$88,178,560
10	Agassiz Community	28.78	0.63	118	$67,470,821	$6,747,082	$33,735,411
11	Myrtle Street and Magnolia Avenue	15.06	0.33	62	$35,302,312	$3,530,231	$17,651,156

Table 22. Estimated Damages from Flooding

ID	Flood Hazard Area	Approximate Area (acres)	% of Total Land Area	Estimated Number of Structures	Replacement Value	Low Estimate of Damages	High Estimate of Damages
12	Cambridge Highlands	21.70	0.48	89	$50,861,058	$5,086,106	$25,430,529
13	Area 4	22.67	0.50	93	$53,139,519	$5,313,952	$26,569,760
14	Hancock Street and Kinnaird Street	9.17	0.20	37	$21,498,417	$2,149,842	$10,749,208
15	Green Street at Kennedy Biscuit Lofts	6.84	0.15	28	$16,030,635	$1,603,063	$8,015,317
16	Cardinal Medeiros Ave	20.12	0.44	82	$47,174,906	$4,717,491	$23,587,453
17	East Cambridge	240.36	5.29	982	$563,448,543	$56,344,854	$281,724,272
18	Corcoran Way and May Street	19.13	0.42	78	$44,850,469	$4,485,047	$22,425,235
	Totals		*17.02*	*3161*	*$1,814,530,554*	*$181,453,055*	*$907,265,277*

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V. HAZARD MITIGATION GOALS

The Cambridge Hazard Mitigation Plan Steering Committee met on June 12, 2013. At that meeting, the team reviewed and discussed the goals from the 2008 Hazard Mitigation Plan for the City of Cambridge. After some discussion, the existing goals were updated to reflect the City's objectives with regard to addressing hazard mitigation in the community.

The following 7 goals, with supporting objectives, were endorsed by the Committee for the 2014 update of the Cambridge Hazard Mitigation Plan:

1. Goal: Protect the health and safety of the public.
    - *Encourage people to be prepared before, during and after a hazard event.*
    - *Identify at-risk populations and keep up to date list of locations*
    - *Ensure that services related to public health can function during and after a hazard, e.g., sanitation, water, debris removal, hospitals, and emergency services.*
    - *Ensure that evacuation can happen in an organized and efficient manner.*
    - *Minimize secondary impacts from hazards, such as the release of pollutants.*
2. Goal: Protect existing properties and structures.
    - *Provide resources for residents and businesses to make their buildings and properties more disaster resistant.*
    - *Educate the public on measures they can take to protect their property.*
    - *Maintain existing mitigation structures.*
    - *Ensure that future development / redevelopment does not make existing properties more vulnerable to hazards.*
    - *Ensure that critical facilities are protected from hazards.*
    - *Complete separation of combined sewers*
3. Goal: Ensure that essential services can function during and after a hazard event.
    - *Ensure that critical infrastructure is protected from natural hazards.*
    - *Ensure that people (key service providers and employees) can get into the city to provide services.*
    - *Build resiliency into the system for faster recovery, e.g., electricity distribution system.*
4. Goal: Avoid chaos and confusion with good communication.

- *Have an effective communication plan.*
- *Perform outreach to non-English speakers and other vulnerable populations before, during and after hazard events*
- *Coordinate efforts with the private sector and institutions and with neighboring communities.*

5. Goal: Work regionally to mitigate impacts from natural hazards and to respond and recover from hazard events.
   - *Continue to participate in regional efforts.*
   - *Cooperate with other agencies, communities, and private entities.*
   - *Understand priorities and capabilities of other entities to allow for resource-sharing, mutual aid, and entering into memoranda of understanding (MOU).*
6. Goal: Determine priorities for directing resources for hazard mitigation and response.
   - *Prioritize mitigation projects.*
   - *Continue to program mitigation projects in the 5 and 10 year CIP.*
   - *Pursue various funding sources.*
   - *Encourage private property-owners to implement measures to protect their own property.*
7. Protect natural resources
   - *Identify mitigation strategies that preserve or restore the function of natural systems.*
   - *Protect indigenous wetland areas, undeveloped floodplains and other natural features that provide mitigation of natural hazards.*
   - *Introduce green infrastructure elements, where possible, to reduce impervious surfaces and introduce natural systems.*
8. Create capacity to monitor existing changes
   - *Identify and understand how climate change many alter where and how the City is vulnerable to natural hazards.*
   - *Review and update current mitigation activities to anticipate future changes in vulnerabilities.*
   - *Review and update current emergency preparedness and response activities to anticipate future changes in vulnerabilities.*

VI. HAZARD MITIGATION STRATEGY

The central component of a hazard mitigation plan is the strategy for reducing the community's vulnerabilities to natural hazard events. Responding to the analysis of risk, vulnerabilities, potential impacts, and anticipated future development, the process for developing this strategy is one of setting goals, understanding what actions the community is already taking that contribute to mitigating the effects of natural hazards and assessing where more action is needed to complement or modify existing measures. The following sections include descriptions of existing mitigation measures, a status update on mitigation measures identified in previous plans, and descriptions of proposed new mitigation measures. All mitigation measures are evaluated by their benefits and potential costs to arrive at a prioritized list of action items.

WHAT IS HAZARD MITIGATION?

Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries, and property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, education programs, infrastructure projects, and other activities. FEMA currently has three mitigation grant programs: the Hazards Mitigation Grant Program (HGMP), the Pre-Disaster Mitigation program (PDM), and the Flood Mitigation Assistance (FMA) program. The three links below provide additional information on these programs.

http://www.fema.gov/government/grant/hmgp/index.shtm

http://www.fema.gov/government/grant/pdm/index.shtm

http://www.fema.gov/government/grant/fma/index.shtm

Hazard Mitigation Measures can generally be sorted into the following groups:

- Prevention: Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. These actions also include public activities to reduce hazard losses. Examples include planning and zoning, building codes, capital improvement programs, open space preservation, and stormwater management regulations.
- Property Protection: Actions that involve the modification of existing buildings or infrastructure to protect them from a hazard or removal from the hazard area. Examples include acquisition, elevation, relocation, structural retrofits, flood proofing, storm shutters, and shatter resistant glass.
- Public Education & Awareness: Actions to inform and educate citizens, elected officials, and property owners about the potential risks from hazards and potential

ways to mitigate them. Such actions include outreach projects, real estate disclosure, hazard information centers, and school-age and adult education programs.

- Natural Resource Protection: Actions that, in addition to minimizing hazard losses also preserve or restore the functions of natural systems. These actions include sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
- Structural Projects: Actions that involve the construction of structures to reduce the impact of a hazard. Such structures include storm water controls (e.g., culverts), floodwalls, seawalls, retaining walls, and safe rooms.
- Emergency Services Protection: Actions that will protect emergency services before, during, and immediately after an occurrence. Examples of these actions include protection of warning system capability, protection of critical facilities, and protection of emergency response infrastructure.

(Source: FEMA Local Multi-Hazard Mitigation Planning Guidance)

EXISTING MITIGATION MEASURES

Existing Multi-Hazard Mitigation Measures

City Of Cambridge Emergency Preparedness - Includes the City performing as an emergency preparedness entity and preparation of comprehensive emergency management plan (CEMP) in both hard copy and electronic versions. The City leads the Local Emergency Planning Committee (LEPC), which in comprised of city officials, private sector representatives, and college and university representatives.

The city uses a reverse 911 flexible communications systems to send alerts and other communications related to emergency preparedness and response. The city also maintains an emergency management website to provide the public with information and resources related to emergency preparedness and response.

Enforcement of the State Building Code – The Massachusetts State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing and snow loads.

City of Cambridge Fire Department (CFD) – The CFD Hazmat Unit that is continuously trained to respond to and manage hazmat incidents. Fire Department also responds to all threats and hazards (e.g. fire, explosions, chemical spills, CBRNE incidents).

City of Cambridge Public Health Department (CPHD) – The CPHD works with other local and regional agencies to enhance public preparedness to major hazards. CPHD operates

a Medical Reserve Corps, serve as co-lead (with CFD) in response to biological threats, coordinates the regional public health preparedness region (4B), and participates in citywide tabletop exercises.

Massachusetts Institute of Technology (MIT) Emergency Preparedness - Includes MIT acting as an emergency preparedness entity and includes: testing and analyzing various disaster scenarios, performing exercises to improve disaster response and a full-time emergency coordinator that is a liaison to city.

Harvard University Emergency Preparedness - Includes the University acting as an emergency preparedness entity and administering an incident management committee, trainings, and individual plans for specific events.

Existing Flood Hazard Mitigation Measures

Catch basin cleaning, maintenance and repairs - Catch basins are normally cleaned on the same day street sweeping occurs on a particular street. Crews typically clean over 50% of catch basins per year in the city. The city responds to requests to clean basins during storms; typically those requests are for a basin already on a repair list or a basin with a lateral connection defect. There are approximately 4,300 catch basins in Cambridge.

Street cleaning and litter pick-up -The Street Cleaning Division is responsible for maintaining clean public ways through a contractual street sweeping operation (currently Millennium Sweeping Services) which runs from April through December each year. Cleaning through the end of December ensures the cleanliness of Cambridge streets through the early winter months. Vacuum sweeping occurs in combination with mechanical street sweeping.

One contractor with two sweepers is used to clean both residential streets and major city squares. In the major squares (e.g., Harvard, Porter, Central, etc.) cleaning occurs 7 days a week. City also maintains Fresh Pond Parkway, which is a DCR facility.

Zoning: Flood Plain Overlay District, Article 19 review, & Permeable Open Space Requirements - This district applies to the 100 year flood plain and requires a special permit from the Planning Board for any structure or building that is constructed, expanded, etc., or for dumping, filling, excavation, etc., within the flood plain.

Two sections (Articles 5.22 and 19) require a minimum amount of permeable open space. Between these two provisions, this requirement applies to virtually all new development, except non-residential development below 25,000 square feet in size. Zoning in the City is administered by the Community Development Department (CDD).

Development Runoff Controls – The City requires that developments store the difference in volume between 2 year 24 hour storm event pre-development runoff & post-development 25 year 24 hour storm event runoff hydrograph through its stormwater policy.

Capital Infrastructure Programming – The City develops and maintains 5- and 10-year capital infrastructure program objectives for municipal storm sewer infrastructure.

Massachusetts Water Resources Authority (MWRA) Review - The MWRA reviews large developments (through State MEPA process) to reduce potential impacts, including system flooding

Public education: Floodplain Information – The City holds meetings and develops brochures to provide the public with information about flood hazard maps and related resources.

Storm Sewer and Drainage Infrastructure Regular Maintenance – The City performs remedial reconstruction of storm sewer and drainage infrastructure, a cleaning program for combined sewer overflows (CSOs) and televised reviews to check on physical condition of structures.

Mapping of Catch Basins and Outfalls: Cambridge- Cambridge uses GPS to map its catch basins and stormwater outfalls.

Mapping of Catch Basins and Outfalls: Division of Conservation and Recreation (DCR) - DCR uses GPS to map its catch basins and stormwater outfalls.

Regular Catch Basin Cleaning and Street Sweeping: DCR -DCR performs catch basin cleaning and street sweeping for DCR property and roadways in Cambridge, with the exception of Fresh Pond Parkway

Cambridge Water Department (CWD) activities in water supply watershed communities - The CWD reviews proposed development projects in watershed communities; visits construction sites and meets with developers; and with USGS jointly collects technical information, including real-time stream information; and review/repair to hurricane gates.

Participation in the National Flood Insurance Program - FEMA maintains a database on flood insurance policies and claims. This database can be found on the FEMA website at http://www.fema.gov/business/nfip/statistics/pcstat.shtm. The reporting period covers January 1, 1978 through December 31, 2014. The following information is provided for the City of Cambridge.

Flood insurance policies in force (as of October 31, 2013)	244
Coverage amount of flood insurance policies	$83,446,600
Premiums paid	$229,362
Total losses (all losses submitted regardless of the status)	58
Closed losses (Losses that have been paid)	38
Open losses (Losses that have not been paid in full)	1
CWOP losses (Losses that have been closed without payment)	19
Total payments (Total amount paid on losses)	$1,938,977.89

Existing Dam Hazard Mitigation Measures

Dam Inspections - Dams are inspected every 2 years by CWD staff. The CWD staff are also trained to anticipate large storms so that control gates can release water appropriately.

Review of Regional Dams - Through the Vulnerability Assessment, the city is assessing the risk of overtopping or bypass for the Amelia Earhart and Charles River dams under climate change scenarios and evaluating the potential impacts.

Existing Wind Hazard Mitigation Measures

GIS layer of trees - The city has created a geographic information system (GIS) layer of trees in the public right of way, which is updated at least on an annual basis through crews working in the field. The city is also completing a tree canopy study to compliment the street tree data.

Management of damaged trees - The Urban Forestry Division is well trained to handle downed limbs and response time has been very good. Currently the city is equipped with several vehicles to deal with any tree issue including bucket and crane trucks, chippers, and stump grinders. The crew mobilizes for major emergencies.

The city has contracts in place to support the forestry division. These contracts include dealing with debris, which specifically addresses wood products, and regular pruning of street trees. The city also has working relationship with NStar to determine where structural pruning is needed in relation to overhead utilities.

Preventative tree maintenance: pruning, treating, planting, protecting trees - The city's Urban Forestry Division provides high quality tree care along city rights-of-way, in parks, and around public buildings. The staff is dedicated to pruning, treating, planting, and protecting trees using the most current arboricultural and safety standards. The staff is led by the City Arborist, who directs two crews, each with a Tree Climber and Forestry Worker (on-ground). These personnel handle the acute hazards, routine pruning requests made by the public, and respond to storm events.

Public education - The city has created a brochure, "Residential Street Tree Planting and Care," as well as additional materials to inform residents about tree maintenance.

Building code - The building code provides structural protections from high winds.

Inspection of construction sites prior to forecasted storms - To minimize damage at construction sites, the city communicates and coordinates with active construction sites prior to forecast storms and recommends measures for contractors to take to minimize potential damage.

Existing Winter Hazard Weather Mitigation Measures

Routine snow operations - The city has operations in place for clearing snow, salting, etc. DPW goals to chemically treat all major arteries within 3 hours of start of snow (prioritizing most traveled roads), plow main arteries throughout storm, clear all streets and sidewalks bordering city property once snow has stopped.

The City uses salt & calcium chloride instead of sand on roads in winter. The city previously used sand on roads during snow storms, but the sand tended to clog catch basins and caused sedimentation. The city has stopped using sand and now relies on salt and calcium chloride.

Snow emergency plan: Cambridge - The city implements emergency parking bans prior to predicted major snow storms. The ban is communicated via electronic and social media, and maps for the parking ban locations are available on the city's website.

Storm Management Plan: DCR - DCR has a Storm Management Plan, with plans and schedules for snow removal. DCR partnered with the Massachusetts Department of Transportation (MassDOT) to share snow removal responsibility with the City.

Public education - The city has created "Snow: Our Winter Challenge" brochure to inform the public about preparing for and responding to winter storms.

Council on Aging Outreach – The Council on Aging can provide residents with contact information for students for hire for snow shoveling.

Existing Extreme Temperature Hazard Mitigation Measures

Local Coordination and Protocols: Extreme Heat and Cold - Various entities cooperate to address vulnerable populations during extreme cold and a protocol is in place to delineate efforts and responsibilities. Heat vulnerability is being assessed under the climate change vulnerability assessment.

