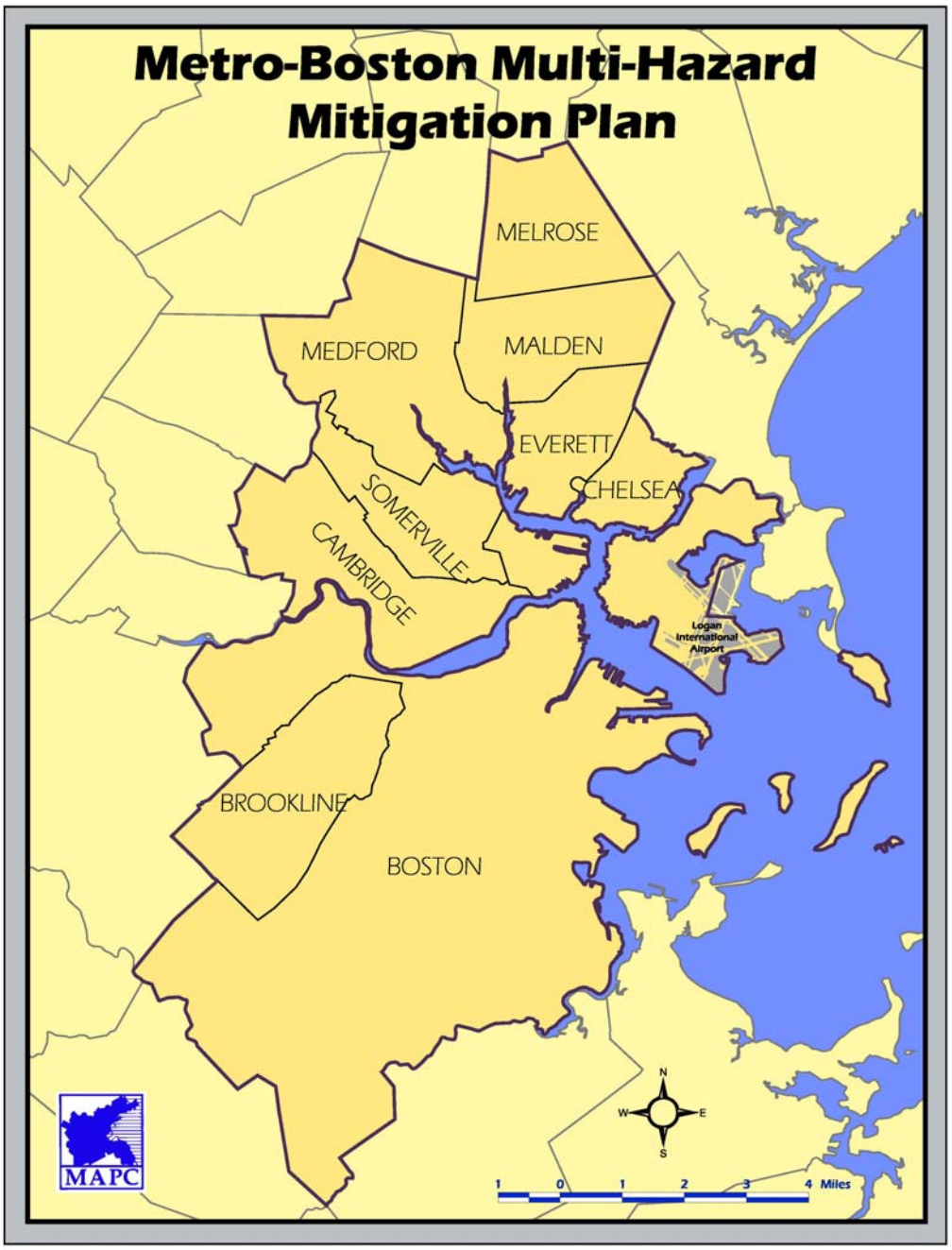

BOSTON ANNEX

March, 2008

Metropolitan Area Planning Council
60 Temple Place
Boston MA 02111

ACKNOWLEDGEMENTS AND CREDITS

This plan was prepared for the City of Boston 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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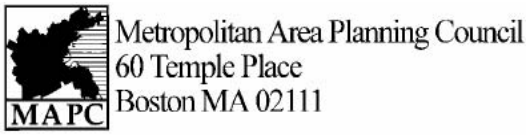

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INTRODUCTION

Planning Requirements under the Federal Disaster Mitigation Act
The Federal Disaster Mitigation Act, passed in 2000, required that after November 1, 2004, all municipalities that wish to continue to be eligible to receive Federal Emergency Management Agency (FEMA) funding for hazard mitigation grants must adopt a local multi-hazard mitigation plan. This planning requirement does not affect disaster assistance funding.

Massachusetts has taken a regional approach and has encouraged the regional planning agencies to apply for grants to prepare plans for groups of communities. The Metropolitan Area Planning Council (MAPC) received a grant from FEMA under the Pre-Disaster Mitigation (PDM) Program to assist the City of Boston and eight other communities with developing a regional multiple-hazard mitigation plan. The regional plan and this local annex meet the requirements of the Disaster Mitigation Act.

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

COMMUNITY PROFILE

Overview
Boston was incorporated as a town in 1630 and then a city in 1822. Since its incorporation as a city, Boston annexed six neighboring cities and towns to reach its size of 49.55 square miles. The city is located in Suffolk County. The city has a mayor-council form of government. The city's website is at www.cityofboston.gov.

Not only is Boston the capital of Massachusetts and therefore home to the State House, but it is the largest city in New England. According to the city's web site, in addition to the people who live and work in the city, Boston attracts 12 million tourists annually (an estimated 17.6 million people visited the Boston area in 2005) from around the county and around the world. Major attractions in the city range from the Museum of Science, Museum of Fine Arts, numerous theaters, Fenway Park, and the Harbor Islands.

Boston is also home to many historic buildings and structures that take diligent efforts and funding to preserve. Protection these assets from natural hazards is critical. These include large and well-known sites and structures such as the U.S. Constitution, numerous burying grounds, the Paul Revere House, Old North Church, etc. . But there are many smaller, lesser-known, but historically important sites scattered around the city.

Critical state offices and facilities are located in Boston. A number of Federal agencies also have offices in the city. These include: FEMA Region 1, Environmental Protection Agency Region 1, the U.S. Coast Guard, the Federal Bureau of Investigation, the Department of Housing and Urban Development, and many others.

Boston is also an economic focal point for the Commonwealth of Massachusetts as well as the greater New England Region, serving as a center for financial institutions, higher education and medical health services. The Boston economy constitutes 18% of the state's economy and 10% for all of New England. The importance of the city's medical and educational facilities is substantial with twenty inpatient hospitals and twenty-five public health clinics providing over 110,000 health service jobs. During 2004-2005 academic year Boston's thirty-two universities, colleges, graduate schools and community colleges had a combined enrollment of approximately 140,000 students, comprising 31% of the state's college students.

Boston borders 14 communities: Quincy, Milton, Canton, Dedham, Needham, Brookline, Newton, Watertown, Cambridge, Somerville, Everett, Chelsea, Revere, and Winthrop. Boston is home to a number of colleges and universities, health care facilities, and cultural and tourism destinations.

The city serves as the center of the region's transit system, with subway lines, commuter rail lines, bus service, ports and Logan International Airport. Logan International is the largest transportation center in New England. It handled over 27 million passengers and 400,000 flights in 2005, according to MassPort. Major ports operated by MassPort in Boston include the Port of Boston, Conley Terminal, Cruiseport and the Boston Autoport.

Two interstates (I-90 and I-93) converge in Boston. A number of state routes also pass through Boston, including Routes 1, 2, 3, 9, 20, 28, and 30.

Boston has a number of distinct neighborhoods with strong identities. For the purpose of this plan we refer to city neighborhoods as defined by the Boston Redevelopment Authority (BRA): Allston, Back Bay, Beacon Hill/West End, Brighton, Charlestown, Chinatown/Leather District, Dorchester, Downtown, East Boston, Fenway/Kenmore, Hyde Park, Jamaica Plain, Mattapan, Mission Hill, North End, Roslindale, Roxbury, South Boston, South End/Bay Village, and West Roxbury.

In 2000, the city's population was 589,141 and the number of housing units was 251,935 (see Table 1 below). Census estimates place the city's population at 596,638 by 2005. Over half of the city's housing units were built before 1940.

Table 1. Boston Characteristics, 2000

Population = 589,141
- 5.4% are under age 5
- 10.4% are over age 65
- 16.3% speak English less than "very well" (over age 5)
- 34.9% of households have no vehicle
- 21.9% have a disability (over age 5)
- 6% live in group quarters

Number of Housing Units = 251,935
- 67.8% are renter-occupied housing units
- 53.5% of housing units were built before 1940

Source: U.S. Census, 2000.

Boston has a unique history of land reclamation. According the city's *Open Space Plan*, the city grew from 1,000 acres to 30,000 acres due to land reclamation and annexation. As a result, large areas of Boston are built on fill. As discussed later, the amount of filled land affects the city's vulnerability to certain natural hazards.

Boston faces a number of challenges when addressing natural hazards. These include:
- Boston is an older, dense city with aging infrastructure and narrow streets.
- The city has a high amount of impervious surfaces.
- Boston has a large percentage of populations that may need special assistance during a natural disaster. Vulnerable populations may include those without cars, those that do not speak English well and those with a disability.
- Boston's housing is old and much was constructed before modern-day building codes.
- Large portions of the city are built on fill.

Existing Land Use

The most recent land use statistics available from the state are from 1999 aerial photography. Table 2 breaks the city into 21 land use category. The table shows the acreage of each land use category and the percentage of land area in Boston in each category.

The BRA presented land use statistics in a series of reports on various land uses. One report, *Residential Land Use in Boston* (February 2004), uses fiscal year 2000 tax assessor's data to break down the city's acreage as follows: Residential (36%), Commercial (9%), Industrial (4%) and Exempt (51%).

Table 2. Existing Land Use, Boston, 1999

Land Use	Acres	% of City
Cropland	18	0.06%
Pasture	35	0.11%
Forest	1,762	5.57%
Non-forested Wetlands	180	0.57%
Mining	49	0.15%
Open Land	757	2.39%
Participatory Recreation	1,938	6.13%
Spectator Recreation	275	0.87%
Water Recreation	119	0.38%
Multi-family Residential	5,383	17.02%
High Density Residential (less than ¼ acre lots)	7,161	22.65%
Medium Density Residential (¼ – ½ acre lots)	236	0.75%
Low Density Residential (Larger than ½ acre lots)	55	0.17%
Salt Water Wetlands	136	0.43%
Commercial	3,782	11.96%
Industrial	1,073	3.39%
Urban Open	3,672	11.61%
Transportation	3,880	12.27%
Waste Disposal	371	1.17%
Water	565	1.79%
Woody Perennials	173	0.55%
Total	**31,616**	**100%**

Source: MassGIS (see www.mass.gov/mgis/lus.htm. for more information on categories).