Shelter Protocols: Extreme Heat - The city has a cool shelter for elderly residents.

Public Outreach: Extreme Heat - The City conducts public outreach during heat emergencies along with other entities such as Professional Ambulance.

Existing Geological Hazard Mitigation Measures

Building code - New construction, as well as construction that includes significant upgrades, must abide by the state building code seismic requirements.

Existing Brush Fire Hazard Mitigation Measures

Outdoor Burning Ban - The city does not allow outdoor burning.

Existing Mosquito-borne Disease Hazard Mitigation Measures

Cambridge West Nile Response Plan – Cambridge (through the CPHD, DPW and Inspectional Services Department [ISD]), in partnership with Eastern Middlesex Mosquito Control Project (EMMCP), created a West Nile Response Plan. The city and EEMCP collect dead birds and send them to the State for testing. The Department of Public Health (DPH) reviews site plans for certain development proposals. The city Inspectional Services Department responds to habitat concerns on construction sites. EMMCP at the city's direction treats land and right-of-ways for mosquito control.

Public Education - The city (through the CPHD, DPW, CDD, and ISD) provides public education through brochures, community events, informal phone inquiries, signage in parks, and trained city staff. The city also uses the web and social media to communicate information about reducing the risks for mosquito-borne diseases.

Existing Drought Hazard Mitigation Measures

In the 1980;s the city developed a Drought Management Plan in conjunction with the Massachusetts Water Resources Authority. The Cambridge Water Department is currently updating the plan, and it is expected to be completed in 2016.

Existing Climate Change Hazard Mitigation Measures

Climate Protection network - The city is part of the ICLEI Cities for Climate Protection network.

Climate Protection plans - The City has developed new climate protection goals and objectives and is engaged in a climate change vulnerability assessment and preparedness plan project.

Climate Protection Action Committee - This advisory committee helps the city carry out its climate protection plan and meet the city's goal of reducing greenhouse gas emissions and advancing preparedness recommendations.

Climate Change Vulnerability Assessment - The city is undertaking a climate change vulnerability assessment, which will serve as the foundation for a climate change resilience and adaptation plan.

Table 23. Cambridge Existing Mitigation Measures

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
EXISTING MULTI-HAZARD MITIGATION MEASURES			
City Of Cambridge Emergency Preparedness	City-wide	Effective. *Emphasis is on emergency preparedness and response.*	None
City of Cambridge Fire Department (CFD)	City-wide	Effective. *Emphasis is on emergency preparedness and response.*	None
City of Cambridge Public Health Department (CPHD)	City-wide	Effective. *Emphasis is on emergency preparedness and response.*	None
Massachusetts State Building Code	City-wide.	Effective for new construction. Many buildings in the City pre-date the most recent, more stringent requirements.	None.
Massachusetts Institute of Technology (MIT) Emergency Preparedness	MIT Campus	Effective. *Emphasis is on emergency preparedness and response.*	None
Harvard University Emergency Preparedness	Harvard Campus	Effective. *Emphasis is on emergency preparedness and response.*	None
EXISTING FLOOD HAZARD MITIGATION MEASURES			
Catch basin cleaning, maintenance and repairs	City-wide	Effective. *Emphasis is on prevention.*	None

Table 23. Cambridge Existing Mitigation Measures

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
Street cleaning and litter pick-up	City-wide	Effective. *Emphasis is on prevention.*	None
Zoning: Flood Plain Overlay District, Article 19 review, and Permeable Open Space Requirements	City-wide	Effective. *Emphasis is on prevention.*	Revised FEMA FIRMs adopted in 2010.
Development Runoff Controls	City-wide	Effective. *Emphasis is on prevention.*	None
Capital Infrastructure Programming	City-wide	Effective. *Emphasis is on structural projects.*	None
Massachusetts Water Resources Authority (MWRA) Review	City-wide	Effective. *Emphasis is on prevention.*	None
Public education: Floodplain Information	City-wide	Effective. *Emphasis is on public education and awareness.*	None
Storm Sewer and Drainage Infrastructure Regular Maintenance	City-wide	Effective. *Emphasis is on prevention.*	None
Mapping of Catch Basins and Outfalls: Cambridge	City-wide	Effective. *Emphasis is on prevention.*	None
Mapping of Catch Basins and Outfalls: Division of Conservation and Recreation (DCR)	DCR facilities and properties	Effective. *Emphasis is on prevention.*	None
Regular Catch Basin Cleaning and Street Sweeping: DCR	DCR facilities and properties	Effective. *Emphasis is on prevention.*	None
Cambridge Water Department (CWD) activities in water supply watershed communities	Regional	Effective. *Emphasis is on prevention.*	*None*

Table 23. Cambridge Existing Mitigation Measures

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
Participation in the National Flood Insurance Program	City-wide	Effective. *Emphasis is on prevention.*	*None*
EXISTING DAM-RELATED HAZARD MITIGATION MEASURES			
Water supply watershed communities	Regional	Effective. *Emphasis is on prevention.*	*None*
Review of regional dams	Regional; Area potentially inundated by dam breach	Effective. *Emphasis is on prevention.*	*None*
EXISTING WIND-RELATED HAZARD MITIGATION MEASURES			
GIS layer of trees	City-wide	Effective. *Emphasis is on prevention.*	None
Management of damaged trees	City-wide	Effective. *Emphasis is on prevention.*	None
Preventative tree maintenance: pruning, treating, planting, protecting trees	City-wide	Effective. *Emphasis is on prevention.*	None
Public education	City-wide	Effective. *Emphasis is on public education and awareness.*	None
Building code	City-wide	Effective. *Emphasis is on prevention.*	None
Inspection of construction sites prior to forecasted storms	City-wide	Effective. *Emphasis is on prevention.*	None

Table 23. Cambridge Existing Mitigation Measures

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
EXISTING WINTER-RELATED HAZARD MITIGATION MEASURES			
Routine snow operations	City-wide	Effective. *Emphasis is on prevention.*	None
Snow emergency plan: Cambridge	City-wide	Effective. *Emphasis is on emergency response.*	None
Storm Management Plan: DCR	City-wide, DCR properties and facilities	Effective. *Emphasis is on emergency response.*	None
Public education	City-wide	Effective. *Emphasis is on public education and awareness.*	None
Council on Aging Outreach	City-wide	Effective. *Emphasis is on public education and awareness.*	None
EXISTING EXTREME TEMPERATURE-RELATED HAZARD MITIGATION MEASURES			
Local Coordination and Protocols: Extreme Heat and Cold	City-wide	Effective. *Emphasis is on emergency response.*	None
Shelter Protocols: Extreme Heat	City-wide	Effective. *Emphasis is on emergency response.*	None
Public Outreach: Extreme Heat	City-wide	Effective. *Emphasis is on public education and awareness.*	None

Table 23. Cambridge Existing Mitigation Measures

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
EXISTING GEOLOGICAL HAZARD MITIGATION MEASURES			
Building code	City-wide	Effective. *Emphasis is on prevention.*	None
EXISTING BRUSH FIRE HAZARD MITIGATION MEASURES			
Outdoor Burning Ban	City-wide	Effective. *Emphasis is on public education and awareness.*	None
EXISTING MOSQUIT0-BORNE DISEASE-RELATED HAZARD MITIGATION MEASURES			
Cambridge West Nile Response Plan	City-wide	Effective. *Emphasis is on prevention.*	*Difficult to change regulations for the treatment of catch basins. Looking to push toward contractors and potential relax regulations.*
Public Education	City-wide	Effective. *Emphasis is on public education and awareness.*	None
EXISTING DROUGHT HAZARD MITIGATION MEASURES			
Drought Management Plan	City-wide	Out of date. .	Plan is being updated, will be completed in 2016
MWRA Emergency Water Connection	City-wide	Effective.	None

Table 23. Cambridge Existing Mitigation Measures

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
EXISTING CLIMATE CHANGE-RELATED HAZARD MITIGATION MEASURES			
Climate Protection network	City-wide	Effective. *Emphasis is on prevention.*	None
Climate Protection plans	City-wide	Effective. *Emphasis is on prevention.*	None
Climate Protection Action Committee	City-wide	Effective. *Emphasis is on prevention.*	None
Climate Change Vulnerability Assessment	City-wide	Effective. *Emphasis is on prevention.*	None

Implementation Progress on Previous Plans

At a meeting of the Cambridge Hazard Mitigation Steering Committee, City staff reviewed the mitigation measures identified in the 2008 Metro Boston Regional Pre-Disaster Mitigation Plan Cambridge Annex and determined whether measures identified in the plan had been implemented or deferred. For implemented projects, they were categorized as either complete or ongoing, with the latter referring to projects were still under development or had begun but not yet completed. If measures had been deferred, the committee evaluated whether the measure should be deleted or carried forward into the 2014 Cambridge Hazard Mitigation Plan. The decision on whether to delete or retain a particular measure was based on the committee's assessment of the continued relevance or effectiveness of the measure and whether the deferral of action on the measure was due to the inability of the City to take action on the measure.

Priority setting for the 2008 plan was based on local knowledge of the hazard areas, cost information and an assessment of benefits. Committee members first individually identified their top priorities and then the committee came to consensus on priority level assignments for each measure based on the cumulative results of each member's selection.

Table 24. Mitigation Measures from the 2008 Plan

Mitigation Measures	Priority	Implementation Responsibility	2014 Status
Complete hydraulic modeling for city	High	DPW	In progress *Substantial portions of the city are already modeled. Approximately 40% has a detailed model and work is continuing to include the remainder of the city.*
Complete new stormwater regulations & update guidelines	High	DPW	Complete
Continue to program flood mitigation & sewer separation projects in CIP.	High	DPW	In progress *Projects continue through engineering and design, and the city is seeking funding for construction.*
Continue remedial reconstruction city-wide/Upgrade aging infrastructure	High	DPW	In progress *225 miles of sewer pipe have been addressed. Improvements being constructed as part of 5 year plan which priorities changes based on condition of street and infrastructure.*
Help private landowners install back flow preventers in targeted areas.	Medium	DPW	Complete *Received grant and provided private landowners with one-on-one technical assistance and produced brochure.*

Table 24. Mitigation Measures from the 2008 Plan

Mitigation Measures	Priority	Implementation Responsibility	2014 Status
Install SCADA system at Fresh Pond to allow remote monitoring & control of elevations at Little Fresh Pond	High	DPW	In progress *Improvement under construction and in the future there may be an expansion to other water systems in city.*
Sewer separations and stormwater management: - East of Fresh Pond Pkwy (area #6) - Between Concord Ave. rotaries & New St. (area #5)	High	DPW	In progress *Under design with separations to be completed by 2016.*
Complete stormwater infrastructure at golf course	High	DPW/CWD	Complete
Sewer separation (CAM 002 CSO area), Porter Square	High	DPW	In progress *Project under development with separation to occur in the future following other separation projects in city*
Improve collection & conveyance system east of 2nd St & north of Charles St. (area #27)	High	DPW	In progress *Project under development with separation to occur in the future following other separation projects in city.*
Implement additional stormwater management measures, School, Pine, Cherry Streets, Windsor (area #26)	High	DPW	In progress *Planned improvements delayed due to additional design work.*

Table 24. Mitigation Measures from the 2008 Plan

Mitigation Measures	Priority	Implementation Responsibility	2014 Status
Implement CAM017 Stormwater Management Program near Tremont & Norfolk Sts (area #25)	High	DPW	Complete
Complete Cambridgeport / CAM017 stormwater management program, Newton, Green, Franklin & Sydney streets (area #28)	High	DPW	In progress *Planned improvements part of 15 year stormwater system improvement plan.*
Complete CAM011 sewer separation & stormwater management program - Irving, Bryant, Crescent, Carver, Sacramento (areas 16, 17) - Kirkland, Myrtle, Magnolia, Cambridge (areas #18, 19) - Ellery St. & Broadway (area # 24)	High	DPW	Partially Complete *Improvements completed with exception of Kirkland, Myrtle, Magnolia, and Cambridge, which will complete in the near future.*
Investigate potential hazardous releases due to any/all natural hazard	High	DPH/Fire Dept.	Complete

Table 24. Mitigation Measures from the 2008 Plan

Mitigation Measures	Priority	Implementation Responsibility	2014 Status
Pursue a more aggressive program to replace older water mains (minimize bursts in cold weather)	High	CWD	In progress *CWD has an ongoing program to replace older water infrastructure through the City.*
Emergency & evacuation plan that spells out roles. Include options for residents without cars	High	EMD	Complete
Develop comprehensive communications plan. Include communication with non-English speakers	High	EMD	Complete
Assess risks to infrastructure including electric, gas, & steam distribution & MBTA subway system	High	DPW	In progress *Work to assess risks occurring as part of ongoing Climate Change Vulnerability Assessment.*
Have a power-loss plan for major power outages	High	Electrical Dept.	In progress *City communicates with N-Star to evaluate outage impact and restoral time.*
Develop MOU between cities, universities, etc., that provides shared access to resources	High	Various	In progress Ongoing *City and universities have informal agreement for sharing resources, such as access to equipment and sheltering locations.*

Table 24. Mitigation Measures from the 2008 Plan

Mitigation Measures	Priority	Implementation Responsibility	2014 Status
Ensure public ROWs are properly maintained & accessible so essential services and deliveries can continue	High	DPW	In progress *City performs regular maintenance of public ways, and additional work is performed prior to storm events to make sure ways are clear or debris and accessible.*
Provide facility for parents to bring infants during heat emergency	Medium	DHSP, EMD	In progress *Services primarily focused on seniors but discussion continues about including other vulnerable population groups.*
Improve communications between City Departments & between universities & the City	Medium	Various	In progress *City and universities, as well as private sector businesses, communicate regularly through the LEPC as well as in relation to specific public events in the city.*
Provide opportunities for "knowledge exchanges" between city agencies & private interests, such as universities on issues relating to hazards	Medium	EMD	In progress *See above, and the City, Universities, and private interests hold joint table top event response exercises during each year.*
Establish funding program for residential structural improvements / flood proofing	Medium	DPW	In progress *The City has not pursued development of a funding program but continues to review the option and distributes information about structural improvements / flood proofing to residents.*

Table 24. Mitigation Measures from the 2008 Plan

Mitigation Measures	Priority	Implementation Responsibility	2014 Status
Maintain, protect, & exercise connection between City's water system & MWRA to ensure operability during emergencies	Medium	CWD	Complete *This activity has been performed and the City and the Water Department continue to review and exercise the connections on a regular basis.*
Locate critical shut-off's for gas, electricity, etc. so they can be located under snow	Medium	DPW	In progress *N-Star has been installing remote switching for electrical system reliability.*
Identify measures to adapt state dams to withstand storm surge of major hurricanes	Medium	DCR/ State	In progress *Work to assess risks occurring as part of ongoing Climate Change Vulnerability Assessment*
Determine vulnerability of roadways and utilities to earthquakes in the high liquefaction areas	Medium	EMD	In progress *Issue still under consideration by Inspectional Services and DPW*
Provide generator at cool shelter or provide back-up shelter	Medium	Electrical Dept.	In progress *The City at this time does not have a mobile generator.*
Ensure public facilities have back-up generators & staff are trained to use & maintain generators	Medium	Electrical Dept.	Complete *Performed in coordination with updating of Critical Infrastructure list.*
Ensure generators are located in areas protected from hazards	Medium	Electrical Dept., DPW	In progress *Work to assess risks occurring as part of ongoing Climate Change Vulnerability Assessment*

Table 24. Mitigation Measures from the 2008 Plan

Mitigation Measures	Priority	Implementation Responsibility	2014 Status
Improve response time by private utilities, especially electrical due to live wire hazards	Medium	Private utilities	In progress *Cambridge Electrical Department regularly meets with utilities to discuss response time and strategies, including meetings in advance of predicted storms.*
Complete SCADA & encourage other depts. to use	Medium	DPW	In progress *DPW in the process of implementing system for public infrastructure in city.*
Develop staffing plan for sustained winter events	Medium	DPW	In progress *Draft plan under development*
Improve energy efficiency of buildings & facilities to address climate change	High	DPW/ CDD	Partially Complete *The city was designated a Green Community by the state in 2010 and work continues to improve energy efficiency in municipal buildings and programs.*
Encourage purchase of fleet & private vehicles with higher fuel economy. Use biodiesel for all city owned diesel vehicles & equipment. Utilize improved vehicle emission technology. (climate change)	High	DPW/ CWD/ CDD	Complete *The city has a 'green fleet' policy and procedures in place for purchasing of new municipal vehicles.*

Table 24. Mitigation Measures from the 2008 Plan

Mitigation Measures	Priority	Implementation Responsibility	2014 Status
Improve communication so city is aware when levels at the Charles River Dam change	Medium	DPW	In progress Ongoing *The city is in ongoing conversations with DCR and other agencies involved and potentially impacted by the dam.*
Reduce impervious area through pavement replacement, green roofs, & use of low impact development (LID) techniques	Medium	CDD/ DPW	In progress *The city has ordinances and policies in place to encourage reduction of impervious areas and encourage LID practices.*
Expand City catch basin cleaning & repairs with more equipment & more staff	Medium	DPW	Complete *The city has increased the frequency of cleaning and evaluating catch basins, and is continuing to do so.*
Public education on post-flooding risks. E.g., mold issues, structural impacts due to dampness or flooding, etc.	Medium	DPH	In progress *The city provides materials on these topics to residents and businesses.*
Hurricane surge zone modeling is based on topography. Need research based on actual drainage issues to see if surge zone is different than this model.	Medium	DPW	In progress *City is currently reviewing updated draft surge zone and evacuation maps and preparing comments about proposed map modifications and related information.*

Table 24. Mitigation Measures from the 2008 Plan

Mitigation Measures	Priority	Implementation Responsibility	2014 Status
Improve snow-fighting equipment	Medium	DPW	In progress *City is currently reviewing options related to snow disposal, especially in cases of large snowfall events.*

The City of Cambridge's staff continually demonstrates commitment and a high level of professionalism with regard to addressing natural hazard mitigation needs in order to prevent impact from natural hazard events and protect the lives and property of the residents and businesses located in the City. As has been previously stated, flooding represents the greatest hazard for the community and staff diligently maintains drainage structures and enforces the regulations that contribute to minimizing the potential impacts of this hazard, within the resources available. The action items identified above represented a wish list of activities that would further reduce hazard risks, but the ability to implement improvements, especially capital investments, was highly dependent on the availability of greater resources.

2014 HAZARD MITIGATION STRATEGY

What is Hazard Mitigation?

Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries, and property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, education programs, infrastructure projects, and other activities. FEMA currently has three mitigation grant programs: the Hazards Mitigation Grant Program (HGMP), the Pre-Disaster Mitigation program (PDM), and the Flood Mitigation Assistance (FMA) program. The three links below provide additional information on these programs.

http://www.fema.gov/government/grant/hmgp/index.shtm

http://www.fema.gov/government/grant/pdm/index.shtm

http://www.fema.gov/government/grant/fma/index.shtm

Hazard Mitigation Measures can generally be sorted into the following groups:

- Prevention: Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. These actions also include public activities to reduce hazard losses. Examples include planning and

zoning, building codes, capital improvement programs, open space preservation, and stormwater management regulations.

- Property Protection: Actions that involve the modification of existing buildings or infrastructure to protect them from a hazard or removal from the hazard area. Examples include acquisition, elevation, relocation, structural retrofits, flood proofing, storm shutters, and shatter resistant glass.
- Public Education & Awareness: Actions to inform and educate citizens, elected officials, and property owners about the potential risks from hazards and potential ways to mitigate them. Such actions include outreach projects, real estate disclosure, hazard information centers, and school-age and adult education programs.
- Natural Resource Protection: Actions that, in addition to minimizing hazard losses also preserve or restore the functions of natural systems. These actions include sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
- Structural Projects: Actions that involve the construction of structures to reduce the impact of a hazard. Such structures include storm water controls (e.g., culverts), floodwalls, seawalls, retaining walls, and safe rooms.
- Emergency Services Protection: Actions that will protect emergency services before, during, and immediately after an occurrence. Examples of these actions include protection of warning system capability, protection of critical facilities, and protection of emergency response infrastructure.

(Source: *FEMA Local Multi-Hazard Mitigation Planning Guidance*)

Proposed Hazard Mitigation Measures

Flood Hazard Mitigation Measures

A) Complete hydraulic modeling for city
B) Complete sewer separation and stormwater management program for Kirkland Street, Myrtle Street, Magnolia Street and Cambridge Street (CAM[2] 011, areas #18 and 19)
C) Complete sewer separation and stormwater management program for areas east of Fresh Pond Pkwy (area #6) and between Concord Avenue rotaries and New Street (area #5)
D) Complete sewer separation at Porter Square (CAM 002 CSO area)
E) Improve collection and conveyance system at area east of 2nd Street and north of Charles Street (area #27)
F) Implement additional stormwater management measures: School, Pine, Cherry and Windsor Streets (area #26)

[2] CAM = Outfall designation (with associated ID number)

G) Complete Cambridgeport stormwater management program: Newton, Green, Franklin and Sidney Streets (CAM 017, area #28)
H) Complete sewer separation and stormwater management program for Irving, Bryant, Crescent, Carver and Sacramento Streets (CAM011, areas #16 and 17)
I) Complete sewer separation and stormwater management program for Ellery Street and Broadway (CAM011, area #24)
J) Establish funding program for residential structural improvements and flood proofing to support flood prevention for homes in the City

Measures to Ensure Compliance with NFIP

K) Floodplain Management - Continue to enforce the relevant zoning (Flood Plain Overlay District, Article 19 review and Permeable Open Space Requirements) and associated building regulations for floodplain areas. Update this district to remain consistent with FEMA guidelines and floodplain mapping.
L) Floodplain Mapping - Maintain up to date maps of local FEMA identified floodplains.

Winter Storm Hazard Mitigation Measures

M) Expand program to clear snow and maintain public ROWs (e.g., travel ways for non-vehicular mobility and access for vulnerable populations)

Geologic Hazard Mitigation Measures

N) Determine vulnerability of roadways and utilities to earthquakes in the high liquefaction areas

Extreme Temperature Mitigation Measures

O) Provide facility for additional vulnerable populations (such as disabled populations and in addition to senior residents) during extreme temperature event

Wind Mitigation Measures

P) Increase public education on the benefits and proper care of trees on private property

Climate Change Mitigation Measures

Q) Complete Climate Change Vulnerability Assessment

R) Complete Climate Change Adaptation Plan

S) Encourage installation of solar photovoltaic systems, cogeneration, and other energy supplies to improve energy reliability and resilience
T) Encourage energy efficiency in buildings through zoning requirements for new development and community outreach for existing buildings.

Other Hazard Mitigation Measures

U) Review evacuation protocols to identify any potential changes that may be needed for communications, preparedness and response protocols

V) Develop program for enhanced staffing for disaster recovery (e.g., flexing of municipal staff for short-term duty in emergency preparedness and response events)

W) Ensure generators are located in areas protected from hazards (e.g., elevated above potential flood levels).

X) Conduct maintenance activities to monitor and reduce brushfire risks

Prioritization of Mitigation Activities

The last step in developing the City's mitigation strategy is to assign a level of priority to each mitigation measure so as to guide the focus of the City's limited resources towards those actions with the greatest potential benefit. At this stage in the process, the Hazard Mitigation Committee has limited access to detailed analyses of the cost and benefits of any given measure, so prioritization is based on the committee member's knowledge of the existing and potential hazard impacts and an approximate sense of the costs associated with pursuing any given measure.

Prioritization occurred through discussion at the third and fourth meetings of the committee and through subsequent review by committee members and public comment. Priority setting was based on local knowledge of the hazard areas, including impacts of hazard events and the extent of the area impacted and the relation of a given mitigation measure to the City's identified goals. In addition, through the discussion, the local committee also took into consideration factors such as the number of homes and businesses affected, whether or not road closures occurred and what impact closures had on delivery of emergency services and the local economy, anticipated project costs, whether the City currently had the technical and administrative capability to carry out the mitigation measures, whether any environmental constraints existed, and whether the City would be able to justify the costs relative to the anticipated benefits.

Table 23 below demonstrates the prioritization. For each mitigation measure, the geographic extent of the potential benefiting area is identified as is an estimate of the overall benefit and cost of the measures. The benefits and costs were evaluated in terms of:

Benefits

High	Action will result in a significant reduction of hazard risk to people and/or property from a hazard event
Medium	Action will likely result in a moderate reduction of hazard risk to people and/or property from a hazard event
Low	Action will result in a low reduction of hazard risk to people and/or property from a hazard event

Costs

High	Estimated costs greater than $50,000
Medium	Estimated costs between $10,000 to $50,000
Low	Estimated costs less than $10,000 or staff time

Priority

High	Action very likely to have political and public support and necessary maintenance can occur following the project, and the costs seem reasonable considering likely benefits from the measure
Medium	Action may have political and public support and necessary maintenance has potential to occur following the project
Low	Not clear if action has political and public support and not certain that necessary maintenance can occur following the project

With this assessment, an approximate timeframe has been identified in which the municipality would attempt to achieve the mitigation measure.

Compared to the 2008 Hazard Mitigation Plan, the priorities for mitigation in this plan update are consistent, with a major emphasis on the need for significant improvements to infrastructure such as the sewer separation projects, improvements to collection and conveyance systems, and addressing the impacts of climate change.

Table 25. Mitigation Measure Prioritization

Mitigation Action	Geographic Coverage	Benefit	Estimated Cost	Priority	Time Frame
Flood Hazard Mitigation Measures					
A) Complete hydraulic modeling for city	City-Wide	High	High	High	2014–2018
B) Complete sewer separation and stormwater management program for Kirkland Street, Myrtle Street, Magnolia Street and Cambridge Street (CAM #011, areas 18 and 19)	Area specific	High	High	High	2014–2018
C) Complete sewer separation and stormwater management program for areas east of Fresh Pond Pkwy (area #6) and between Concord Avenue rotaries and New Street (area #5)	Area specific	High	High	High	2014-2016
D) Complete sewer separation at Porter Square (CAM 002 CSO area)	Area specific	High	High	High	2014–2018
E) Improve collection and conveyance system at area east of 2nd Street and north of Charles Street (area #27)	Area specific	High	High	High	2014–2018
F) Implement additional stormwater management measures: School, Pine, Cherry and Windsor Streets (area #26)	Area specific	High	High	High	2014–2018
G) Complete Cambridgeport stormwater management program: Newton, Green, Franklin and Sidney Streets (CAM 017, area #28)	Area specific	High	High	High	2014–2018

Table 25. Mitigation Measure Prioritization

Mitigation Action	Geographic Coverage	Benefit	Estimated Cost	Priority	Time Frame
H) Complete sewer separation and stormwater management program for Irving, Bryant, Crescent, Carver and Sacramento Streets (CAM011, areas #16 and 17)	Area specific	High	High	High	2014–2017
I) Complete sewer separation and stormwater management program for Ellery Street and Broadway (CAM011, area #24)	Area specific	High	High	High	2014–2017
J) Establish funding program for residential structural improvements & floodproofing	City-Wide	Medium	High	Medium	2016-2018
K) Floodplain Management	City-Wide	Low	Low	Low	2014-2018
L) Floodplain Mapping	City-Wide	Low	Low	Low	2014-2018
Winter Storm Hazard Mitigation Measures					
M) Expand program to clear snow and maintain public ROWs (e.g., travel ways for non- vehicular mobility, access for vulnerable populations)	City-Wide	High	Medium	Medium	2014-2018
Geologic Hazard Mitigation Measures					
N) Determine vulnerability of roadways and utilities to earthquakes in the high liquefaction areas	City-Wide	Low	Medium	Medium	2016-2018
Extreme Temperature Mitigation Measures					
O) Provide facility for additional vulnerable populations during extreme temperature event	City-Wide	Medium	Medium	Medium	2014-2016

Table 25. Mitigation Measure Prioritization

Mitigation Action	Geographic Coverage	Benefit	Estimated Cost	Priority	Time Frame
Wind Mitigation Measures					
P) Increase public education on the benefits and proper care of trees on private property	City-Wide	Medium	Low	Low	2015-2017
Climate Change Mitigation Measures					
Q) Complete Climate Change Vulnerability Assessment	City-Wide	High	High	High	2014
R) Complete Climate Change Adaptation Plan	City-Wide	High	High	High	2014-2015
S) Encourage installation of solar photovoltaic systems, cogeneration, and other energy supplies	City-Wide	Low	Low	Low	2014-2017
T) Encourage energy efficiency in buildings through zoning requirements and community outreach	City-Wide	Low	Low	Low	2014-2017
Other Hazard Mitigation Measures					
U) Evacuation Protocol Review	City-Wide	High	Low	High	2015-2016
V) Develop program for enhanced staffing for disaster recovery	City-Wide	High	Low	Medium	2014-2016
W) Ensure generators are located in areas protected from hazards	City-Wide	Medium	Medium	Medium	2015-2017
X) Conduct maintenance activities to monitor and reduce brushfire risks	Area Specific	Low	Low	Low	2014-2018

INTRODUCTION TO POTENTIAL MITIGATION MEASURES (TABLE 26)

Description of the Mitigation Measure – The description of each mitigation measure is brief and cost information is given only if cost data were already available from the community. The cost data represent a point in time and would need to be adjusted for inflation and for any changes or refinements in the design of a particular mitigation measure.

Measure Type – Each measure was categorized as one of the following mitigation categories: Prevention, Property Protection, Public Education & Awareness, Natural Resource Protection, Structural Projects, and Emergency Services Protection.

Implementation Responsibility – The designation of implementation responsibility was done by MAPC based on a general knowledge of each municipal department's responsibility. It is likely that most mitigation measures will require that several departments work together and assigning staff is the sole responsibility of the governing body of each community.

Priority – The designation of high, medium, or low priority was done at the meeting of the Local Multiple Hazard Community Planning Team meeting as described in the section above on Prioritization of Mitigation Measures. The designations reflect discussion and a general consensus developed at the meeting but could change as conditions in the community change. In determining project priorities, the local team considered potential benefits and project costs.

Time Frame – The time frame was based on a combination of the priority for that measure, the complexity of the measure and whether or not the measure is conceptual, in design, or already designed and awaiting funding. Because the time frame for this plan is five years, the timing for all mitigation measures has been kept within this framework. The identification of a likely time frame is not meant to constrain a community from taking advantage of funding opportunities as they arise.