Potential Future Land Use

The following section provides information on the location and type of potential future development in Boston. This is not a comprehensive list of all projects. Because the extent and nature of future development in a city the size of Boston is very complex, this section breaks out the "core" section of Boston from many of its neighborhoods. For the core area, the BRA provided estimates of total square footage and residents from future development.

For the remaining neighborhoods outside the core area, this section lists actual projects based on those already planned or under construction, but only includes larger-scale developments (those with at least 100 housing units or roughly a half-million square feet). This information came from the BRA's website and from MAPC's knowledge of projects and initiatives.

Core Area

This area generally includes: Downtown, Back Bay, Beacon Hill/West End, Chinatown/Leather District, East Boston, Fenway/Kenmore, North End, South Boston and the South End/Bay Village. Table 3 provides a breakdown of potential non-residential square footage and residential units for various parts of the Core Area.

Table 3. Potential Future Development in Core Area, Boston

Area	Total Square Footage*	Residential Units	Type of Commercial Development
North Station / Bullfinch Triangle / West End	6,616,911	2,027	Office, hotel, retail
East Boston Water Front	2,388,283	1,542	Retail
Downtown / South Station / Dewey Square	11,189,439	2,687	Office, hotel, retail
South End / Bio-Square	3,676,465	1,075	Office, retail
Prudential / Boylston St.	2,905,766	1,063	Office, hotel, retail
South Boston Waterfront	21,169,071	6,604	Office, hotel, retail
LMA / Fenway / Kenmore Square	8,371,968	1,951	Office, retail
Chinatown / South Bay	7,325,171	3,154	Office, hotel, retail
Total	**63,643,074**	**20,103**	

*Includes parking.
Source: BRA, 2006.

Other Neighborhoods

Allston/Brighton

- Chestnut Hill Waterworks, Beacon Street, 108 housing units
- St. John of God – Monarch, 487 Washington Street, 200 housing units including assisted living
- 9-23 Griggs Street, 100 housing units
- Harvard University – Allston area. Harvard recently unveiled its campus plan for 200 acres. The plan includes placing a portion of Soldiers Field Road underground, constructing a pedestrian bridge across the Charles River, 4 – 5 million square feet of buildings for retail, dormitories and academic uses, and open space
- Boston University – Dormitories, underground parking for 1,000 car parking facility, structured courtyards and 1,430 student dormitory beds on Commonwealth Avenue
- St. Elizabeth's Medical Center Institutional Master Plan includes a new emergency department, access road, three story addition to the garage, new infill building on Cambridge Street, and a helipad; located on Cambridge Street
- Turnpike Air Rights Parcels 1, 4, 5 and 6. Guidelines from *A Civic Vision for Turnpike Air Rights in Boston* call for cultural or academic with research facilities

Charlestown

- Charlestown Navy Yard Parcel 4, Harborview Point, First Avenue, 425,000 square feet, 215 housing units, retail
- Hood Business Park, 480-570 Rutherford Avenue, 1,168,820 square feet, mixed use development to be developed over a 15 year period
- Littleneck Lofts, 48-56 Brighton Avenue, 146 housing units
- Charlestown Navy Yard – Future development will mostly be public spaces, not significant scale development

Dorchester

- Ashmont Station Transit Oriented Development, 1950 Dorchester Avenue, 190,000 square feet, 105 housing units, retail
- Mount Vernon Street Housing Project, 401 Mount Vernon Street, 303,220 square feet, 333 housing units

Hyde Park

- Riley House, 39 Maple Street/1256 Hyde Park Avenue, 122 residential units

Jamaica Plain

- Blessed Sacrament Campus Redevelopment, 365 Centre Street, 118 housing units, retail space
- Forward Inc., Project, 2055 Columbus Avenue/409 Walnut Street, 123,683 square feet, 100 housing units including for elderly and mentally ill
- Jackson Square, vision includes 430 housing units, retail, community uses

Mattapan

- Mattapan Heights, Phases 2 and 3, 249 River Street, 373,000 square feet, 156 housing units
- Olmsted Green, 287 homeownership units, 153 rental units, 123-bed skilled nursing facility, 83 units of senior rental housing, community center

Mission Hill

- Basilica Court, 80-100 Smith Street, 142,500 square feet, 218 housing units
- Terrace Street Lofts, 150, 160, 17 Terrace Street, 145,000 square feet, 350 housing units

Roslindale

- Sophia Snow House, 1215 Center Street, 94,600 square feet, 102 housing units including assisted living and elderly housing

Roxbury

- Albany Fellows Mixed Use Development, 817 Albany Street, 265 units and retail
- Crosstown Center Phases I and II, Hampden Street and Massachusetts Avenue, includes hotel, retail and office
- Northeastern University, proposal for two student dormitories: 500,000 square feet on Parcel 18 in Roxbury, 1,200 beds, dining facility; and 200,000 square feet with 600 beds, on St. Botolph Street in the Fenway

West Roxbury

No large projects were under construction or in the permitting phase at this time.

PUBLIC PARTICIPATION

Public participation in developing this plan occurred at two levels: the regional committee and the Boston Multiple Hazard Community Planning Team. In addition, the city held one public meeting to present the plan and solicit input.

Boston's Participation in the Regional Committee
In November 2004, MAPC notified the nine communities of the first meeting of the Metro Boston Regional Hazard Mitigation Community Planning Team and requested that the Chief Elected Official designate at least two municipal employees and/or officials to represent the community.

The Metro Boston Regional Hazard Mitigation Community Planning Team met during the course of plan development on the following dates:

- December 16, 2004
- May 19, 2005
- October 14, 2005
- February 23, 2006
- November 16, 2006

Agendas from these meetings are located in Appendix B.

The Local Multiple Hazard Community Planning Team
In addition to the regional committee meetings, MAPC worked with the local community representatives to organize a local Multiple Hazard Community Planning Team for Boston. MAPC met with local officials in September 2005 to introduce the project. Attendance for that meeting and a second team meeting is found in Table 4.

MAPC met with other city officials outside of team meetings to collect information. Those other meetings are listed in Table 5; this does not include meetings to collect GIS data. In addition, MAPC collected information via phone interviews or email.

As discussed later, MAPC met with the Cultural Emergency Management Team (CEMT). They are a group comprised of cultural institutions in Boston and neighboring communities and they are working to reduce the impacts of hazards on cultural facilities and their collections.

Table 4. Attendance at the Boston Local Multiple Hazard Community Planning Team Meetings

September 26, 2005
Arthur Torigian, Lieutenant, Police Department
Jeanne Richardson, Boston Water and Sewer Commission (BWSC)
John Hardiman, Mayor's Office of Emergency Preparedness (MOEP)
Philip McGovern, III, MOEP
Gerald Fontana, MOEP
Carl Walter, Police Department
December 14, 2006
Jim Hunt, Environment and Energy Department
Jeanne Richardson, BWSC
Gerald Fontana, Fire Department
Charles Jewell, BWSC
John Sullivan, BWSC
William Tyrell, BWSC
Rene Fielding, MOEP
Jake Sullivan, Mayor's Office of Intergovernmental Relations
Chris Busch, Environment Department
Molly Dunford, Mayor's Office of Intergovernmental Relations
Aldo Ghirin, Parks and Recreation Department
Jim Fitzgerald, BRA
Joseph Canavan, Department of Public Works (DPW)

Table 5. Other Local Meetings

Date	**Participants**
August 17, 2005	Joseph Casazza, Joseph Canavan, DPW
September 25, 2006	Joseph Canavan, DPW
October 3, 2006	Chris Busch, Conservation Agent
October 5, 2006	Charlie Jewell, John P. Sullivan, BWSC
October 12, 2006	Aldo Ghirin, Kenneth Crasco, Stanley J. Ivan, Parks and Recreation Department
October 24, 2006	Mark Lynch, H. David Troup, Jr., Boston Police Department
November 16, 2006	Kevin MacCurtain, Kathleen Kirleis, John P. Henderson, Gerald Fontana, Chief DiBenedetto, Boston Fire Department.
January 12, 2007	Harold McGonagle, Gary Moccia, James Lane, Michael Mackan and Thomas Goodfellow, Inspectional Services Dept. (ISD)

The Public Meeting
MAPC presented the draft annex at the April 18, 2007 meeting of the Boston Conservation Commission. The meeting was listed on the Commission's agenda. Commissioners offered general comments on the plan during the meeting and then forwarded written comments to the Conservation Agent. Comments included:

- Need for funding
- A question about the Fire Alarm Building proposal
- A concern about proposed snow melting technology
- Need for full-functioning emergency pumps on the Charles River Dam and that the condition of the pumps should be a high priority
- Need for remediation of soils if Moon Island Bridge is restored; range should be indoors
- Important to send street sweepers out after severe flooding and hurricane events to clear catch basins and remove debris from roads that can flatten emergency vehicle tires
- Tide gates at Morrissey Boulevard have been updated and has helped to reduce floodint
- LaGrange and Brookfarm Roads in West Roxbury are prone to flooding.

OVERVIEW OF HAZARDS AND VULNERABILITIES

This section provides a general overview of how a number of natural hazards impact Boston. The next section provides more detail about impacts at specific locations and existing mitigation efforts. Maps are located in Appendix A.

Overview of Hazards and Impacts
The 2004 *Massachusetts Hazard Mitigation Plan* provides an overview of natural hazards in Massachusetts. It indicates that Massachusetts is subject to the following natural hazards (listed in order of frequency): floods, heavy rainstorms, nor'easters, coastal erosion, hurricanes, tornadoes, urban and wildfires, drought and earthquakes. Table 6 summarizes the hazard risks for the state and notes where risks in Boston differ from the state assessment.

The Boston Fire Department maintains a database of incidents. From 2001 through 2005 an average of 203 incidents were reported. Table 7 indicates days with heavier than normal incidents and the causes, if known.