Potential Funding Sources – This column attempts to identify the most likely sources of funding for a specific measure. The information on potential funding sources in this table is preliminary and varies depending on a number of factors. These factors include whether or not a mitigation measure has been studied, evaluated, or designed, or if it is still in the conceptual stages. MEMA and DCR assisted MAPC in reviewing the potential eligibility for hazard mitigation funding. Each grant program and agency has specific eligibility requirements that would need to be taken into consideration. In most instances, the measure will require a number of different funding sources. Identification of a potential funding source in this table does not guarantee that a project will be eligible for, or selected for funding. Upon adoption of this plan, the local committee responsible for its implementation should begin to explore the funding sources in more detail.

Additional information on funding sources – The best way to determine eligibility for a particular funding source is to review the project with a staff person at the funding agency. The following websites provide an overview of programs and funding sources.

- Army Corps of Engineers (ACOE) – The website for the North Atlantic district office is http://www.nae.usace.army.mil/. The ACOE provides assistance in a number of types of projects including shoreline/streambank protection, flood damage reduction, flood plain management services and planning services.
- Massachusetts Emergency Management Agency (MEMA) – The grants page http://www.mass.gov/dem/programs/mitigate/grants.htm has a useful table that compares eligible projects for the Hazard Mitigation Grant Program and the Flood Mitigation Assistance Program.
- United States Department of Agriculture – The USDA has programs by which communities can get grants for firefighting needs. Please use this link for some example: http://www.rurdev.usda.gov/rd/newsroom/2002/cfg.html

Abbreviations Used in Table 26

FEMA Mitigation Grants includes:
FMA = Flood Mitigation Assistance Program.
HMGP = Hazard Mitigation Grant Program.
PDM = Pre-Disaster Mitigation Program

ACOE = Army Corps of Engineers.

DHS/EOPS = Department of Homeland Security/Emergency Operations

EPA/DEP (SRF) = Environmental Protection Agency/Department of Environmental Protection (State Revolving Fund)

USDA = United States Department of Agriculture

Mass DOT = Massachusetts Department of Transportation

MBTA = Massachusetts Bay Transportation Authority

DCR = MA Department of Conservation and Recreation

DHCD = MA Department of Housing and Community Development

Table 26. Cambridge Potential Mitigation Measures

Mitigation Action	Measure Type	Implementation Responsibility	Priority	Time Frame	Potential Funding Sources
Flood Hazard Mitigation Measures					
A) Complete hydraulic modeling for the city	Prevention	DPW	High	2014–2018	City of Cambridge
B) Complete sewer separation and stormwater management program for Kirkland Street, Myrtle Street, Magnolia Street and Cambridge Street (CAM #011, areas 18 and 19)	Structural Projects	DPW	High	2014-2016	City of Cambridge
C) Complete sewer separation and stormwater management program for areas east of Fresh Pond Pkwy (area #6) and between Concord Avenue rotaries and New Street (area #5)	Structural Projects	DPW	High	2014-2016	City of Cambridge
D) Complete sewer separation at Porter Square (CAM 002 CSO area)	Structural Projects	DPW	High	2014–2018	City of Cambridge
E) Improve collection and conveyance system at area east of 2nd Street and north of Charles Street (area #27)	Structural Projects	DPW	High	2014–2018	City of Cambridge
F) Implement additional stormwater management measures: School, Pine, Cherry and Windsor Streets (area #26)	Structural Projects	DPW	High	2014–2018	City of Cambridge
G) Complete Cambridgeport stormwater management program: Newton, Green, Franklin and Sidney Streets (CAM 017, area #28)	Structural Projects	DPW	High	2014–2018	City of Cambridge

Table 26. Cambridge Potential Mitigation Measures

Mitigation Action	Measure Type	Implementation Responsibility	Priority	Time Frame	Potential Funding Sources
H) Complete sewer separation and stormwater management program for Irving, Bryant, Crescent, Carver and Sacramento Streets (CAM011, areas #16 and 17)	Structural Projects	DPW	High	2014–2017	City of Cambridge
I) Complete sewer separation and stormwater management program for Ellery Street and Broadway (CAM011, area #24)	Structural Projects	DPW	High	2014–2017	City of Cambridge
J) Establish funding program for residential structural improvements and flood proofing	Prevention/ Property Protection	CDD, DPW	Medium	2016-2018	City of Cambridge, FEMA
K) Floodplain Management	Prevention	Conservation Commission	Low	2014-2018	City of Cambridge
L) Floodplain Mapping	Prevention	CDD, Conservation Commission	Low	2014-2018	City of Cambridge
Winter Storm Hazard Mitigation Measures					
M) Expand program to clear snow and maintain public ROWs (e.g., travel ways for non-vehicular mobility and access for vulnerable populations)	Prevention	DPW	Medium	2014-2018	City of Cambridge, DCR, MassDOT
Geologic Hazard Mitigation Measures					
N) Determine vulnerability of roadways and utilities to earthquakes in the high liquefaction areas	Prevention	EMD, DPW, Inspectional Services	Medium	2016-2018	City of Cambridge

Table 26. Cambridge Potential Mitigation Measures

Mitigation Action	Measure Type	Implementation Responsibility	Priority	Time Frame	Potential Funding Sources
Extreme Temperature Mitigation Measures					
O) Provide facility for additional vulnerable populations during extreme temperature event	Prevention/ Public Education & Awareness	DHSP, EMD	Medium	2014-2016	City of Cambridge
Wind Mitigation Measures					
P) Increase public education on the benefits and proper care of trees on private property	Public Education & Awareness	Inspectional Services, EMD	Low	2015-2017	City of Cambridge, MEMA
Climate Change Mitigation Measures					
Q) Complete Climate Change Vulnerability Assessment	Prevention	CDD	High	2014	City of Cambridge
R) Complete Climate Change Adaptation Plan	Prevention	CDD	High	2014-2015	City of Cambridge, EOEEA
S) Encourage installation of solar photovoltaic systems, cogeneration, and other energy supplies	Prevention	CDD	Low	2014-2017	City of Cambridge
T) Encourage energy efficiency in buildings through zoning requirements and community outreach	Prevention	CDD	Low	2014-2017	City of Cambridge
Other Hazard Mitigation Measures					
U) Evacuation Protocol Review	Emergency Services Protection	EMD	High	2015-2016	City of Cambridge
V) Develop program for enhanced staffing for disaster recovery	Prevention/ Emergency Services Protection	Inspectional Services, CPHD	Medium	2014-2016	City of Cambridge

Table 26. Cambridge Potential Mitigation Measures

Mitigation Action	Measure Type	Implementation Responsibility	Priority	Time Frame	Potential Funding Sources
W) Ensure generators are located in areas protected from hazards	Emergency Services Protection	Electrical Dept., DPW	Medium	2015-2017	City of Cambridge
X) Conduct maintenance activities to monitor and reduce brushfire risks	Prevention/ Natural Resource Protection	Fire	Low	2014-2018	City of Cambridge

REGIONAL AND INTER-COMMUNITY CONSIDERATIONS

Regional Issues

Some hazard mitigation issues are strictly local. The problem originates primarily within the municipality and can be solved at the municipal level (e.g., capacity issues in local drainage system). Other issues are inter-community issues that involve cooperation between two or more municipalities (e.g., upstream issues related to upstream flooding on the Mystic River or on Alewife Brook). There is a third level of mitigation which is regional; involving a state, regional, or federal agency or an issue that involves three or more municipalities (e.g., any potential issues related to the Amelia Earhart Dam, which is owned by the DCR).

Regional Partners and Hazard Mitigation Coordination

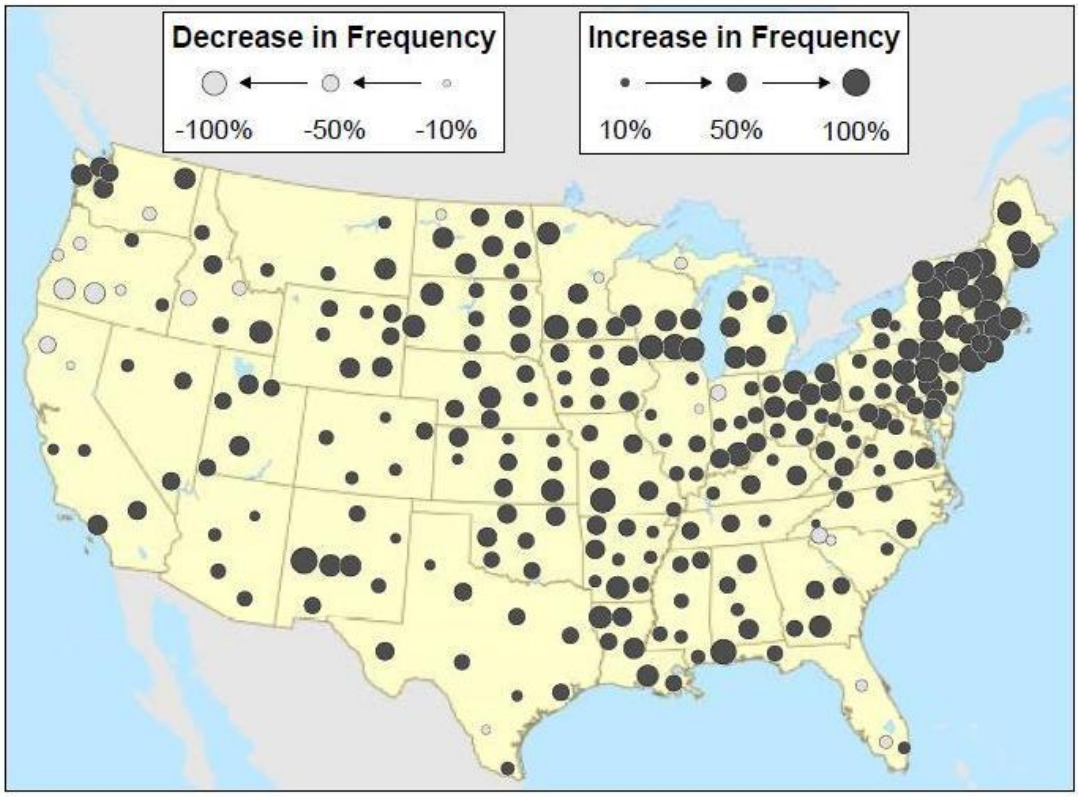
In the densely developed communities of the study area, mitigating natural hazards, particularly flooding, is more than a local issue. The drainage systems that serve these communities are a complex system of storm drains, roadway drainage structures, pump stations and other facilities owned and operated by a wide array of agencies. These include but not limited to the City of Cambridge, the Department of Conservation and Recreation (DCR), the Massachusetts Water Resources Authority (MWRA), Massachusetts Department of Transportation (MassDOT), and the Massachusetts Bay Transportation Authority (MBTA).

The planning, construction, operations, and maintenance of these structures are integral to the flood hazard mitigation efforts of communities. These agencies must be considered the communities regional partners in hazard mitigation. These agencies also operate under the same constraints as communities do including budgetary and staffing constraints and numerous competing priorities. The following is a list of recommendations from the 2008 plan that had planned to be undertaken in coordination with or by regional agencies.

CLIMATE CHANGE

The entirety of Massachusetts, and in particular the Commonwealth's cities and towns on or proximate to the coast, faces potential risk from Climate Change. Many of the natural hazards that cities like Cambridge have historically experienced are likely to be exacerbated by climate change in future years. This is particularly true for flooding caused by extreme precipitation, flooding, and extreme heat. For example, according to the 2012 report *When It Rains It Pours – Global Warming and the Increase in Extreme Precipitation from 1948 to 2011,* intense rainstorms and snowstorms have become more frequent and more severe over the last half century in the northeastern United States. Extreme downpours are now happening 30 percent more often nationwide than in 1948. In other words, large rain or snow storms that happened once every 12 months, on average, in the middle of the 20th century, now happen every nine months.

Figure 7. Extreme Precipitation Trends



Source: When It Rains It Pours – Global Warming and the Increase in Extreme Precipitation, Environment America Research and Policy Center, July 2012

Attempts to mitigate climate change or adapt to its potential impacts are largely outside the scope of this Hazard Mitigation Plan, which relies primarily on historic trends to assess risk and vulnerability. However, the City of Cambridge has already embarked on assessing how these hazards may change the city's vulnerability and is thinking about how best to adapt to these changes.

Currently, the City is taking steps to make Cambridge more prepared and resilient to climate change. Building from its 2002 Climate Protection plan, the City is currently conducting a Climate Change Vulnerability Assessment. Coordinated by an inter-departmental steering committee consisting of the Public Works, Public Health, and Community Development Departments, the assessment will identify how Cambridge is vulnerable or resilient to a changing climate in terms of impacts to people, infrastructure, public health, and the economy. When complete, the assessment will serve as the basis for a climate change preparedness plan that will provide recommendations on how to maximize the city's inherent resiliency and to adapt to potential new risks from natural hazard risks due to climate change. Information and the current status of the Climate Change Vulnerability Assessment can be found here:

http://www.cambridgema.gov/CDD/Projects/Climate/climatechangeresilianceandadaptation.aspx.

The City also continues to be supported by the Climate Protection Action Committee (CPAC), which is an advisory committee assisting in the implementation of the City's Climate Protection Plan. The Committee develops recommendations to the City Manager and is active participant in climate change vulnerability and adaptation initiatives. For more information on the CPAC and the City's broader set of climate and energy initiatives please visit http://www.cambridgema.gov/CDD/climateandenergy.aspx.

In addition to understanding how physical infrastructure will be impacted by the changing characteristics of natural hazards, it is important to identify how vulnerable populations may suffer impacts under future climate change scenarios. Vulnerable populations could include the elderly, the very young, low-income groups, immigrants and the homeless, among others, and could disproportionately suffer the effects of extreme events, like flooding and heat waves, be least-equipped to adapt. Here, too, the City is already taking action by providing shelter for seniors during extreme weather events and identifying mitigation measures to encompass and provide support for other vulnerable populations. The continuation of these efforts will make the City more prepared for potential impacts to vulnerable populations and offer more opportunities to coordinate among the involved departments and divisions like CPHD, CDD, the Human Rights Commission, the Commission for Persons with Disabilities, and the Council on Aging.

VII. PLAN ADOPTION AND MAINTENANCE

PLAN ADOPTION

The City of Cambridge Hazard Mitigation Plan was adopted by the City Council on [ADD DATE]. See Appendix D for documentation. The plan was approved by FEMA on [ADD DATE] for a five-year period that will expire on [ADD DATE].

PLAN MAINTENANCE

Although several of the mitigation measures from the City's previous Hazard Mitigation Plan have been implemented, since that plan was adopted there has not been an ongoing local process to guide implementation of the plan and integrate it with other city planning processes. Such a process is needed over the next five years for the implementation of this plan update, and will be structured as described below.

MAPC worked with the Cambridge Hazard Mitigation Planning Team to prepare this plan. This group will continue to meet on an as-needed basis to function as the Local Hazard Mitigation Implementation Group, with the Cambridge Emergency Planning Committee Chairman designated as the coordinator. Additional members could be added to the local implementation group from businesses, non-profits, and institutions.

The City will continue public participation during the next 5-year planning cycle. Following the adoption of the plan update, the planning team will continue to provide residents, businesses, and other stakeholders the opportunity to learn about the hazard mitigation planning process and to contribute information that will update the city's understanding of local hazards. This will occur through a combination of in-person meetings, presentations at regular committee meetings, and provision of information on the city's website. It will also occur through day-to-day sharing of information received from the public with applicable departments, such as residents' calls to inform about flooding and feedback about changes following infrastructure improvements.

IMPLEMENTATION SCHEDULE

Bi-Annual Survey on Progress– The coordinator of the Hazard Mitigation Implementation Team will prepare and distribute a biannual survey in years two and four of the plan. The survey will be distributed to all of the local implementation group members and other interested local stakeholders. The survey will poll the members on any changes or revisions to the plan that may be needed, progress and accomplishments for implementation, and any new hazards or problem areas that have been identified.

This information will be used to prepare a report or addendum to the local hazard mitigation plan. The Hazard Mitigation Implementation Team will have primary responsibility for tracking progress and updating the plan.

Develop a Year Four Update – During the fourth year after initial plan adoption, the coordinator of the Hazard Mitigation Implementation Team will convene the team to begin to prepare for an update of the plan, which will be required by the end of year five in order to maintain approved plan status with FEMA. The team will use the information from the year four biannual review to identify the needs and priorities for the plan update.

Prepare and Adopt an Updated Local Hazard Mitigation Plan – FEMA's approval of this plan is valid for five years, by which time an updated plan must be approved by FEMA in order to maintain the City's approved plan status and its eligibility for FEMA mitigation grants. Because of the time required to secure a planning grant, prepare an updated plan, and complete the approval and adoption of an updated plan, the local Hazard Mitigation Planning Team should begin the process by the end of Year 3. This will help the City avoid a lapse in its approved plan status and grant eligibility when the current plan expires.

At this point, the Hazard Mitigation Implementation Team may decide to undertake the update themselves, contract with the Metropolitan Area Planning Council to update the plan or to hire another consultant. However the Hazard Mitigation Implementation Team decides to update the plan, the group will need to review the current FEMA hazard mitigation plan guidelines for any changes. The update of the Cambridge Hazard Mitigation Plan will be forwarded to MEMA and DCR for review and to FEMA for approval.

INTEGRATION OF THE PLANS WITH OTHER PLANNING INITIATIVES

Upon approval of the Cambridge Hazard Mitigation Plan by FEMA, the Cambridge Emergency Planning Committee Chairman, with support from members of the Local Hazard Mitigation Implementation Group, will provide all interested parties and implementing departments with a copy of the plan and will initiate a discussion regarding how the plan can be integrated into that department's ongoing work.

At a minimum, the plan will be reviewed and discussed with the following departments during the first six (6) months following plan adoption:

- Fire / Emergency Management
- Police
- Public Works
- Engineering
- Community Development Department
- Conservation
- Health
- Inspectional Services

The updated Hazard Mitigation Plan will be integrated with the Envision Cambridge (citywide) plan that is just starting in 2016, and with the Cambridge Climate Change Preparedness & Resilience Plan.

Other groups that will be coordinated with include large institutions, Chambers of Commerce, land conservation organizations, and watershed groups. This coordination will occur to provide input to groups about the hazard mitigation strategy and offer opportunities for the public to participate in related meetings.

The plans will also be posted on the City's website with the caveat that local team coordinator will review the plan for sensitive information that would be inappropriate for public posting. The posting of the plan on a web site will include a mechanism for citizen feedback such as an e-mail address to send comments.

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VIII. LIST OF REFERENCES

In addition to the specific reports listed below, much of the technical information for this plan came from meetings with City department heads and staff.

City of Cambridge Zoning Ordinance.

City of Cambridge Open Space and Recreation Plan, 2009-2016.

City of Cambridge Master Plan and Growth Policy (and Related Initiatives): https://www.cambridgema.gov/CDD/planud/masterplan.aspx.

Historic Districts and Neighborhood Conservation Districts in Cambridge, MA: http://www2.cambridgema.gov/historic/districts.html.

2013 Town Gown Report Summary.

Metro-Boston Multi-Hazard Mitigation Plan, Cambridge Annex, 2008.

Metropolitan Area Planning Council, Geographic Information Systems data.

Metropolitan Area Planning Council, Regional Plans, and Data.

Commonwealth of Massachusetts, State Hazard Mitigation Plan, 2013.

FEMA, Local Multi-Hazard Mitigation Planning Guidance, 2008.

FEMA, Flood Insurance Rate Maps for Cambridge, MA, 2010.

New England Seismic Network, Boston College Weston Observatory, website: http://aki.bc.edu/index.htm

Northeast States Emergency Consortium, website http://www.nesec.org/

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APPENDIX A
MEETING AGENDAS

Don Boyce
DIRECTOR

dcr

Edward M. Lambert Jr.
COMMISSIONER

MAPC

Marc D. Draisen
EXECUTIVE DIRECTOR

THE COMMONWEALTH OF MASSACHUSETTS

Deval Patrick, Governor

MASSACHUSETTS EMERGENCY MANAGEMENT AGENCY
400 WORCESTER ROAD, FRAMINGHAM, MA 01702-5399 508-820-2000 FAX 508-820-1404

DEPARTMENT OF CONSERVATION AND RECREATION
251 CAUSEWAY STREET, SUITE 600-900, BOSTON, MA 02114-2104 617-626-1250 FAX 617-626-1351

METROPOLITAN AREA PLANNING COUNCIL
60 TEMPLE PLACE, 6TH FLOOR, BOSTON, MA 02111 617-451-2770 FAX 617-482-7185

Metro Boston Hazard Mitigation Planning Team

First Meeting

Wednesday, April 13, 10:00 AM

Everett City Hall, Keverian Room (3rd floor)
484 Broadway (Route 99), Everett

AGENDA

METRO BOSTON HAZARD MITIGATION PLANNING TEAM

Boston
Brookline
Cambridge
Chelsea
Everett
Malden
Medford
Somerville

10:00 WELCOME & INTRODUCTIONS

10:10 OVERVIEW OF HAZARD MITIGATION PLANNING & GRANTS

- State Hazard Mitigation Plan & FEMA Grants–Sarah White, MEMA
- FEMA Hazard Mitigation Program and Grants – Nan Johnson, FEMA
- Regional & Local Mitigation Plans - Martin Pillsbury, MAPC

10:30 UPDATING THE METRO BOSTON HAZARD MITIGATION PLAN

- FEMA Requirements & Grant Eligibility
- Review of Scope of Work & Schedule –MAPC
- Questions & Discussion – Local issues & Priorities

11:00 GETTING STARTED: MAPPING AND CRITICAL FACILITIES DATABASE FOR THE METRO BOSTON PLAN UPDATE

- Susan Brunton, GIS Analyst, MAPC

11:20 NEXT STEPS

11:30 ADJOURN

If you have any questions please contact Martin Pillsbury at MAPC:
617-451-2770, ext. 2012 or mpillsbury@mapc.org

Local Team Meeting #1 Agenda
Local Natural Hazard Plan Update
City of Cambridge

1) Welcome and Introductions	1:00 PM
2) Overview of Project	1:10 PM
3) Introduce City of Cambridge Hazard Mitigation Planning Map Series and Digitized Ortho Photo Map.	1:15 PM
4) Identify: a) Flood Hazard Areas (incl. areas with concentration of repetitive loss properties) b) Fire Hazard Areas (incl. approx. # of annual wildfires and recent incidences that resulted in property damage) c) Other Hazards and their Profiles d) Future Potential Development Areas e) Historical, Cultural or Natural Resource Areas f) Dams (incl. type and ownership)	1:25 PM
5) Review and Assess Plan Goals (see over)	2:15 PM
6) Discuss Public Involvement and Outreach (see over)	2:30 PM
7) Set Date for First Public Meeting and Discuss Public Outreach	2:45 PM
8) Conclude and Set Tentative Date Second Staff Meeting to: a) Review Existing Mitigation Measures b) Review Mitigation Measures from the 2005 Plan c) Discuss Potential Mitigation Measures d) Prioritize Mitigation Measures	2:55 PM

Project Overview - MAPC received a grant to prepare natural hazards *Pre-Disaster Mitigation Plan* for the communities of Boston, Brookline, Cambridge, Chelsea, Everett, Malden, Medford and Somerville. MAPC is working with the eight communities to update their plans to mitigate potential damages of natural hazards such as floods, winter storms, hurricanes, earthquakes and wild fires, before such hazards occur. The federal *Disaster Mitigation Act of 2000* requires that all municipalities adopt a *Pre-Disaster Mitigation Plan* for natural hazards in order to remain eligible for FEMA Disaster Mitigation Grants.

This FEMA planning program is separate from new or ongoing homeland security initiatives, and is focused solely on addressing natural hazards, although some of the data collected for this plan may be useful for other aspects of emergency planning as well.

Local Team Meeting #3 Agenda
Local Natural Hazard Plan Update
June 2013
City of Cambridge

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1) Welcome and Introductions	1:30 PM
2) Project Update a) Public Meetings b) Critical Infrastructure	1:35 PM
3) Conclude and Set Tentative Date Second Staff Meeting to: a) Discuss Progress on 2008 Plan Implementation and Maintenance b) Review Existing Mitigation Measures c) Review Status of Proposed New Mitigation Measures from the 2008 Plan d) Identify and Discuss Potential New Mitigation Measures for Update e) Prioritize Mitigation Measures for Update	1:45 PM
4) Plan for Second Public Meeting and related Public Outreach	3:15 PM
5) Meeting Conclusion	3:30 PM

Project Overview - MAPC received a grant to prepare natural hazards *Pre-Disaster Mitigation Plan* for the communities of Boston, Brookline, Cambridge, Chelsea, Everett, Malden, Medford and Somerville. MAPC is working with the eight communities to update their plans to mitigate potential damages of natural hazards such as floods, winter storms, hurricanes, earthquakes and wild fires, before such hazards occur. The federal *Disaster Mitigation Act of 2000* requires that all municipalities adopt a *Pre-Disaster Mitigation Plan* for natural hazards in order to remain eligible for FEMA Disaster Mitigation Grants.

This FEMA planning program is separate from new or ongoing homeland security initiatives, and is focused solely on addressing natural hazards, although some of the data collected for this plan may be useful for other aspects of emergency planning as well.

APPENDIX B
HAZARD MAPPING

The MAPC GIS (Geographic Information Systems) Lab produced a series of maps for each community. Some of the data came from the Northeast States Emergency Consortium (NESEC). More information on NESEC can be found at http://www.serve.com/NESEC/. Due to the various sources for the data and varying levels of accuracy, the identification of an area as being in one of the hazard categories must be considered as a general classification that should always be supplemented with more local knowledge. The documentation for some of the hazard maps was incomplete as well.

The map series consists of four panels with two maps each plus one map taken from the State Hazard Mitigation Plan.

Map 1.	Population Density
Map 2.	Potential Development
Map 3.	Flood Zones
Map 4.	Earthquakes and Landslides
Map 5.	Hurricanes and Tornadoes
Map 6.	Average Snowfall
Map 7.	Composite Natural Hazards
Map 8.	Hazard Areas

Reduced-scale copies of the map series are included in this Appendix for general reference. Full sized higher resolution PDF's of the maps can be downloaded from the MAPC File Transfer Protocol (FTP) website at:

ftp://ftp.mapc.org/Hazard_Mitigation_Plans/PDM-2R/Cambridge/

Map1: Population Density – This map uses the US Census block data for 2000 and shows population density as the number of people per acre in seven categories with 60 or more people per acre representing the highest density areas.

Map 2: Development – This map shows potential future developments, and critical infrastructure sites. MAPC consulted with City staff to determine areas that were likely to be developed or redeveloped in the future. The map also depicts current land use.

Map 3: Flood Zones – The map of flood zones used the FEMA NFIP Flood Zones as depicted on the FIRMs (Federal Insurance Rate Maps) as its source. At the time this plan was developed, these flood zones had not yet been officially adopted and were therefore considered draft. This map is not intended for use in determining whether or not

a specific property is located within a FEMA NFIP flood zone. The currently adopted FIRMS for Cambridge are kept by the City. For more information, refer to the FEMA Map Service Center website http://www.msc.fema.gov. The definitions of the flood zones are described in detail on this site as well. The flood zone map for each community also shows critical infrastructure and repetitive loss areas.

Map 4: Earthquakes and Landslides – This information came from NESEC. For most communities, there was no data for earthquakes because only the epicenters of an earthquake are mapped.

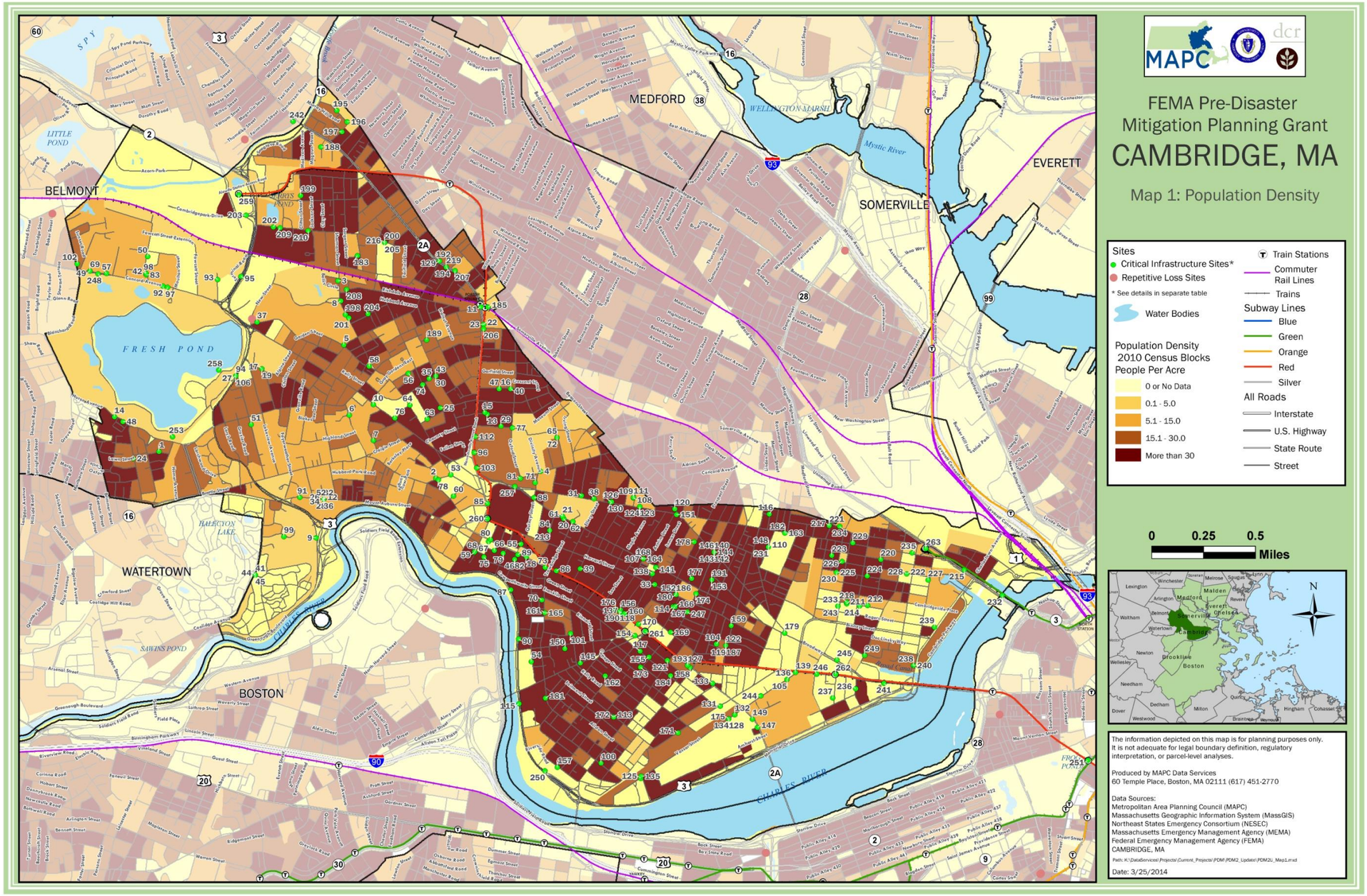
The landslide information shows areas with either a low susceptibility or a moderate susceptibility to landslides based on mapping of geological formations. This mapping is highly general in nature. For more information on how landslide susceptibility was mapped, refer to http://pubs.usgs.gov/pp/p1183/pp1183.html.