Table 6. Frequency and Severity of Natural Hazards in the State and Boston

Hazard	Frequency	Severity	Comments
Flood	High	Serious to extensive	
Dam Failure	Low	Extensive	
Hurricanes	Medium	Extensive to catastrophic	Boston has an extensive coast line
Severe Storms (wind, hail, lightning)	Medium	Serious	High density and on-street parking in urban areas can make street tree damage a concern
Tornados	Medium	Extensive to catastrophic	No tornadoes recorded in Boston
Winter Storms	High	Serious	High density can pose challenges
Earthquakes	Low	Catastrophic	Higher potential for damages in areas prone to liquefaction. Boston area at higher risk than rest of state
Landslides	Low	Minor	Coastal erosion issues in Boston
Brush Fires	Medium	Serious	

Definitions Used in the Commonwealth of Massachusetts State Hazard Mitigation Plan

Frequency
- Very Low Frequency: Events that occur less frequently than once in 1,000 years (less than 0.1% per year).
- Low Frequency: Events that occur from once in 100 years to once in 1,000 years (0.1% to 1% per year).
- Medium Frequency: Events that occur from once in 10 years to once in 100 years (1% to 10% per year).
- High Frequency: Events that occur more frequently than once in 10 years (greater than 10% per year).

Severity
- Minor: Limited and scattered property damage; no damage to public infrastructure (roads, bridges, trains, airports, public parks, etc.); contained geographic area (i.e., 1 or 2 communities); essential services (utilities, hospitals, schools, etc) not interrupted; no injuries or fatalities.
- Serious: Scattered major property damage (more than 50% destroyed); some minor infrastructure damage; wider geographic area (several communities); essential services are briefly interrupted; some injuries and/or fatalities.
- Extensive: Consistent major property damage; major damage to public infrastructure (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and fatalities.
- Catastrophic: Property and public infrastructure destroyed; essential services stopped, thousands of injuries and fatalities.

Table 7. Reported Incidents, Boston

Date	No. of Incidents	Cause (if known)
July 18, 2006	293	Heat
June 23, 2006	298	Rain
May 14, 2006	274	Heavy rain
January 18, 2006	275	
December 9, 2005	283	Snow, wind
October 25, 2005	301	Rain, nor'easter
August 31, 2005	271	Wind
August 5, 2005	281	Wind
August 2, 2005	331	Thunder, lightning, rain, wind

Table 7. Reported Incidents, Boston

Date	No. of Incidents	Cause (if known)
July 6, 2005	270	Rain
January 24, 2005	311	Blizzard
January 23, 2005	313	Blizzard
January 19, 2005	282	Cold
December 21, 2004	292	
January 18, 2004	318	
January 17, 2004	515	
January 16, 2004	407	Cold
January 12, 2004	439	Cold
January 11, 2004	414	Cold
January 10, 2004	349	Cold
January 9, 2004	297	Cold
December 15, 2003	275	Snow
August 22, 2003	294	Heat
February 17, 2003	277	Snow
February 16, 2003	276	Snow
February 7, 2003	288	Snow
January 25, 2003	276	
January 24, 2003	296	
January 23, 2003	278	Cold
January 18, 2003	275	Cold
December 25, 2002	290	Wind
December 20, 2002	276	Wind, rain
September 28, 2002	317	Remnants of Hurricane Isidore
September 11, 2002	289	Warm, wind
July 4, 2002	316	Warm
July 3, 2002	300	Warm
June 27, 2002	338	Wind, thunder
October 15, 2001	299	Drizzle, damp, fog
October 12, 2001	281	
October 4, 2001	276	Warm
August 10, 2001	345	Warm, thunderstorms
August 9, 2001	278	Warm
August 4, 2001	278	Thunderstorms
August 3, 2001	378	Warm, rain
July 24, 2001	281	Warm, windy
July 1, 2001	273	Windy
June 30, 2001	365	Warm, windy, thunderstorms
June 20, 2001	299	Thunderstorms, wind
June 17, 2001	312	Rain
June 16, 2001	283	

`Source: Boston Fire Department, 2006.

Flooding

Flooding occurs during hurricanes, nor'easters, severe rainstorms and thunderstorms and is often worsened by coastal storm surges and high tides. Local officials noted that while hurricanes are not frequent, resulting floods cause problems. Most of the flooding in Boston occurs in low-lying, natural flood plains.

There have been a number of major rain storms that have resulted in significant flooding in eastern Massachusetts over the last fifty years. Excluding hurricanes, significant rain storms include:

- August 1954
- March 1968
- January 1979
- April 1987
- October 1991 ("The Perfect Storm")
- October 1996
- June 1998
- March 2001
- April 2004
- October 2005
- May 2006

The state plan indicates that Massachusetts is one of the 10 states that cumulatively account for 76% of all repetitive loss buildings in the United States. There are 17 repetitive loss structures in Boston, located throughout the city. As defined by the Community Rating System (CRS) of the National Flood Insurance Program (NFIP), a repetitive loss property is any property for which the NFIP has paid two or more flood claims of $1,000 or more in any given 10-year period since 1978.

From 1978 to December 2003, Boston property owners filed a total of 207 losses with the National Flood Insurance Program. Of these, 134 have been paid for a total of just under $800,000.

In addition to property damage, flooding can cause transportation impacts as experienced by the MBTA near the Muddy River. These transportation impacts also can affect emergency response. Flooding can also create unsanitary conditions. Power outages due to flooding can put public health and safety at risk. Details on specific impacts are discussed later.

According to the 2004 "CLIMB" study on sea-level rise, sea level has risen approximately 0.3 meters over the last century. Continued sea level rise will lead to more flooding and will give storm surges more power. The result is that the 10-year storm will have the same intensity of a current 100 year storm and the 100 year storm will have the intensity of today's 500 year storm.

High Winds and Hurricanes

Wind-related hazards include hurricanes and tornadoes as well as high winds during severe rainstorms and thunderstorms. Table 7 indicates dates with high numbers of incidents reported,

many due to high winds. The city has a 100-year wind speed of 110 miles per hour. No tornadoes have been recorded in Boston.

The region has been impacted by hurricanes throughout its history, starting with the Great Colonial Hurricane of 1635. The eye of one hurricane passed right through Boston in 1944. Much of the coast lies within hurricane storm surge zones – called SLOSH zones. Hurricane storm surge is an abnormal rise is sea level accompanying a hurricane or other intense storm. This is discussed in more detail later. Hurricanes that have occurred in the region include[1]:

- 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 Hazel October 15, 1954
- Hurricane Diane August 17-19, 1955
- Hurricane Donna September 12, 1960
- Hurricane Gloria September 27, 1985
- Hurricane Bob August 19, 1991

*Category 3.

Not included in this list is the Portland Gale of November 26-28, 1898, which may well have been the most damaging coastal storm in Massachusetts history.

Winter Storms

In Massachusetts, northeast coastal storms known as nor'easters occur one to two times per year. Winter storms are a combination of hazards because they often involve wind, flooding and snow. Table 7 shows dates with high numbers of incidents reported. Impacts from snow are a constant concern since storms occur every year. The area has a long history of severe and damaging winter storms. According to data from the hazard mapping, the average annual snowfall is 36.1 to 48 inches in half of the city (mostly closest to coast) and 48.1 to 72 inches in the remainder of the city. Significant storms that have hit the region, ranked by snowfall amounts, are:

- February 6, 1978, 27.1 inches
- February 24, 1960, 26.3 inches
- March 31, 1997, 25.4 inches
- January 20, 1978, 21.4 inches
- March 3, 1960, 19.9 inches
- February 15, 1958, 19.4 inches
- February 8, 1994, 18.7 inches
- December 20, 1975, 18.2 inches *(tie)*
- January 7, 1996, 18.2 inches *(tie)*
- February 5, 1920, 17.3 inches
- February 20, 1921, 16.5 inches[2]

[1] Information on storms provided by Cambridge Emergency Management Department. It is assumed that these same storms affected the entire 9-Community region, including Boston.
[2] Information provided by City of Cambridge. Snow amounts are likely applicable to Boston.

As a denser, built-out community with many narrow streets and on-street parking, snow storms pose a number of challenges to the city. As expected, a number of public safety issues can arise during snow storms. Impassible streets are a challenge for emergency vehicles and affect residents and employers. Snow-covered sidewalks force people to walk in streets, which are already less safe due to snow, slush, puddles and ice. Large piles of snow can also block sight lines for drivers, particularly at intersections. Not all residents are able to clear their properties, especially the elderly. And when that snow melts, flooding occurs. Refreezing of melting snow can cause dangerous roadway conditions. In addition, the city must use large amounts of sand to keep its streets safe. Sand can in turn cause clogging and flooding issues.

Fire-Related Hazards

According to the Fire Department, Boston experiences a number of brush fires a year: 122 in 2003, 141 in 2004 and 166 in 2005. Brush fires are more prevalent in those parts of the city with more vegetation, such as West Roxbury, Hyde Park, Dorchester and Roslindale.

It is important to remember that fire can also be a result of other events, such as the aftermath of an earthquake.

Geologic Hazards

Earthquakes

Although new construction under the most recent building codes generally will be built to seismic standards, much of the development in the city pre-dates the most recent building code. While an earthquake would affect the entire city, a number of areas in Boston are at high risk for liquefaction, as discussed below.

According to the *State Hazard Mitigation Plan*, New England experiences an average of five earthquakes per year. From 1627 to 1989, 316 earthquakes were recorded in Massachusetts. Most have originated from the La Malbaie fault in Quebec or from the Cape Anne fault located off the coast of Rockport. The region has experienced larger earthquakes, of magnitude 6.0 to 6.5 in 1727 and 1755. Other notable earthquakes occurred here in 1638 and 1663 (Tufts University).

Earthquakes can result in many impacts beyond the obvious structural impacts. Buildings may suffer structural damage that is not readily apparent. Earthquakes can cause major damage to roadways, making emergency response difficult. Water lines and gas lines can break, causing flooding and fires. Equipment in buildings can be vulnerable. 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.

One additional impact of particular concern in the Boston metropolitan area is liquefaction, 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, beach deposits, fluvial

deposits and flood plain deposits. Non-engineered artificial fill is what is typically known 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 and many of those structures pre-date the seismic provisions of the current Massachusetts State Building Code.

William Lettis & Associates, Inc., and Tufts University recently prepared regional susceptibility maps using geological maps and soil borings. This data is shown on Map 4. Areas in Boston that are at high risk for liquefaction are discussed later.

It is important to remember three points when viewing this map:

- This is a regional map and should not be used for site-specific analysis.
- There can be great variability within a given area. For example, a building located in an area shown as highly susceptible could in fact be built on a pocket of low susceptibility. The reverse is also true.
- When new buildings are built on filled areas, engineered fill replaces the existing fill, thereby strengthening the soils.

Landslides

Most of Boston is classified as a moderate landslide risk. Those parts of Boston furthest from the coast are classified as low risk.