Map 5: Hurricanes and Tornadoes – This map shows a number of different items. The map includes the storm tracks for both hurricanes and tropical storms. This information must be viewed in context. A storm track only shows where the eye of the storm passed through. In most cases, the effects of the wind and rain from these storms were felt in other communities even if the track was not within that community. This map also shows the location of tornadoes with a classification as to the level of damages. What appears on the map varies by community since not all communities experience the same wind-related events. These maps also show the 100 year wind speed.

Map 6: Average Snowfall - This map shows the average snowfall and open space. It also shows storm tracks for nor'easters, if any storms tracked through the community.

Map 7: Composite Natural Hazards - This map shows four categories of composite natural hazards for areas of existing development. The hazards included in this map are 100 year wind speeds of 110 mph or higher, low, and moderate landslide risk, FEMA Q3 flood zones (100 year and 500 year) and hurricane surge inundation areas. Areas with only one hazard were considered to be low hazard areas. Moderate areas have two of the hazards present. High hazard areas have three hazards present and severe hazard areas have four hazards present.

Map 8: Hazard Areas – For each community, locally identified hazard areas are overlaid on an aerial photograph dated April, 2008. The critical infrastructure sites are also shown. The source of the aerial photograph is Mass GIS.


MAPC
dcr
FEMA Pre-Disaster
Mitigation Planning Grant
CAMBRIDGE, MA
Map 1: Population Density
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Water Bodies
Population Density
2010 Census Blocks
People Per Acre
0 or No Data
0.1 - 5.0
5.1 - 15.0
15.1 - 30.0
More than 30
Train Stations
Commuter Rail Lines
Trains
Subway Lines
Blue
Green
Orange
Red
Silver
All Roads
Interstate
U.S. Highway
State Route
Street
0 0.25 0.5
Miles
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
CAMBRIDGE, MA
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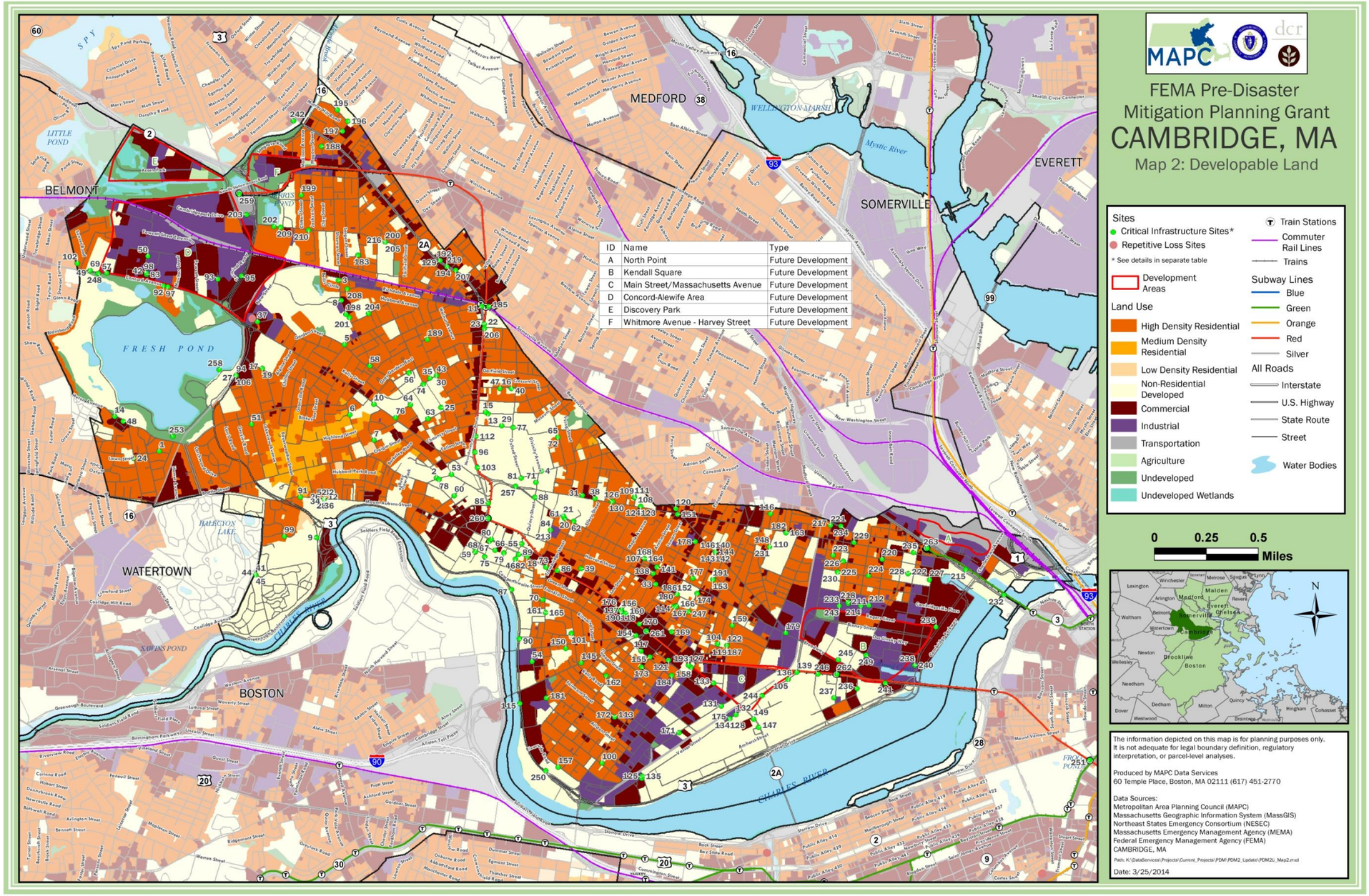
Date: 3/25/2014
BELMONT
WATERTOWN
BOSTON
MEDFORD
SOMERVILLE
EVERETT
FRESH POND
LITTLE POND
HALCYON LAKE
SAWINS POND
WELLINGTON MARSH
Mystic River
CHARLES RIVER


MAPC
dcr
FEMA Pre-Disaster
Mitigation Planning Grant
CAMBRIDGE, MA
Map 2: Developable Land
MEDFORD
SOMERVILLE
EVERETT
BELMONT
WATERTOWN
BOSTON
FRESH POND
LITTLE POND
SPY POND
HALCYON LAKE
SAPIN'S POND
WELLINGTON-MARSH
Mystic River
CHARLES RIVER
ID | Name | Type
A | North Point | Future Development
B | Kendall Square | Future Development
C | Main Street/Massachusetts Avenue | Future Development
D | Concord-Alewife Area | Future Development
E | Discovery Park | Future Development
F | Whitmore Avenue - Harvey Street | Future Development
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Development Areas
Land Use
High Density Residential
Medium Density Residential
Low Density Residential
Non-Residential Developed
Commercial
Industrial
Transportation
Agriculture
Undeveloped
Undeveloped Wetlands
Train Stations
Commuter Rail Lines
Trains
Subway Lines
Blue
Green
Orange
Red
Silver
All Roads
Interstate
U.S. Highway
State Route
Street
Water Bodies
0 0.25 0.5
Miles
N
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CAMBRIDGE, MA
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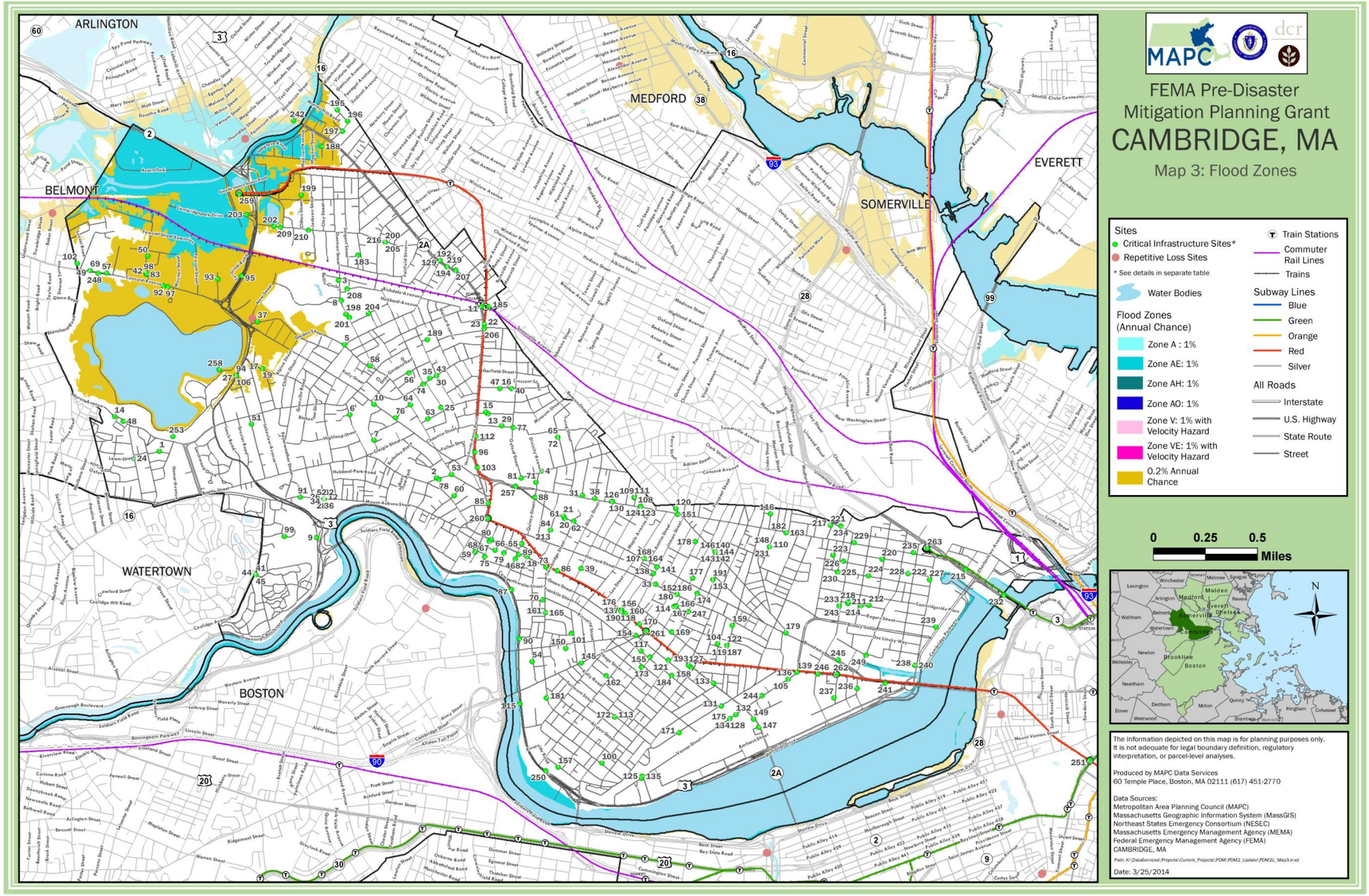
ARLINGTON
BELMONT
WATERTOWN
BOSTON
MEDFORD
SOMERVILLE
EVERETT
MAPC
dcr
FEMA Pre-Disaster
Mitigation Planning Grant
CAMBRIDGE, MA
Map 3: Flood Zones
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Water Bodies
Flood Zones
(Annual Chance)
Zone A : 1%
Zone AE: 1%
Zone AH: 1%
Zone AO: 1%
Zone V: 1% with
Velocity Hazard
Zone VE: 1% with
Velocity Hazard
0.2% Annual
Chance
Train Stations
Commuter
Rail Lines
Trains
Subway Lines
Blue
Green
Orange
Red
Silver
All Roads
Interstate
U.S. Highway
State Route
Street
0 0.25 0.5
Miles
N
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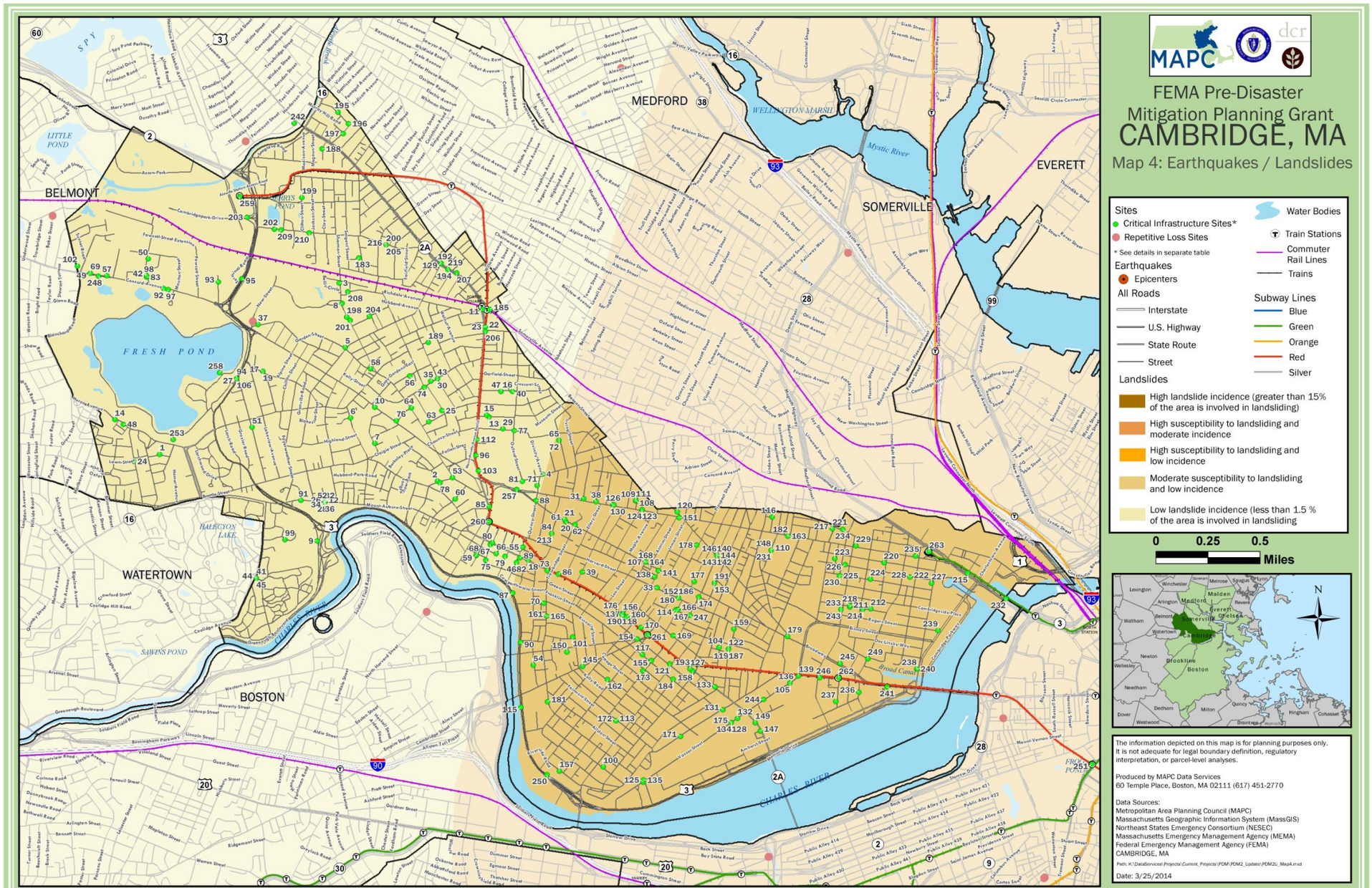
CAMBRIDGE, MA
Date: 3/25/2014


MAPC
dcr
FEMA Pre-Disaster
Mitigation Planning Grant
CAMBRIDGE, MA
Map 4: Earthquakes / Landslides
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Earthquakes
Epicenters
All Roads
Interstate
U.S. Highway
State Route
Street
Landslides
High landslide incidence (greater than 15% of the area is involved in landsliding)
High susceptibility to landsliding and moderate incidence
High susceptibility to landsliding and low incidence
Moderate susceptibility to landsliding and low incidence
Low landslide incidence (less than 1.5 % of the area is involved in landsliding
Water Bodies
Train Stations
Commuter Rail Lines
Trains
Subway Lines
Blue
Green
Orange
Red
Silver
0 0.25 0.5
Miles
N
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
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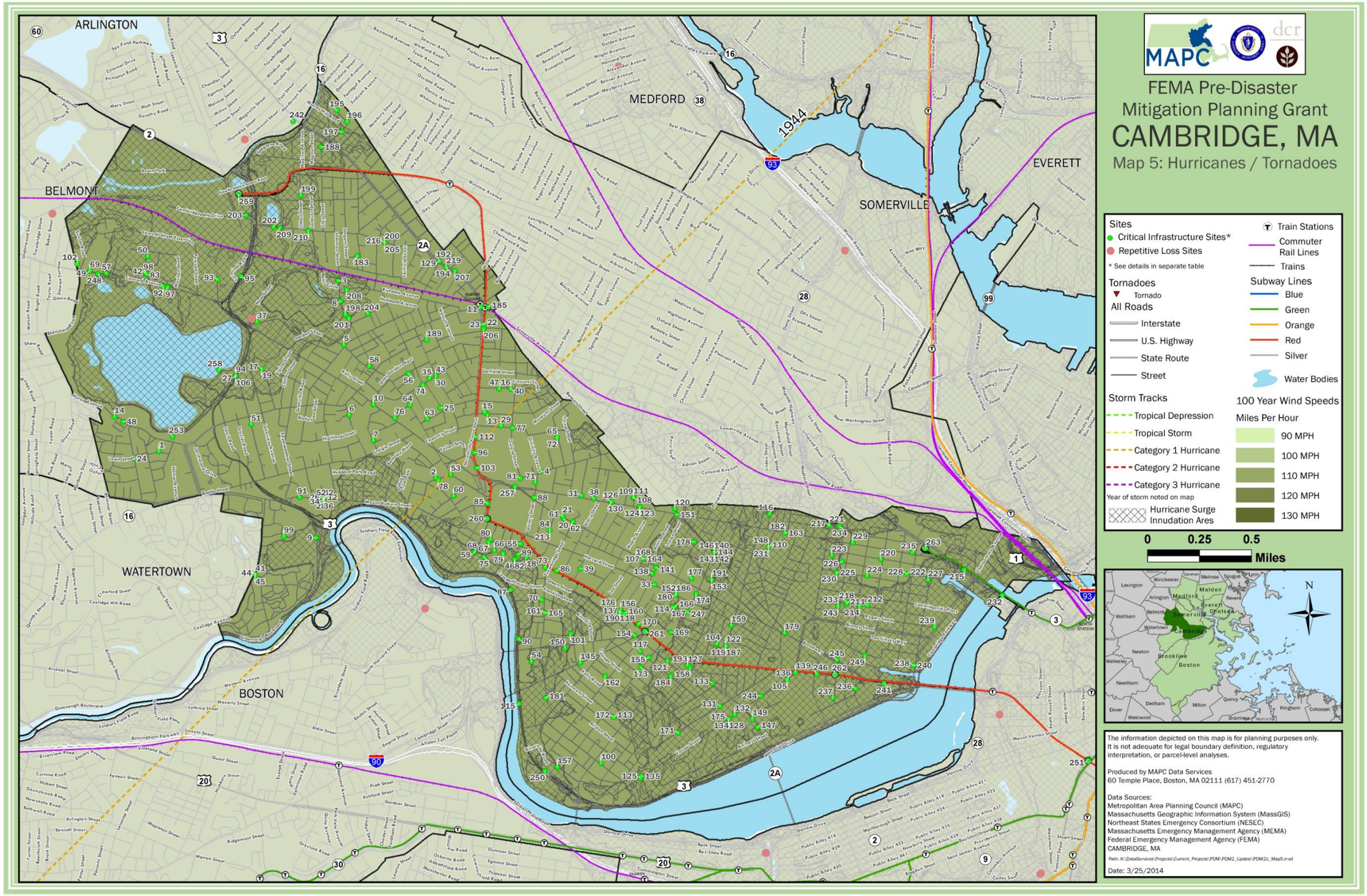
CAMBRIDGE, MA
Date: 3/25/2014
BELMONT
WATERTOWN
BOSTON
MEDFORD
SOMERVILLE
EVERETT
CHARLES RIVER
FRESH POND
WELLINGTON MARSH
Mystic River


ARLINGTON
BELMONT
WATERTOWN
BOSTON
MEDFORD
SOMERVILLE
EVERETT
1944
MAPC
dcr
FEMA Pre-Disaster
Mitigation Planning Grant
CAMBRIDGE, MA
Map 5: Hurricanes / Tornadoes
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Tornadoes
Tornado
All Roads
Interstate
U.S. Highway
State Route
Street
Storm Tracks
Tropical Depression
Tropical Storm
Category 1 Hurricane
Category 2 Hurricane
Category 3 Hurricane
Year of storm noted on map
Hurricane Surge
Innudation Ares
Train Stations
Commuter
Rail Lines
Trains
Subway Lines
Blue
Green
Orange
Red
Silver
Water Bodies
100 Year Wind Speeds
Miles Per Hour
90 MPH
100 MPH
110 MPH
120 MPH
130 MPH
0
0.25
0.5
Miles
The information depicted on this map is for planning purposes only.
It is not adequate for legal boundary definition, regulatory
interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
CAMBRIDGE, MA
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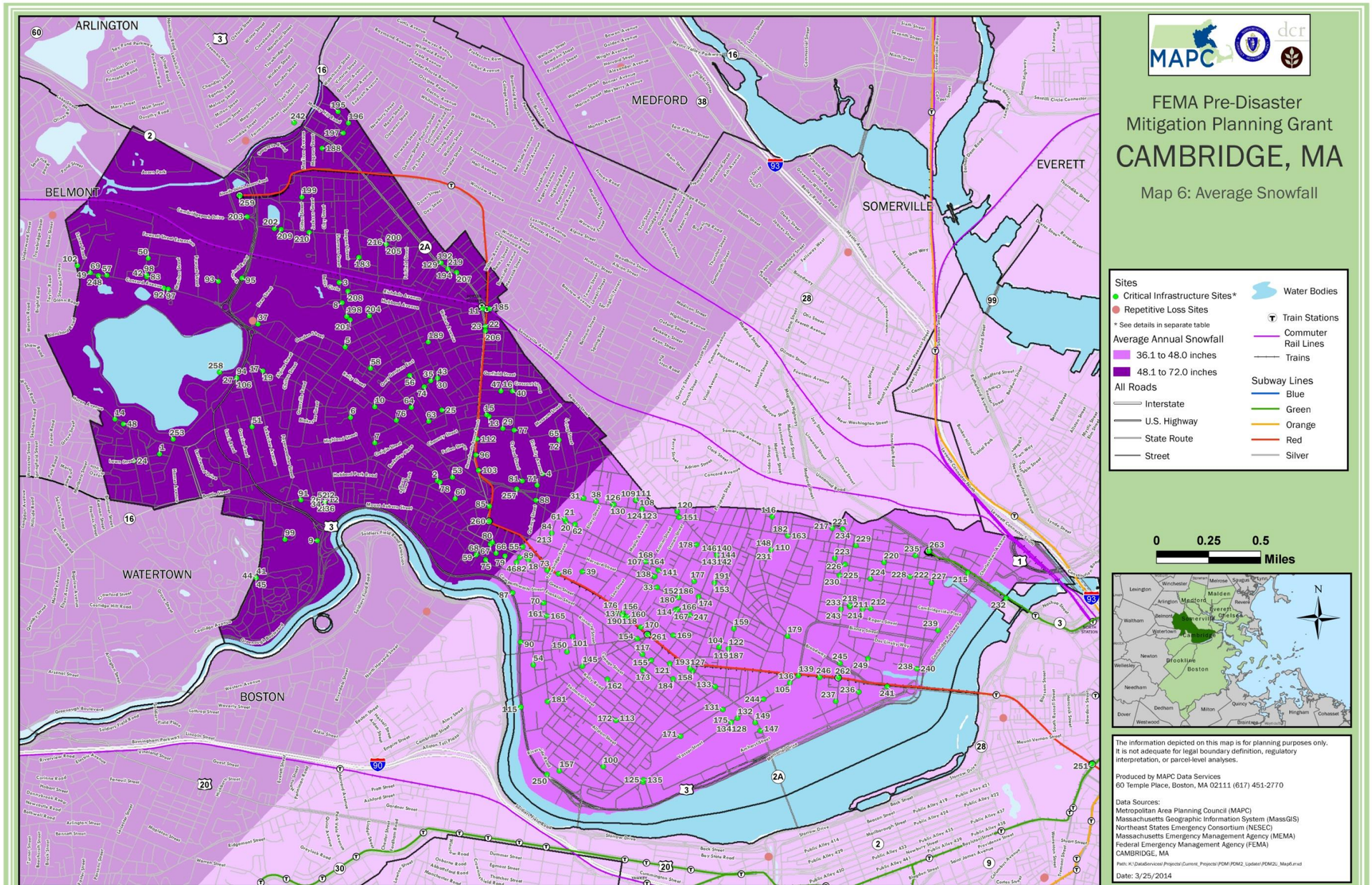
Date: 3/25/2014


ARLINGTON
BELMONT
MEDFORD
SOMERVILLE
EVERETT
WATERTOWN
BOSTON
MAPC
dcr
FEMA Pre-Disaster
Mitigation Planning Grant
CAMBRIDGE, MA
Map 6: Average Snowfall
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Average Annual Snowfall
36.1 to 48.0 inches
48.1 to 72.0 inches
All Roads
Interstate
U.S. Highway
State Route
Street
Water Bodies
Train Stations
Commuter Rail Lines
Trains
Subway Lines
Blue
Green
Orange
Red
Silver
0 0.25 0.5
Miles
N
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Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
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Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
CAMBRIDGE, MA
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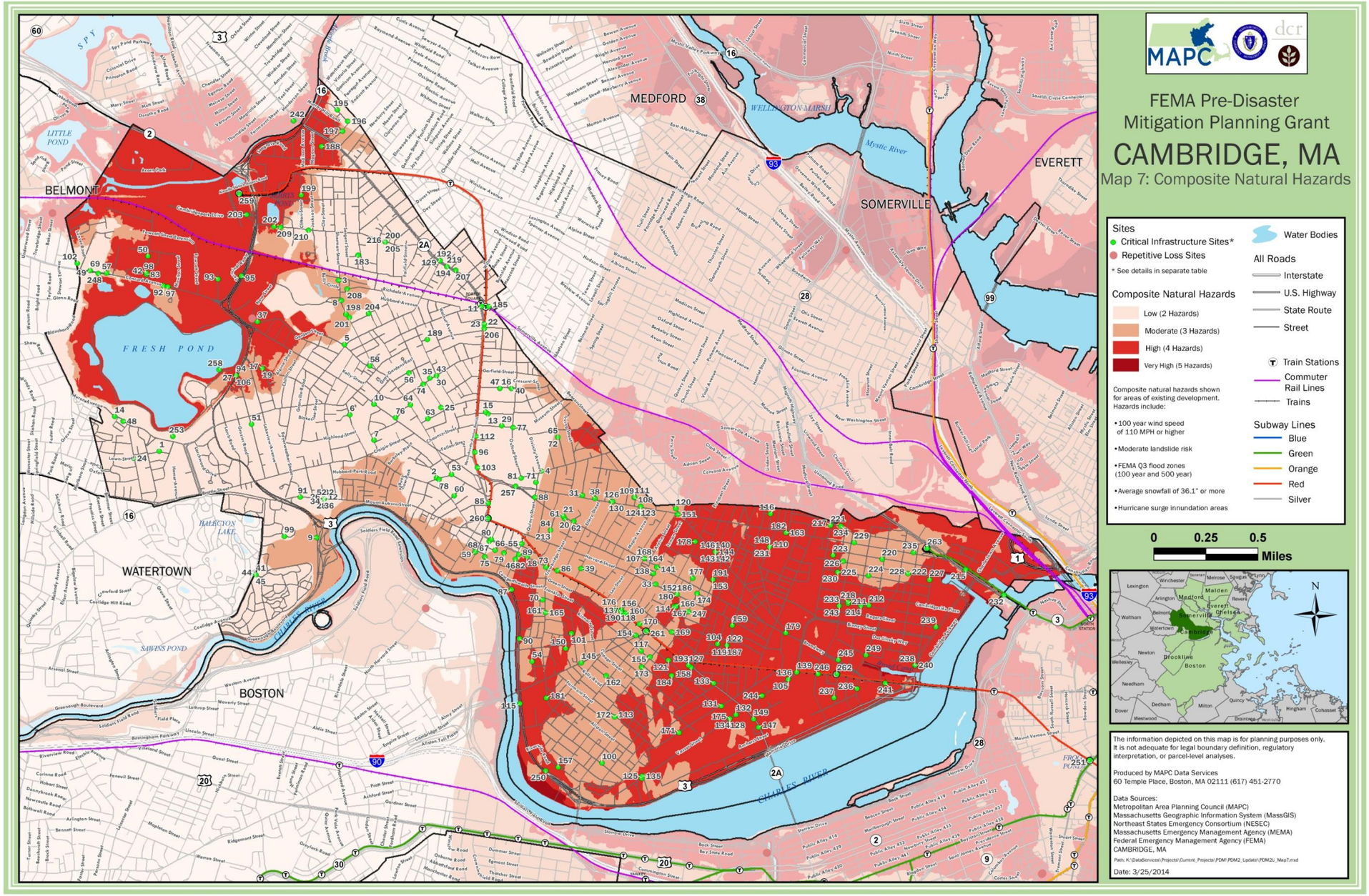
Date: 3/25/2014