Coastal Erosion

Boston has an expansive coastline (10 miles along Boston Harbor) and a number of islands. Much of the shoreline is located in the velocity zone (V zone). These areas are subject to repeated wave action and winds. These natural processes not only destabilize coastal structures, but also lead to shoreline change. The state Office of Coastal Zone Management (CZM) has been working on this issue and mapping coastal change.[3] According to CZM, impacts from coastal change can "expose septic systems and sewer pipes, contaminating shellfish beds and other resources; release oil, gasoline, and other toxins to the marine environment; and sweep construction materials and other debris out to sea. Public safety is also jeopardized when buildings collapse or water supplies are contaminated."

CZM has established a Coastal Hazards Commission. The Commission, among other tasks, will be looking at data gaps and making recommendations on how to minimize future damage.

Specific coastal areas in Boston that are affected by erosion / destabilization are discussed later.

<u>Climate Change</u>

Federal studies have predicted that the average temperature in New England will increase 6 to 10 degrees Fahrenheit during this century. Impacts include the creation of habitat for disease-carrying insects that do not currently occur here, changes in rain and snowfall patterns, sea-level rise, and greater coastal storm damage. In other words, many of the natural hazards discussed earlier could have greater impacts in the future.

[3] See http://www.mass.gov/czm/shorelinechange.htm for more details.

Overarching Impacts from Natural Hazards

There are certain overarching impacts that can occur from virtually any of the natural hazards discussed above and can have great impacts on the city, its residents, businesses and institutions. Impacts from power outages can result in the closure of commercial establishments, interruptions of research, public health concerns, and overall safety issues. Impacts to the public transportation system and road network in the region can impact Boston residents and employers, interrupting the delivery of essential services and making evacuations difficult.

As noted earlier, CEMT represents a number of cultural institutions in Boston and neighboring communities that are working to protect cultural resources from damage. CEMT provided information on the vulnerabilities of these facilities to natural hazards. Many of Boston's cultural facilities can be highly vulnerable to damage from high winds and tornados, floods, and earthquakes. Even some of Boston's largest and newest museums, libraries and archives, because of their need for prime publicly accessible exhibition, study and function space, store collections in basement areas vulnerable to flooding. While some of the newer buildings in the area have been designed and constructed to be earthquake resistant, the vast majority of collections, both in storage and on display, have not been retrofitted to protect fragile objects during tremors. Fire remains one of the great risks to cultural heritage because the resultant loss is so often irrecoverable and irreplaceable.

Critical Facilities in Hazard Areas

Maps 1 through 8 and Table 8 list critical facilities in Boston. Critical facilities include those facilities that perform an important function during a natural disaster such as shelters, emergency operation centers, and public utilities. Critical facilities also can include locations that house sensitive populations, such as schools or nursing homes, or sensitive sites. The maps and the table illustrate potential vulnerabilities of critical facilities to various natural hazards. There are other critical facilities and infrastructure that are not mapped because the information was not available. These include utilities and communication facilities.

A very large number of critical facilities are located in Boston, making it impossible to fit all on one map. Maps 1 through 8 are broken out into four series (A, B, C, and D) as follows:

- A Series – Emergency services that generally are relied upon before, during and after a natural hazard event
- B Series – Other critical infrastructure such as pumping stations and city buildings
- C Series – Elderly housing, nursing homes and correctional facilities
- D Series – Schools and day-cares

The purpose of mapping the natural hazards and critical facilities is to present an overview of hazards in the community and how they relate to critical facilities. Because such a large portion of Boston was constructed on fill and because of the city's extensive coast line, a large number of critical facilities and vulnerable populations are located in hazard zones and a number are located in more than one hazard zone. It is important to note that the Flood Zone column in Table 8 is based on FEMA-mapped flood zones. In many cases, these maps are out of date or their scale precludes their use for parcel or site analyses. This means that critical facilities not listed as being in a flood zone could actually be located in one. Site-specific verifications are necessary to confirm.

This table does not include utilities or transportation corridors, but Map 8 indicates that all evacuation routes from downtown including transit lines are located in multi-hazard areas. Maps 4 and 5 indicate that components of the city's transportation infrastructure are also located within or partially within both hurricane surge zones and areas at high risk for liquefaction. This includes Storrow Drive, Soldiers Field Road, I-90, and I-93.

ID #	Earthquake	Hurricane	Flood Zone
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4	3	2	
5	3	2	
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16	3	2	
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24	3	2	
25			
26	3		
27	3	1	AE
28	3	2	AE
29		2	
30	3		
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ID #	Earthquake	Hurricane	Flood Zone
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36	3	2	
37	3	2	
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42		4	
43	3	2	
44	3	2	X500
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59	3	4	
60	3	2	
61	3	1	
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64		4	
65	3	2	
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67	3	2	
68	3	2	
69	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
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83	3	2	
84	3	1	
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87	3	4	
88	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
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120	3	4	
121	3	2	
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132	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
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159	3	2	AE
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162		4	
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164	3	2	
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166	3	2	
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169	3	2	
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179	3	2	
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182	3	4	
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184		2	

ID #	Earthquake	Hurricane	Flood Zone
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190	3	2	
191	3	2	
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193		4	
194	3	1	
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201	3	2	
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211	3	1	AE
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220	3	4	
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ID #	Earthquake	Hurricane	Flood Zone
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233	3	2	
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244		2	
245	3	4	
246	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
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268	3	1	AE
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270	3	2	X500
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272	3	1	
273	3	2	
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276	3	2	
277	3		
278	3	2	
279		2	
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ID #	Earthquake	Hurricane	Flood Zone
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302	3	4	
303	3	4	
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307	3	2	
308	3	2	
309	3	2	
310	3		
311	3	2	
312	3		
313		2	
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320	3	2	
321	3	2	
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332	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
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347	3	2	
348		2	
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351	3	2	
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354	3		
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356	3	2	
357	3		
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360	3	4	
361		2	
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363	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
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382	3	2	
383		4	
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385	3	2	
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387	3	2	
388	3		
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397		2	X500
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399	3	2	
400	3	1	AE
401		4	
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405	3	2	
406	3	2	
407	3	2	
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412	3	1	

ID #	Earthquake	Hurricane	Flood Zone
413	3		
414	3	2	X500
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429	3	2	
430	3	2	
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434	3	2	
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439	3		
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441	3	2	
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449	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
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452	3		
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456	3	2	
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465	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
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501		4	
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515		4	
516		4	
517	3	2	
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522	3	3	
523	3		
524	3	1	X500
525	3	1	
526	3	2	

ID #	Earthquake	Hurricane	Flood Zone
527	3	2	
528	3	2	
529	3		AE
530	3	2	
531	3	2	
532	3	2	
533	3	1	
534	3	1	
535	3	2	
536	3	2	AE
537	3	4	
538	3	2	
539	3	2	
540	3	1	
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ID #	Earthquake	Hurricane	Flood Zone
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ID #	Earthquake	Hurricane	Flood Zone
604		2	
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ID #	Earthquake	Hurricane	Flood Zone
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ID #	Earthquake	Hurricane	Flood Zone
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ID #	Earthquake	Hurricane	Flood Zone
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ID #	Earthquake	Hurricane	Flood Zone
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ID #	Earthquake	Hurricane	Flood Zone
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792	3	2	
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820	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
829	3	2	
830			
831	3		
832	3	2	
833	3	2	
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ID #	Earthquake	Hurricane	Flood Zone
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Explanation of Columns in Table 8

Column 1: ID #: ID number which appears on the maps. See Appendix A.

Column 2: Earthquake Liquefaction Risk: Whether there is a high or moderate risk for liquefaction during an earthquake. This data was provided by Tufts University.

Column 3: Hurricane Surge Area: Whether the site is located within a hurricane surge area and the potential degree of inundation during a hurricane. The following explanation of hurricane surge areas is taken from the U.S. 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. There are about 40 SLOSH models from Maine to Texas. 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." 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 3: Flood Zone: Risk of flooding. 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). If there is an entry in this column, it indicates the type of flood zone as follows:

> **Zone A** - 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 -** 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 B, C, and X500 -** Zones B, C, and X are the flood insurance rate zones that correspond to areas outside of the 100-year floodplains, areas of 100-year sheet flow flooding where average depths are less than 1 foot, areas of 100-year stream flooding where the contributing drainage area is less than 1 square mile, or areas protected from the 100-year flood by levees. No BFEs or depths are shown within this zone.

Zone VE - **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.**

Potential Damages to Existing Development

HAZUS-MH is a tool to help estimate potential damages from certain types of natural hazards. We used HAZUS to estimate losses from a hurricane and earthquake. We did not use HAZUS to estimate flooding damages, for reasons explained below. The following overview of the HAZUS-MH is taken from the FEMA website. For more information, go to http://www.fema.gov/plan/prevent/hazus/.

> "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 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."

This analysis is level 1 – it relies upon default data on building types, utilities, transportation, etc., from national databases and census data. While the databases include a wealth of information on the nine communities that are a part of this study, 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 a starting point to understanding potential damage from the hazard events. If interested, communities could build a more accurate database and further test disaster scenarios. Table 9 displays damages from category 2 and 4 hurricanes. Table 10 displays damages if an historic earthquake were to occur today and if a stronger (7.0) earthquake were to occur.

Damages from Hurricanes

According to the *State Hazard Mitigation Plan*, between 1858 and 2000, there were 15 hurricanes; 60% were Category 1, 33% were Category 2 and 7% were Category 3. For the purposes of this plan, a Category 2 and a Category 4 storm were chosen to illustrate damages. While the region has not experienced a Category 4 hurricane, modeling one helps to illustrate a "worst case scenario." This can 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 9. Estimated Damage in Boston from a Category 2 or 4 Hurricane

	Cat. 2	Cat 4*
Building Characteristics		
Estimated total buildings	76,183	
Estimated total building value (Year 2002 $)	$38,104,000,000	
General Building Damage		
# of buildings sustaining minor damage	2,173	17,890
# of buildings sustaining moderate damage	432	21,178
# of buildings sustaining severe damage	19	13,329
# of buildings destroyed	2	7,396
Population Needs		
% of hospital beds available on day of event	90%	0%
# of households displaced	389	85,535
# of displaced people seeking public shelter	102	23,576
Debris		
Building debris generated (tons)	27,722	1,553,786
Tree debris generated (tons)	87,786	153,671
# of truckloads to clear building debris	1,129	62,046
Value of Damages		
Total property damage	$125,748,980	$14,114,728,370
Total business interruption loss	$14,441,700	$2,330,165,600

*No category 4 or 5 hurricanes have been recorded in New England.
Source: HAZUS-MH.

Damages from Earthquakes

The HAZUS earthquake module allows users to define different types of earthquakes and to input various parameters. The module is more useful when there is a great deal of data available on earthquakes. In New England, defining the parameters of a potential earthquake is much more difficult because there is little historical data. The earthquake module does offer the user the opportunity to select a number of historical earthquakes that occurred in Massachusetts. For the purposes of this plan, two earthquakes were selected: a 1963 earthquake with a magnitude of 5.0 and an earthquake with a magnitude of 7.0.