MAPC
dcr
FEMA Pre-Disaster
Mitigation Planning Grant
CAMBRIDGE, MA
Map 7: Composite Natural Hazards
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Composite Natural Hazards
Low (2 Hazards)
Moderate (3 Hazards)
High (4 Hazards)
Very High (5 Hazards)
Composite natural hazards shown for areas of existing development. Hazards include:
•100 year wind speed of 110 MPH or higher
•Moderate landslide risk
•FEMA Q3 flood zones (100 year and 500 year)
•Average snowfall of 36.1" or more
•Hurricane surge innundation areas
Water Bodies
All Roads
Interstate
U.S. Highway
State Route
Street
Train Stations
Commuter Rail Lines
Trains
Subway Lines
Blue
Green
Orange
Red
Silver
0 0.25 0.5
Miles
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60 Temple Place, Boston, MA 02111 (617) 451-2770
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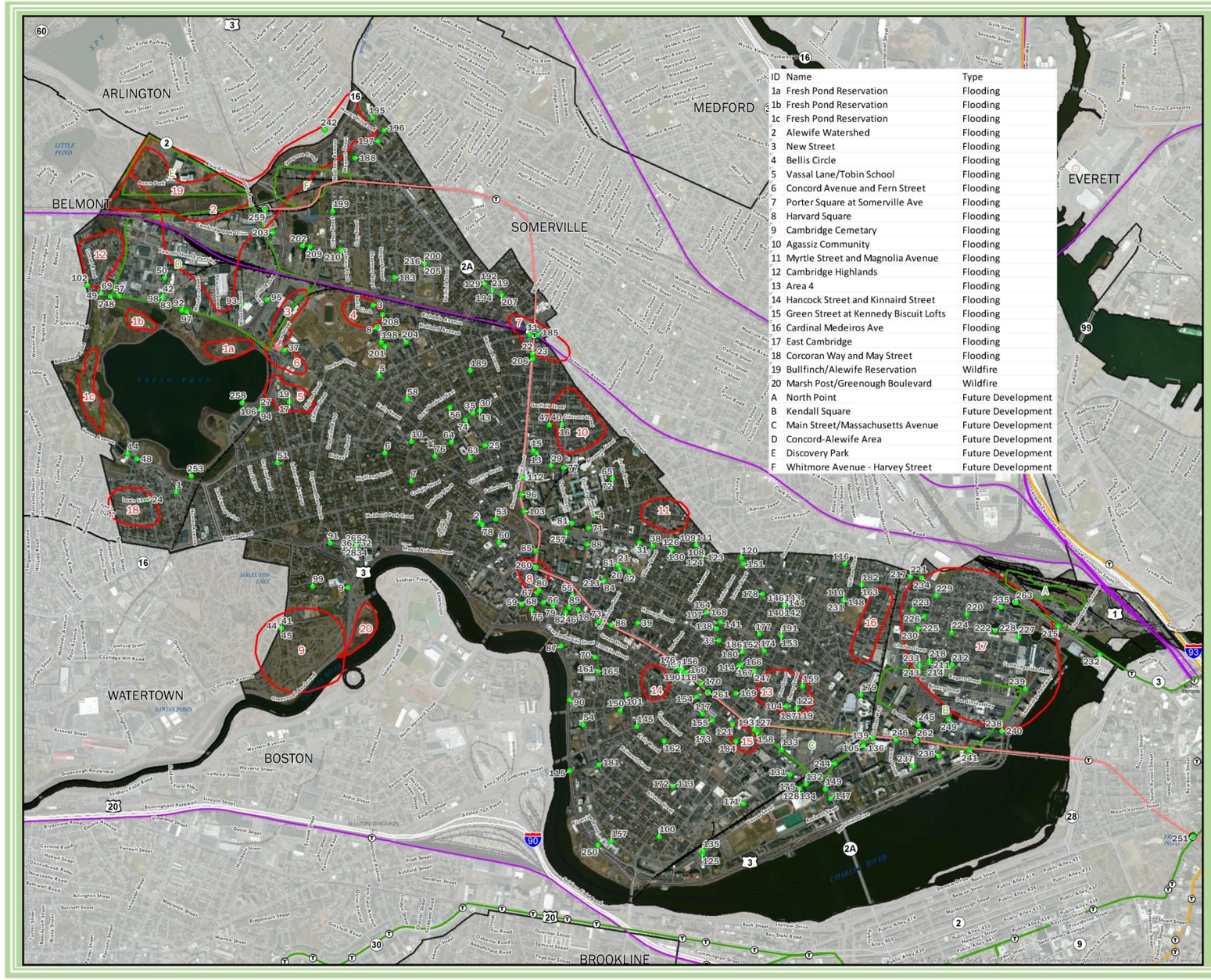
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
CAMBRIDGE, MA
Path: K:\DataServices\Projects\Current_Projects\PDM\PDM2_Update\PDM2U_MapT.mxd
Date: 3/25/2014
BELMONT
WATERTOWN
BOSTON
MEDFORD
SOMERVILLE
EVERETT
FRESH POND
LITTLE POND
HALCYON LAKE
SAWINS POND
WELLINGTON MARSH
Mystic River
CHARLES RIVER



ID	Name	Type
1a	Fresh Pond Reservation	Flooding
1b	Fresh Pond Reservation	Flooding
1c	Fresh Pond Reservation	Flooding
2	Alewife Watershed	Flooding
3	New Street	Flooding
4	Bellis Circle	Flooding
5	Vassal Lane/Tobin School	Flooding
6	Concord Avenue and Fern Street	Flooding
7	Porter Square at Somerville Ave	Flooding
8	Harvard Square	Flooding
9	Cambridge Cemetary	Flooding
10	Agassiz Community	Flooding
11	Myrtle Street and Magnolia Avenue	Flooding
12	Cambridge Highlands	Flooding
13	Area 4	Flooding
14	Hancock Street and Kinnaird Street	Flooding
15	Green Street at Kennedy Biscuit Lofts	Flooding
16	Cardinal Medeiros Ave	Flooding
17	East Cambridge	Flooding
18	Corcoran Way and May Street	Flooding
19	Bullfinch/Alewife Reservation	Wildfire
20	Marsh Post/Greenough Boulevard	Wildfire
A	North Point	Future Development
B	Kendall Square	Future Development
C	Main Street/Massachusetts Avenue	Future Development
D	Concord-Alewife Area	Future Development
E	Discovery Park	Future Development
F	Whitmore Avenue - Harvey Street	Future Development

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FEMA Pre-Disaster Mitigation Planning Grant

CAMBRIDGE, MA

Map 8: Local Hazard Areas

Sites
- Critical Infrastructure Sites*
- Repetitive Loss Sites

* See details in separate table

- Locally Identified Hazard Areas
- Development Sites

All Roads
- Interstate
- U.S. Highway
- State Route
- Street

- Train Stations
- Commuter Rail Lines
- Trains

Subway Lines
- Blue
- Green
- Orange
- Red
- Silver

0 0.25 0.5 Miles

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Data Sources:
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Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
CAMBRIDGE, MA

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Date: 3/25/2014

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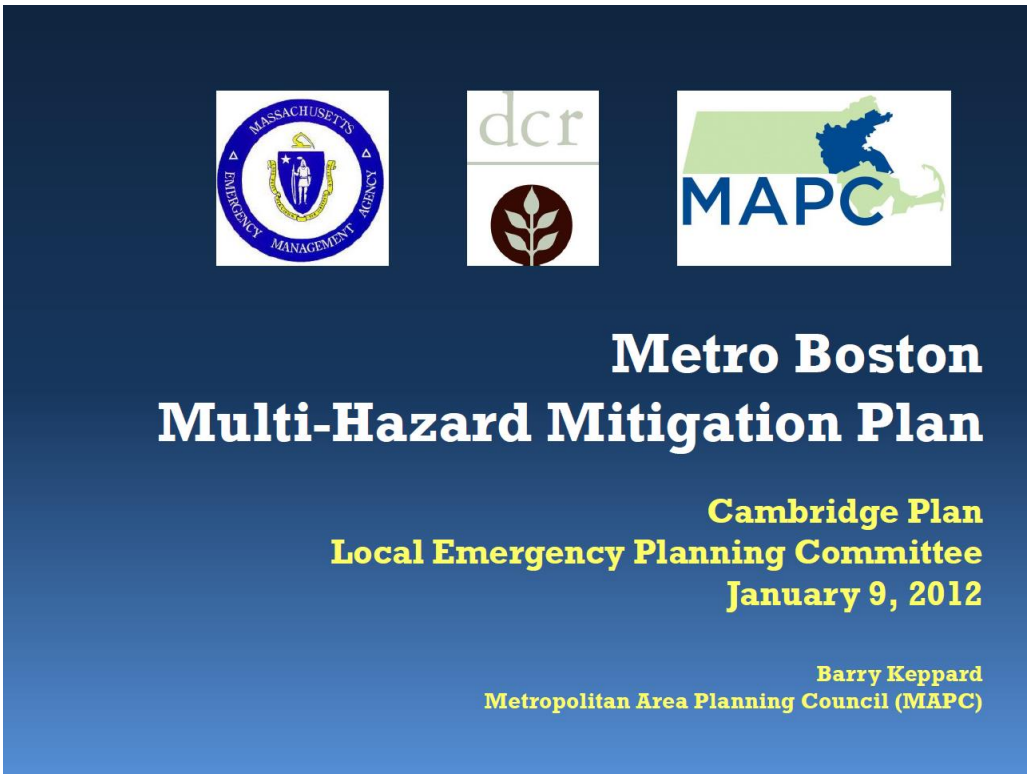
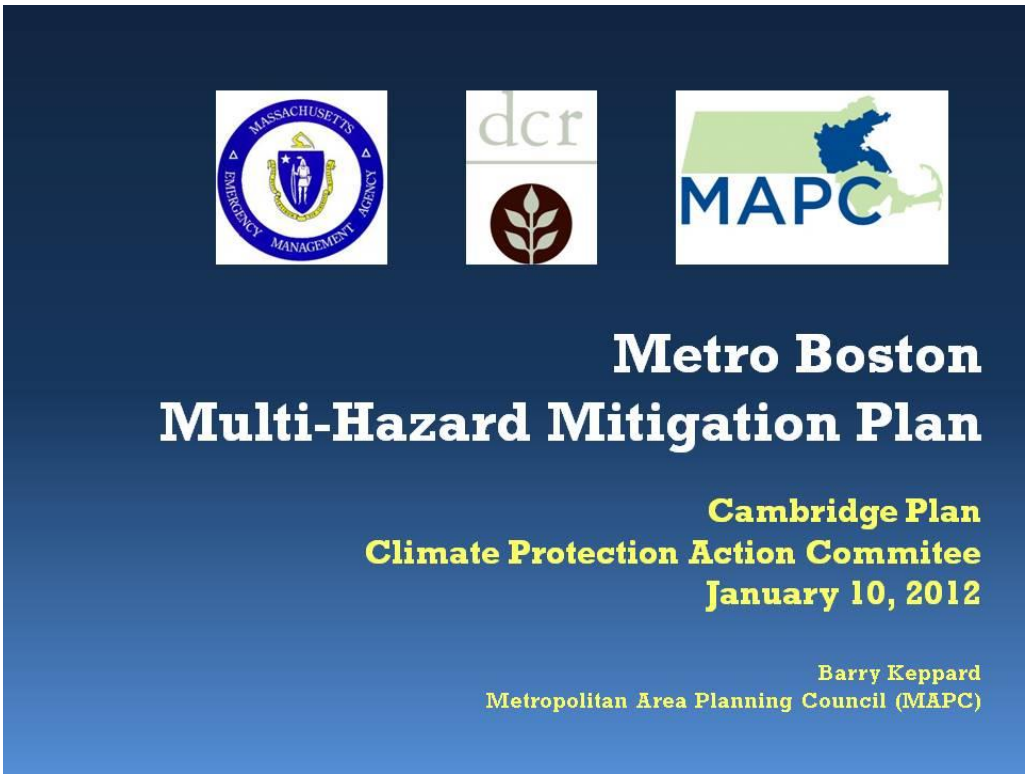
APPENDIX C
DOCUMENTATION OF PUBLIC PARTICIPATION


MASSACHUSETTS EMERGENCY MANAGEMENT AGENCY
dcr
MAPC
Metro Boston
Multi-Hazard Mitigation Plan
Cambridge Plan
Local Emergency Planning Committee
January 9, 2012
Barry Keppard
Metropolitan Area Planning Council (MAPC)


MASSACHUSETTS EMERGENCY MANAGEMENT AGENCY
dcr
MAPC
Metro Boston
Multi-Hazard Mitigation Plan
Cambridge Plan
Climate Protection Action Commitee
January 10, 2012
Barry Keppard
Metropolitan Area Planning Council (MAPC)

HAZARD MITIGATION PLAN PUBLIC MEETING

Natural hazards can have serious impacts on the City of Cambridge and its residents



The Cambrdidge Hazard Mitigation Plan presents a strategy for reducing the City's vulnerability to the impacts of natural hazard events such as flooding, hurricanes, and winter storms.

Join the City for a presentation and discussion about the update to the Cambridge Hazard Mitigation Plan

Date: Tuesday, March 18, 2014
Time: 6:30PM -7:30PM
Location: Department of Public Works
147 Hampshire Street

For more information, please contact

Barry Keppard via phone at (617) 933-0750 or email bkeppard@mapc.org

MAPC
METROPOLITAN AREA PLANNING COUNCIL

If you need any special accommodations, such as language interpretation, assistive listening devices or meeting materials in alternate formats, please use the contact information above to notify us in advance. We would appreciate notice as soon as possible, but at least one week prior to the event would be appreciated.


MASSACHUSETTS EMERGENCY MANAGEMENT AGENCY
dcr
MAPC
Metro Boston
Multi-Hazard Mitigation Plan
Cambridge Plan Update
DPW Building
March 18, 2014
Barry Keppard
Metropolitan Area Planning Council (MAPC)

APPENDIX D
DOCUMENTATION OF PLAN ADOPTION

<CITY LETTERHEAD>

CERTIFICATE OF ADOPTION
CITY COUNCIL

CITYOF CAMBRIDGE, MASSACHUSETTS

A RESOLUTION ADOPTING THE
CITY OF CAMBRIDGE
HAZARD MITIGATION PLAN 2015 UPDATE

WHEREAS, the City of Cambridge, MA established a Committee to prepare the *City of Cambridge Hazard Mitigation Plan 2015 Update*; and

WHEREAS, the *Cambridge Hazard Mitigation Plan Update* contains several potential future projects to mitigate potential impacts from natural hazards in the City of Cambridge, and

WHEREAS, duly-noticed public meetings were held by the City on January 9, 2013, January 10, 2013, and March 18, 2014, and

WHEREAS, the City of Cambridge authorizes responsible departments and/or agencies to execute their responsibilities demonstrated in the plan update,

NOW, THEREFORE BE IT RESOLVED that the Cambridge City Council adopts the *City of Cambridge Hazard Mitigation Plan 2015 Update*, in accordance with M.G.L. 40 §4 or the charter and ordinances of the City of Cambridge.

ADOPTED AND SIGNED this Date. _____

Name(s) / Title(s) Signature(s)

ATTEST