Table 10. Estimated Damage in Boston from Magnitude 5.0 and 7.0 Earthquakes

	Magnitude 5.0	Magnitude 7.0
Building Characteristics		
Estimated total number of buildings	76,183	
Estimated total building replacement value (Year 2002 $)	$38,104,000,000	
Building Damages		
# of buildings sustaining slight damage	411	16,545
# of buildings sustaining moderate damage	100	8,713
# of buildings sustaining extensive damage	10	2,601
# of buildings completely damaged	1	520
Population Needs		
# of households displaced	41	10,099
# of people seeking public shelter	11	2,762
Debris		
Building debris generated (tons)	13,000	1,491,000
# of truckloads to clear building debris	520	59,640
Value of Damages		
Total property damage	$26,150,000	$2,529,810,000
Total losses due to business interruption	$4,200,000	$718,140,000

Source: HAZUS-MH.

Damages from Flooding

HAZUS-MH did not provide useable results for estimating flood damages. In addition to technical difficulties with the software, the riverine module is not a reliable indicator of flooding in densely developed urban areas. In lieu of using HAZUS, actual damages have been calculated for the city's largest and most damaging area of flooding – the Muddy River. Flooding in 1996 caused $63 million in damages, though this damage extends beyond the Boston boundary.

Potential Impacts to Future Development

Table 11 compares larger areas of future development with natural hazard areas. All areas where future growth is expected are within a number of hazard zones. This is inevitable in a city like Boston, where much of the land is fill and there is an extensive coastline.

Table 11. Future Development in Hazard Areas

Area	100 Year Flood Zone or Velocity Zone	Hurricane Surge Zone	Earthquake Liquefaction Susceptibility
North Station / Bullfinch Triangle / West End		X	X
East Boston Waterfront	X	X	X
Downtown / South Station / Dewey Square		X	X
South End / Bio-Square		X	X
Prudential / Boylston Street		X	X
South Boston Waterfront	X	X	X
LMA / Fenway / Kenmore Square	X	X	X
Chinatown / South Bay		X	X

X = located within or partially within hazard area.

HAZARDS AND EXISTING MITIGATION MEASURES

This section provides more detail on how natural hazards affect specific parts of Boston. Existing mitigation measures are discussed under each hazard heading and existing mitigation measures for all natural hazards are compiled in Table 12.

Multi-Hazard Issues
Many issues and mitigation strategies apply to any natural hazard and are summarized here.

A number of local officials expressed a need for a redundant disaster center. They felt that the city needed one large enough to staff emergency workers during a prolonged hazard event. The issue of reducing the impacts to critical city departments during power outages came up. Many departments have generators, but not all. Of 34 Fire Stations, only half have emergency generators. In addition, stray voltage presents a public safety hazard.

With a large coast line, the Police Department's Harbor Patrol and the Fire Department's Marine Unit play important public safety functions. The Police Department's boats and harbor patrol infrastructure are currently exposed to tides, waves and ice sheets. The Fire Marine Unit is not under cover and therefore vulnerable during storms.

Existing Mitigation Measures

- Comprehensive Emergency Management Plan (CEMP) – Every community in Massachusetts is required to have a CEMP. These plans address mitigation, preparedness, response and recovery from a variety of natural and man-made emergencies. These plans contain important information regarding flooding, dam failures and winter storms. Therefore, the CEMP is a mitigation measure that is relevant to many of the hazards discussed in this plan.

- Adoption 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. The building code can be viewed in its entirety at http://www.mass.gov/bbrs/newcode.htm.

- The City of Boston's Emergency Management Division is one of two operational elements of the MOEP and is staffed by five, full time, inter-disciplinary members that work to mitigate, plan, and prepare for emergencies; educate the public about preparedness, coordinate resources for emergency response and recovery efforts; collect and disseminate critical information; and, seek further opportunities to support the overall preparedness of the City of Boston. In addition, the Emergency Management Division plays a critical role within routine and non routine emergencies by maintaining on-scene and remote situational awareness of the incident as well as coordinating inter-agency response. Moreover, the Emergency Management Division also has the responsibility of managing and utilizing the Emergency Operations Center during a time of need. Such Division will work with other entities throughout the Region to ensure proper hazard mitigation measures are put into place.

- The city recently prepared and distributed *Ready Boston: An Emergency Preparedness and Evacuation Guide for City Residents*. The guide is available in English, Spanish, French, Chinese, Portuguese, and Vietnamese. Highlights of the plan include:
  - How to assemble an emergency supply kit and create a household preparedness plan
  - Small and large scale evacuations, including provisions for those without cars
  - The city set up a phone system that can contact 60,000 residents in an hour

- The importance of ensuring that communications systems work during a natural event was reiterated by local officials. The city is currently addressing this issue through its homeland security work.

- The Public Health Commission provides information on disaster preparedness for residents, employers, and health care providers. See http://www.bphc.org/programs/program.asp?b=7&d=0&p=200

- One criterion for capital improvement projects is “mitigates an environmental hazard.”

- Pilings at the Police Harbor Patrol site have been repaired and the pier will also be repaired. Current practice for the Fire Marine Unit is to move it to the dam locks if a hurricane is forecasted.

- To help address issues of stray voltage, DPW now requires non-conductive covers to be installed, including some retroactively.

- The city recently adopted zoning Article 37, Green Buildings. The purpose of this ordinance is to reduce environmental impacts from new buildings, to conserve natural resources, and promote sustainable developments. Reducing environmental impacts of new buildings can help to mitigate the impact of natural hazards by reducing greenhouse emission and better handling storm water, among other provisions.

Flooding

Drainage

The city's major rivers are the Charles River, Mystic River, Chelsea River, Muddy River and the Neponset River. The Chelsea River is the only river without a dam. Many brooks and streams feed into these rivers, and like many urban areas, a number of them are now underground. Major streams and brooks include Stony Brook, Mother Brook, Bussey Brook, Sawmill Brook, and Dana Brook.

Boston saw large acreages of its wetlands filled or drained over the last few centuries. The largest remaining wetland system in Boston is Belle Isle Marsh. Other important wetland systems are found at the Neponset River Reservation, Stony Brook Reservation, and Brook Farm Reservation.

Parts of the city are located within the 100 year flood plain, 500 year flood plain and the velocity zone. Based on FEMA data, the following summarizes which areas are in flood hazard zones (please note that mapped flood plains can change over time and site verifications are needed to confirm location within a flood hazard zone).

Areas in the 100 year flood plain generally include:

- Most of the entire coastline including Deer Island, and the Harbor Islands
- In East Boston, Belle Isle Marsh, Constitution Beach and the Wood Island Bay Marsh area; the flood plain at Belle Isle Marsh is protected as part of the Belle Isle Marsh Reservation
- Parts of the coast at Deer Island
- Portions of piers and land in Charlestown in the Navy Yard area, along the Little Mystic Channel and along the Mystic River
- Most of the wharves from the Charlestown Bridge down to the Northern Avenue Bridge area
- In South Boston, the MassPort Marine Terminal area and portions of other piers along Boston Harbor; land on the southern side of the Reserved Channel; some land between A Street and the Fort Point Channel; Castle Island; the Conley Terminal; and

the coast along Dorchester Bay extending to Columbus Park and including William J. Day Boulevard
- Coastline along the Charles River
- Land along the Muddy River from the Charles River to Jamaica Pond
- In Dorchester, land around the Bayside Exposition Center, land along the southern coast of Columbia Point, the coast around Savin Hill including Morrissey Boulevard, the Victory Road Park and Tenean Beach area including land west of I-93, the Port Norfolk area, and land along the Neponset River including the Neponset River Reservation
- In West Roxbury, land along the Charles River including land between the river and the VFW Parkway near Bridge Street and along Millennium Park
- In Roslindale, land within the Stony Brook Reservation
- In Hyde Park and Mattapan, land along the Neponset River including the Neponset River Reservation, land along Mill Pond and Mother Brook

Areas generally within or partially within the velocity zone include:
- In East Boston, the southeastern coast at Logan Airport and a few piers near the airport in Boston Harbor including the East Boston Piers Park
- The coast around Deer Island and the coasts of the Harbor Islands
- Portions of the outermost piers at the Navy Yard in Charlestown
- The outermost parts of a number of the wharves from the North End to South Boston
- In South Boston, small outermost portions of some piers along Boston Harbor; the entire coast along Dorchester Bay; and the sea-side of the Castle Island and the causeway
- In Dorchester, parts of Columbia Point, parts of the Savin Hill coast and a portion of the coast in the Victory Road area

The city's stormwater is handled predominantly by a manmade system of storm drains. Similar to older communities, much of the system was a combined system, where sewage and storm water were carried in the same pipes. While the city and the Massachusetts Water Resources Authority (MWRA) have been working to separate stormwater and sewer systems, some small areas are still served by combined systems.

Key drainage infrastructure maintained by the BWSC includes:
- 578 miles of storm drains
- 249 miles of combined sewers
- 8 pumping stations
- 2 gatehouses
- 40 permitted combined sewer outfalls (CSO)
- 180 regulators
- 199 tide gates
- 34,896 catch basins

Tide gates are controlled by BWSC and DCR.

Existing Mitigation Measures

- BWSC prepares a 3-year Capital Improvement Program (CIP). The CIP has a number of inspections, upgrades and repairs for drainage pipes programmed city-wide. The CIP is reviewed and updated annually. They coordinate with other city entities and look for opportunities to coordinate projects. This system of coordination has been effective.

- Catch Basin and Drain Cleaning and Maintenance. Boston cleans its catch basins typically every three years. The city has created a GIS-based database of information on its catch basins and is developing a city-wide catch basin preventive maintenance plan. A city-wide cleaning set the baseline and now the amounts of debris removed are recorded and used to determine the future cleaning schedule. Extra maintenance occurs in areas that tend to flood. The Department of Conservation and Recreation (DCR) aims to clean its catch basins once per year.

- Regular Street Sweeping. DPW sweeps posted arterials year-round and non-posted ones once every week to two weeks. Global Positioning System (GPS) has been installed in the sweepers to improve efficiency.

- Pre-Storm Preparations. Sandbags can be deployed. BWSC will prepare certain drain systems for forecasted storms by cleaning grates, checking for blockages, and other measures.

- Erosion and Sediment Control / Storm Water Management. BWSC requires developers to install particle separators on all newly constructed storm drains serving outdoor paved areas that are 7,500 square feet or greater. They can also require developers to install particle separators on existing storm drains. Developers are also required to evaluate the feasibility of retaining stormwater on site. The city may require anyone seeking to construct, repair or modify a sewer or storm drain to prepare an Erosion and Sediment Control Plan to prevent sediment from entering drains.

- Use of Natural Low-Lying Areas for Flood Control. Various low-lying areas around the city have been protected from development and provide flood storage capacity. These parcels include a parcel along Bussey Brook that is leased by the Arnold Arboretum, the western campus of the Boston State Hospital site at the Boston Nature Center, and a 100-foot buffer zone along Canterbury Brook on the eastern campus.

- Inflow/Infiltration (I/I) Removal. The city has an I/I reduction program. BWSC undertook a comprehensive flow analysis in 1982 and undertook sewer system evaluation studies to determine sources. The results feed into rehabilitation work and projects for I/I removal.

- Floodplain Overlay District (Article 25). There is little new construction in the flood plains – mostly existing development. These regulations set floor standards for construction in a flood hazard district, prohibit certain activities and uses (such as mobile homes) and require the review of some activities by the Conservation Commission.

- Many projects undergo two coordinated public review processes – the city's Article 80 zoning review and state MEPA review. These reviews incorporate Chapter 90 review, flood plain issues, water access, storm water and drainage. Under the MEPA process, a number of city, regional and state entities and the public are able to review the project and provide input.

- BWSC review of projects via Article 80 and MEPA works well. BWSC will also make recommendations on additional drainage provisions. The process is effective because BWSC must sign off on site plans before building permits can be issued.

- The city has adopted sustainable building regulations and encourages new development or redevelopment to incorporate low impact development (LID) techniques.

- Article 29 (Greenbelt Protection Overlay District) requires open space preservation. It does not address flooding specifically.

- The city has established a number of Conservation Protection Subdistricts. Article 80 review applies to certain projects within a Conservation Protection Subdistrict. It is through the Article 80 review process that issues related to drainage and erosion would be addressed. There are a total of 34 subdistricts in the following neighborhoods:
    - Brighton - 11
    - Jamaica Plain - 10
    - West Roxbury - 10
    - Mission Hill - 1
    - Dorchester - 1
    - East Boston - 1

- Underground utility protection. The street light system is protected from flooding by being buried 33 inches deep, with openings at the bottom to allow water to drain out. Fire crews maintain the fire box system. Private utilities and the city are responsible for other underground utilities.

- Public Education. The BWSC website provides information on various items such as keeping catch basin grates clear of debris and sediment and the need for backflow valves to protect properties in areas that flood. The Mayor's office reminds residents to keep catch basin grates clear of leaves.

- To mitigate safety and health impacts after flooding occurs, ISD will shut off electricity and will condemn food as needed on private properties.

- Combined Sewer Separation. The city and the MWRA have been working to separate its storm sewers for a number of years. This reduces public health impacts during heavy rains. Since 1978, 44 miles of new storm drains have been installed due to separation activity. Projects completed or underway include:
  - Dorchester
  - Stony Brook (Jamaica Plain, Roxbury and Mission Hill); this 5 year project began in 2001
  - Fort Point Channel; the expected completion date is 2007
  - Morrissey Boulevard Drainage Conduit; stormwater from larger storms will be directed to this conduit and flow from smaller storms will be directed to the North Dorchester Bay Storage Tunnel; the expected completion date is 2009

Site-Specific Flooding

Muddy River
The Muddy River is a major natural resource corridor. In the 1880's the river was incorporated into the Emerald Necklace park system. The river flows 3.5 miles from Jamaica Pond to the Charles River. Three entities own and manage parts of this park system – the Town of Brookline, the City of Boston, and DCR. The watershed is 7.5 square miles.

While the park system was originally designed to help with flood storage, over the years sediment has built up in the river thereby restricting the channel. Sediment and debris come from erosion along banks and upland areas, decayed leaves and brush, street sanding, construction sites, and litter and animal waste. Also, most of the watershed has become impervious, reducing flood storage capacity. Finally, some culverts are undersized and restrict flow. As a result, the Muddy River floodplain experiences severe flooding. Portions of the river have been dredged roughly every 30 years to remove the excess sediment.

Past flooding has caused tremendous damage in the area – an October 1996 storm caused $70 million in damage, including damage to the subway system. Flooding also occurred in June 1998. The area surrounding the Muddy River is densely populated – over 30,000 people live within ¼ mile of the project area according to studies. In addition to MBTA transit facilities, a number of other important land uses are affected by flooding including schools, hospitals, and cultural institutions.

Critical emergency facilities are located in the corridor including the Fire Alarm Building. The Boston Fire Department Fire Alarm Building is a receiving station for all fire alarms in the city and is the primary dispatch center for fire personnel. The building is also critical for providing mutual aid support to 34 other municipalities. It houses a radio repair shop and backup operations and dispatch for the Police Department. The facilities operate 24 hours a day, year-round. It is located in the 100 year flood plain.

Many studies have focused on the Muddy River, including studies by FEMA, the Army Corps of Engineers (ACOE), and the Executive Office of Environmental Affairs (EOEA). CDM prepared the project's initial plan and MEPA EIR, which has been approved by the Massachusetts Executive Office of Environmental Affairs. The U.S. ACOE will be providing 65% funding and preparing the project's design and environmental permit applications.

The Colleges of Fenway, which recently completed a natural hazard mitigation plan, notes that the flood plain mapping for the Muddy River is inaccurate and out of date.

Here, we focus on mitigation that is completed or underway. Mitigation measures that have been proposed, but not yet undertaken are listed later as "Potential Mitigation Measures."

Existing Mitigation Measures

- An important function of the Emerald Necklace is to provide stormwater management and flood storage. Simply maintaining the Emerald Necklace is a critical flood mitigation measure.

- The city, along with the Town of Brookline and the state are undertaking the Muddy River Flood Control, Water Quality and Habitat Enhancement and Historic Landscape Preservation Project. The project proposes to fix the current problem (increase the river's hydraulic capacity) and address the cause of the problem (establish management practices to reduce sediment and debris in the watershed). Camp Dresser & McKee Inc., has been designing the mitigation project and preparing environmental permit applications.

- An extensive public process has guided the design of mitigation for the Muddy River project. The Secretary of Environmental Affairs created a Citizens Advisory Committee (CAC), comprised of 29 members. The CAC has provided extensive comments on the project and seven public meetings were held on the project. In addition, 65 groups and institutions are active supporters of the project, ranging from the Charles River Watershed Association to colleges, universities and religious institutions.

- One part of the mitigation project has been completed – dredging of the Charlesgate area in Boston. This project entailed the removal of waterway obstructions under Ipswich Street, dredging 4,000 cubic yards of sediment and debris, and landscape rehabilitation. This land has reverted back to DCR. During this process, the Maintenance Management and Oversight Committee was established as an independent oversight committee that will function for the duration of the entire project.

- DCR has a goal of sweeping streets once per week along Muddy River. DCR removes leaves along Muddy River during spring and fall and it empties trash barrels daily during summer and once every three days during spring and fall. DCR also

performs weekly litter patrol along the Muddy River. The city's practices were mentioned earlier.

- The city commissioned a risk assessment for the Boston Fire Alarm building. The assessment provides specific recommendations to minimize impacts from hazards including natural hazards. Interim measures have been employed, including using sump pumps, conducting inspections during storms, and having a full back-up generator.

- The city's gauge in the Stony Brook conduit can be viewed via the internet by institutions so that they can monitor water levels and plan accordingly for high water levels.

Longwood Medical Area
MASCO (Medical Academic and Scientific Community Organization, Inc.) has contacted the BWSC to discuss five locations that are experiencing flooding problems.

Existing Mitigation – BWSC will conduct a study next year on these areas. BWSC programmed $900,000 over multiple years for the study.

Storrow Drive
Storrow Drive, which is owned and maintained by DCR, carries 100,000 vehicles per day through Boston. According to materials prepared by DCR for the Storrow Drive Reconstruction project, leaks occur in the tunnel roof, walls and base slab. One impact due to the leakage is that the water forms ice, causing roadway accidents. City officials noted that there have been flooding problems near Beacon Street and Hereford Street (though this has not been a large problem lately) and near the Harvard Bridge, when pumps are not working.

Existing Mitigation Measures
- Maintenance by DCR – ensuring pumps work and cleaning drainage pipes and catch basins.

- DCR has begun exploring alternatives and preparing MEPA documents for the Storrow Drive Reconstruction project.

St. Botolph Street, Back Bay
Flooding occurs here during larger storms. The problem area is between Massachusetts Avenue, Huntington Ave., Garrison Street and MBTA property. The flooding problems occur in privately-owned alleys that have undersized drainage pipes. Garden apartments have flooded.

Existing Mitigation – BWSC built a storm system under Garrison Street last year. They are currently designing a system that will increase infiltration and pump excess water to Stony Brook.

Archdale Area, Roslindale
The Archdale area has seen damages due to flooding in the past, particularly during the 1998 storms. Houses were impacted, with flooding and foundation damages. Sewers surged and backed up into basements and onto streets, causing contamination and pavement damage. The neighborhood has not recently experienced this level of flooding and now most of the flooding is limited to the Arboretum, which can provide natural flood storage.

Existing Mitigation Measures

- Maintaining natural flood storage capacity. For example, there are two urban wild properties (Elden Street 1 and 2) in this area and many of the vacant parcels are undevelopable and will likely remain natural.

- A natural ravine now provides storm water storage of up to four feet deep. The water then releases to Bussey Brook.

- The MWRA built a connection to allow drainage to Stony Brook. This connection has been used roughly five times since constructed and has worked effectively.

- When water levels are high, the BWSC can open the gate at the Fens Gatehouse so that water can bypass the conduit.

Canterbury Brook, Mattapan
Canterbury Brook, a tributary to Stony Brook, is partially culverted. The brook runs parallel to Morton Street, turns 90 degrees under the street, and passes under the American Legion Highway. These two bridges may constrict water flow and contribute to flooding problems. In addition, the watershed is urbanized and subject to flash floods. Trash clogs catch basins, also contributing to the problem.

Three entities have jurisdiction over Canterbury Brook – BWSC, the MWRA and the State Division of Capital and Asset Management and Maintenance (DCAM).

Existing Mitigation Measures

- DCAM conducted a baseline study in 2002 and plans to make improvements.

- Developments in this area are incorporating Low Impact Development (LID) techniques.

- BWSC has installed a chain link fence to act as a trap to intercept trash before it reaches catch basins. This measure has been effective.

Neponset River Area, Dorchester
This is a low-lying area that provides storm water storage. However, because development is located nearby, yards have flooded in the past. New development is planned nearby which could

also be impacted by additional flooding. DCR is studying the impacts of removing its dam along the Neponset River.

Existing Mitigation Measures

- A fair amount of natural land has been protected along the river. This land provides flood storage.
- Sediment has been removed from the river, increasing its capacity.

Pine Neck Creek, Between I-93 and Port Norfolk
Water flow has backed up here in the past.

Existing Mitigation – BWSC installed rip-rap treatment and restored the salt marsh.

Morrissey Boulevard, (south of UMass)
This is a DCR roadway, located in a low-lying flood plain.

Existing Mitigation – Tide gates have been updated.

Day Boulevard, South Boston
Day Boulevard is a DCR roadway, located in the low-lying flood plain. It has flooded during hurricanes. The M Street seawall, which helps to protect this roadway, had collapsed.

Existing Mitigation Measures

- Sand bags have been used to address flooding.
- DCR is fixing the M Street seawall.

Belle Isle Marsh, East Boston
This natural flood storage area provides important flood control and flood capacity. The state has designated Belle Isle Marsh as an Area of Critical Environment Concern (ACEC).

Existing Mitigation – DCR has begun a flood control project here. Dredging is on-going. The goal of the project is to re-establish elevations for flood control.

East Boston Greenway Corridor
Part of the greenway is located in the 100 year flood plain. Flooding has resulted in the temporary loss of use of the bike path / pathway. Engine 9, located next to the greenway, has also been impacted by flooding, particularly during hurricanes.

Existing Mitigation Measures

- The Parks and Recreation Department built a storm water system. The system is designed so that water first infiltrates. Remaining water goes to a storage tank and is

then pumped uphill to a combined sewer. Two pumps have been installed. Because this new system has been effective, both pumps have not been needed at the same time. This project was completed a few years ago and thus far has effectively reduced flooding here.

- The Massachusetts Turnpike Authority (MTA) is constructing the Bremen Street Park in this area. The park will maintain flood storage capacity.

Havre Street, East Boston
There has been some flooding on this low lying street.

Existing Mitigation – The MWRA has plans for a relief sewer here. Construction should begin in a year and should resolve flooding problems.

Centre Terrace, Wedgemere, West Roxbury
Areas here have flooded in the past.

Existing Mitigation Measures

- BWSC made improvements that can handle up to the 10 year storm. This has been effective at improving drainage.

- BWSC also inspects grates.

- A private developer built a detention basin in this area. The basin is designed for the 50 year storm.

George Wright Golf Course, Hyde Park
This is a city-owned golf course. There has been some flooding here, mainly due to clogged catch basins. Flooding has impacted houses and affected the use of the golf course.

Existing Mitigation – The Parks and Recreation Department practices active prevention by inspecting catch basins and drains and unclogging them as needed.

Engine 20, Dorchester
This fire station, located on Neponset Avenue, has had extensive flooding problems with up to 9 feet of flood water. The station is located in the flood plain. Impacts from the flooding include the loss of use of the basement for storage and the formation of mold.

Existing Mitigation – Pumps were used, but they have not been effective. Holding tanks have been built in the vicinity also.

Charlestown Underpass
Flooding occurs here, resulting in road closures.

Existing Mitigation – DPW has resealed some areas.

Dams
There are a number of dams in Boston, with the largest being the Charles River Dam. It is owned and operated by the DCR and runs across the Charles River between Boston and Cambridge. The dam, which replaced an earlier dam in 1978, has six pump stations to control water levels in the river and a lock system to allow boats to pass through. According to data from ACOE, the dam is 160 feet long; it is composed of rolled earth fill, rock slope protection and sheet piling; and its top elevation is 12.35 feet NGVD.

According to DCR's database of dams, the following dams are located in or partially in Boston:

- Chestnut Hill Bradley Basin Dam at the Chestnut Hill Reservoir; owned by DCR
- Southwest Campus Dam – located on Saw Mill Brook and owned by the city
- Neponset River Dam - Lower Mills (also called the Walter Baker Dam) – located on the Neponset River and owned by DCR
- Neponset River Dam - Hyde Park (also called the Tilman and Hollingsworth Dam) – located on the Neponset River and owned by DCR

As noted earlier, DCR is studying the removal of its dams along the Neponset River.

Existing Mitigation Measures

- DCR raises and lowers water levels at the Charles River Dam based on weather forecasts and when they exercise the dam equipment. For flood control purposes, they need to begin lowering water levels well ahead of a predicted storm. After a storm it may seem like the water level is still low for a while, because they must mind the tides when changing the water levels. DCR has established operating parameters that control the water levels. If they are going to raise or lower water levels outside of these parameters, they will inform the local emergency management personnel.

- The Charles River Dam has diesel pumps to use when needed. Otherwise DCR prefers to use the gates on the dams for changing the water levels for environmental reasons. The operation of these dams is coordinated with MEMA and ACOE, and DCR works with these two agencies as a unit when there is a storm.

- The new regulations on dam safety will require earthquake vulnerability analyses when dams are built or improved.

- The Charles River Dam is designed so that it will not fail in the event of an earthquake.

High Winds and Hurricanes
High winds can cause utility and communication disruptions when equipment can not withstand the winds or tree limbs fall on the equipment. The city's communications equipment/antennae are located around the city. Those at highest risk are on the tallest buildings where winds are stronger. The BWSC also has metering equipment on building roofs that may be vulnerable to high winds.

According to the city Tree Warden, high winds cause various types of tree damage from limbs falling and trees coming down. There is not much damage due to winds under 55 miles per hour. While heavy, wet snow may build up on limbs, wind is what ultimately brings limbs down. Pear trees and Linden trees are usually most prone to damage. The city estimates that 80% of the damage is due to trees on private properties falling into the public right-of-way. The city does keep track of addresses with damage. The city will receive 200 to 300 phone calls due to tree damage in the fall and also sees a large volume of calls in the spring. In general, the city does not see much damage to overhead wires due to winds, though the utility companies are responsible for tree maintenance in those areas.

Street lights are generally not impacted unless there are hurricane force winds.

The Occupational Health and Safety Administration (OSHA) regulates staging and scaffolding on construction sites. In general, the city does not see too many impacts to construction sites during high wind events.

The recent assessment for the Fire Alarm Building noted that the building is vulnerable to wind and water filtration.

The bridge to Long Island is old and the effects of coastal storms has made the bridge unsafe for supporting fire apparatus.

Existing Mitigation Measures

- The Parks and Recreation Department has regulatory and operational responsibilities for public shade trees. The Department's maintenance program includes pruning, disease control, removals, and storm damage repairs.
- When wires do come down, the city relies on NStar.
- ISD inspects construction sites to make sure materials and scaffolding is stored or erected correctly.
- Street lights are rated for 90 mph with 1.3 gust factor (117 mph gusts). Most light systems are underground.
- Critical repairs have been made annually to the Long Island Bridge.

Winter-Related Hazards

As with many older, dense communities, managing snow can be a challenging and expensive task. Generally the denser areas of the city, such as Beacon Hill, Charlestown, and the North End pose great challenges to snow removal. On street parking, particularly double and triple parking can cause issues and prevent adequate plowing. This is most evident in parts of South Boston, such as on Broadway. Residents and property owners often have little land to place snow that accumulates on their driveways, parking lots and sidewalks, so they often shovel snow onto roadways, especially in Roxbury, South Boston, East Boston and Dorchester.

In recent years, the city has used approximately 100 tons of salt over a given winter. Most, if not all, of the salt is imported from overseas. The city has been seeking additional supply options so as to not rely on one vendor. There are seven locations for salt storage, with capacity for approximately 40,000 tons.

Boston has a 'black pavement policy' meaning that every street is to be cleared. The city is divided into 15 plow districts. Approximately 350 pieces of equipment are used for snow control and roughly 80% of workforce is contracted. The main objective is to ensure that streets are passable for emergency vehicles.

The greatest impacts are seen when the city is hit by back-to-back storms without time for existing snow to melt. The result has been street closures. Timing of a storm is also a key factor in the extent of impacts. Overnight storms are easier to plow since there are fewer commuters on the road. Daytime storms on a weekday are much more of a challenge and cause greater impacts.

Like its neighboring communities, there are few places to store plowed snow in Boston. According to DPW, the city will need to find new ways to handle the plowed snow within the next two years.

Impacts from winter weather – in addition to non-passable streets and sidewalks – include catch basins being buried and sometimes clogged by snow, water service pipes bursting and shut-off valves are buried (more common when cold and windy), fire hydrants being buried by snow, older water mains bursting, and dangerous icicles forming on buildings. Snow can also block building ventilation, increasing the risk of indoor carbon monoxide poisoning. Snow can also place a heavy load on roofs, but this was not considered to be a large issue in Boston.

During storms, City Hall is the control center and traffic signals are located there.

Existing Mitigation Measures

- The city has a plan for addressing traffic during snow storms. The city actively keeps all arterials clear of cars and uses bull horns to clear arterials.
- The city has regulations regarding property owners' responsibilities in terms of sidewalk clearing and parking bans and those regulations are reasonable well enforced.
- The city has a contract with vendors for snow melters on an emergency basis.
- Boston has a snow strategy for plowing with 2 teams: 1 for major arterials (go back and forth on same stretches); 1 for residential streets (loops that take about 4 hours; usually 2-3 rounds).
- Fire hydrants are being recorded with GPS so they can be easily found when buried in snow.

- Public education on preventing pipes from freezing. BWSC provide tips in its bill mailings on how to minimize pipe freezing; television advisories provide tips on preventing pipes from freezing; and, the Mayor's office provides public warnings.

- Roofs on new buildings are required to handle snow loads. The Mayor's office will also provide warnings on the matter.

- ISD can order building owners to remove dangerous icicles. When warranted, ISD will cordon off the area.

- City Hall puts out advisories to remind property owners to keep their ventilation equipment clear of snow.

- The City's Emergency Operations Center can be used as a back-up to City Hall as the snow storm control center.

Fire
Local officials did not identify significant issues related to brush fires in Boston.

Geologic Hazards

Earthquakes
A number of areas in Boston have high potential for liquefaction:

- Almost the entire waterfront, including along the Charles River
- Almost all of East Boston, including Logan Airport
- Most of Charlestown except around Bunker Hill
- Parts of the North End
- Much of South Boston, including the South Boston waterfront, City Point and along I-93
- The Boston UMass Campus
- Almost the entire length of I-93
- Most of Back Bay and the South End
- Much of Chinatown
- Parts of the Financial District
- A very small area in Hyde Park
- Much of the Beacon Hill / West End neighborhoods, including Massachusetts General Hospital
- Parts of Roxbury along Massachusetts Avenue and Melnea Cass Boulevard
- In Dorchester, the area from roughly I-93 to the waterfront

As noted, new construction must meet the building code. However, just over 50% of the residential structures in the city were built before 1940. This figure does not account for non-residential structures that also predate modern building codes. Local officials noted that older low rise masonry structures are likely at risk and that infrastructure, including the city's water supply, would be at great risk during an earthquake. The city's current water boat is old and could not handle the water pumping needs to fight fires that could result from an earthquake.

Also important is ensuring that emergency communications infrastructure is not damaged during an earthquake. It is also important that police and fire stations, which serve as community centers during disasters, can withstand an earthquake.

Because this region has not seen a damaging earthquake in hundreds of years, it is difficult to build support for major earthquake mitigation projects, especially when resources are short for mitigating more common hazards such as flooding.

Existing Mitigation Measures

- The State Building Code addresses earthquake standards. This applies to new construction and renovations.

- Communications equipment in the Police Department Headquarters has been secured to withstand an earthquake. The Department's back-up system is located at its Frontage Road facility. This building is solid and likely provides needed protection for the back-up equipment.

- Three police stations are being rebuilt or renovated (Districts 3, 5 and 7), thereby bringing them up to modern building standards.

Landslides

Landslides were not identified as a problem in Boston. Jamaica Plain and Mission Hill are characterized by steep slopes. While there have been some very localized landslide issues, they have been stabilized.

Coastal Erosion

The following areas are affected by coastal erosion.

Columbia Point – This area is home to UMass, the John F. Kennedy Museum and the Harbor Point development. Parts of the embankment are unprotected and vulnerable to further erosion. The area is composed of fill. UMass owns the area that is unstable.

Long Island – The island is owned by the city and contains a sensitive population – the Public Health Commission has a shelter here with almost 400 beds. A part of the embankment is eroded and the bank is fairly steep.

Existing Mitigation – Work has been done by the Public Facilities Commission to stabilize the southwestern part of the island. The remainder needs attention.

Rainford Island – This island is located southeast of Long Island and experiences erosion problems. Continued erosion could impact important archeological resources on the island.

Moon Island – Although the island is located in Quincy, the City of Boston has important facilities located here. The Police firing range and Fire training facilities are on the island. The

island has experienced some erosion that could worsen. In addition, the seawall is unlikely to withstand a major storm.

> *Existing Mitigation* – Inspections and an assessment were conducted in 2005 and 2006. A number of recommendations were put forth.

East Eagle Street, East Boston – This area is located along Chelsea Creek. The embankment is eroded. Channel Fish's driveway and parking lot are adjacent to the bank and could be impacted by further erosion. The city also owns property here and will need to use the land for future city facilities.

> *Existing Mitigation* – ACOE conducted a study of this area in 1989. The study is being re-reviewed. Natural vegetation has grown in, offering some stabilization.

BRA properties, East Boston – Along the western shore of East Boston, the BRA owns a number of properties. Some of these properties have eroding bulkheads and aging pilings. As noted later, these issues will likely be addressed by private parties through redevelopment.

MWRA / DCAM land, East Boston – Both the MWRA and DCAM own land near the Chelsea Street Bridge. Some erosion is occurring here.

> *Existing Mitigation* – Boston DPW is working to address this issue.

Reserved Channel – Outfalls are located here. Debris and old boats are scattered here and the shore line conditions are degraded. Critical infrastructure is located here – NStar's K Street Substation.

> *Existing Mitigation* – Sewer separation is under design. Debris is being cleaned up.

Fort Point Channel – Some seawalls along the eastern bank of the channel need repairs. They are privately owned and will likely be upgraded through private redevelopment.

Pier 5, Charlestown – While most of Charlestown's waterfront is well-maintained, a part of Pier 5 is degraded with rusted sheet piling and bulkheads. The BRA owns the pier and leases it out. As noted later, this will likely be upgraded through private redevelopment.

West Roxbury, Millennium Park – This park is built on a capped land fill and has a methane-burner. While the site is stable, some city officials felt that in the future, stability could be improved.

Compilation of Existing Mitigation

The following table summarizes many existing natural hazard mitigation measures already in place in Boston. Because of the number of entities, public and private, involved in natural hazard mitigation, it is likely that this list is a starting point for a more comprehensive inventory of all measures. Updates of the plan should continue to add to this table.

Table 12. Existing Natural Hazard Mitigation Measures, Boston

Hazard	Area	Mitigation Measure
Multi-Hazard	City-wide	CEMP
		State building code
		Emergency Management Division efforts to mitigate, plan, and prepare for emergencies, public education, resource coordination, information collection and dissemination, etc.
		Multi-language evacuation and emergency preparation guides; disaster preparedness information for residents, employers and health care providers
		Phone alert system, reverse 911
		Interoperatibility communications project underway with Homeland Security funding
		Criteria for city CIP projects include “mitigates an environmental hazard”
		Pilings at the Police Harbor Patrol site have been repaired and the pier will also be repaired
		Current practice for the Fire Marine Unit is to move the boat to the dam locks if a hurricane is forecasted
		To help address issues of stray voltage, DPW now requires non-conductive covers to be installed, including some retroactively
Flooding	City-wide	BWSC 3 year CIP, coordinated with other agencies
		City catch basin, drain cleaning, maintenance program
		Regular street sweeping
		Pre-storm preparations (e.g., sandbags, inspections)
		Erosion and Sediment Control / Storm Water Management. BWSC requirements
		Preserving flood control capacity of low-lying areas
		Inflow/Infiltration (I/I) Removal
		Floodplain Overlay District (Article 25)
		MEPA and Article 80 development review
		Sustainable building regulations, encouragement of low impact development techniques
		Article 29 (Greenbelt Protection Overlay District)
		Conservation Protection Subdistricts
		Underground utility protection
		Public education
		Preventing health impacts when flooding affects electricity. ISD shuts off electricity & will condemn food
		Combined sewer separation
	Muddy River	Portions of river dredged every 30 years

Table 12. Existing Natural Hazard Mitigation Measures, Boston

Hazard	Area	Mitigation Measure
		Number of studies conducted on Muddy River
		Charlesgate area in Boston dredged
		DCR removes leaves along Muddy River during spring & fall & empties trash barrels daily during summer & once every 3 days during spring & fall
		City street sweeping, catch basin practices as outlined above
		DCR goal of sweeping streets 1/week along Muddy River
		DCR weekly litter patrol along the Muddy River
		Boston Fire Alarm Building assessment completed
		Internet monitoring of Stony Brook conduit water levels
	Longwood Medical Area	BWSC study of five areas that flood ($900,000 over five years)
	Storrow Drive	DCR maintenance of pumps, pipes, catch basins
		DCR beginning process for reconstruction project
	St. Botolph Street, Back Bay	BWSC built storm system under Garrison St.; designing system to increase infiltration, pump excess water to Stony Brook
	Archdale Area, Roslindale	Maintaining natural flood storage capacity
		Ravine provides flood storage, releases to Bussey Brook
		MWRA built connection to Stony Brook
	Canterbury Brook, Mattapan	DCAM baseline study
		Encouragement of LID techniques
		BWSC installed chain link fence to trap trash, reduce clogging
	Neponset River area, Dorchester	Natural land has been protected, provides flood storage
		DCR is studying impacts of removing its dams
		Sediment removal from river to increase capacity
	Pine Neck Creek	BWSC installed rip-rap treatment, restored salt marsh
	Day Boulevard	Have used sand bags
		DCR is fixing M Street seawall
	Belle Isle Marsh	DCR has begun flood control project
	East Boston Greenway Corridor	Parks & Rec. Dept. built storm water system
		Bremen Street Park will preserve flood storage capacity
	Havre Street, East Boston	MWRA sewer relief project to begin soon
	Centre Terrace, Wedgemere,	BWSC improvements for up to 10 year storm
		BWSC inspects grates

Table 12. Existing Natural Hazard Mitigation Measures, Boston

Hazard	Area	Mitigation Measure
	West Roxbury	Detention basin built in private development
	George Wright Golf Course, Hyde Park	Active prevention with inspections of catch basins and drains
	Engine 20, Dorchester	Tried pumps, but not effective
		Holding tanks built in vicinity
	Charlestown Underpass	DPW has resealed some areas (temporary solution)
Dams	Charles River	DCR raises, lowers based on forecasts
		Diesel pumps
		New dam regulations
	Neponset River	DCR studying dam removal
Winds and Hurricanes	City-wide	Parks & Rec. Dept. regular tree maintenance
		NStar clearing of downed wires
		ISD inspections of construction sites
		Underground lights systems, street lights rated for high winds
	Long Island Bridge	Annual critical repairs
Winter Storms	City-wide	Traffic plan during snow storms
		Regulations requiring sidewalk clearing by abutter and parking bans
		Contract with vendor for snow melters on emergency basis
		Snow plowing strategy
		Fire hydrant locations recorded with GPS
		Public education on preventing frozen pipes
		New roofs must be designed to handle snow loads
		Public warnings on snow loads on roofs
		ISD can order building owners to remove dangerous icicles; when warranted, ISD will cordon off area
		Advisories to keep ventilation clear of snow
		Emergency Operations Center can be used as back-up snow storm control center
Earthquake	City-wide	State building code addresses earthquake standards for new construction and renovations
		Communications equipment in Police Headquarters secured to withstand earthquake. Back-up at Frontage Road likely sturdy also
		3 police stations being rebuilt or renovated
Coastal Erosion	Long Island	Public Facilities Commission is stabilizing southwest part of island
	Moon Island	Inspections and assessment conducted

Table 12. Existing Natural Hazard Mitigation Measures, Boston

Hazard	Area	Mitigation Measure
	East Eagle Street, East Boston	USACE study in 1989, study being re-reviewed
		Vegetation has grown in and stabilized to a degree
	MWRA/DCAM land, East Boston	DPW is working to address erosion
	Reserved Channel	Sewer separation under design
		Debris being cleaned up

HAZARD MITIGATION GOALS AND OBJECTIVES

At the December 14, 2006 Local Team meeting, attendees formulated goals and objectives for natural hazard mitigation planning in Boston.

Goal: Protect the health and safety of the public.

- Encourage people to be prepared before, during and after a hazard event.
- 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. E.g., covering salt piles.

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.
- Protect natural areas to ensure that they buffer impacts to built areas during a natural disaster.

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.
- Ensure interdepartmental communication is seamless.
- Maintain the Comprehensive Emergency Management Plan (CEMP) and evacuation plan.

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).

Goal: Determine priorities for directing resources for hazard mitigation and response.

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

POTENTIAL MITIGATION

What is Hazard Mitigation?
Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries and property damage resulting from natural and human-made hazards through long-term strategies. These long-term strategies include planning, policy changes, programs, projects and other activities. FEMA currently has three mitigation grant programs: the Hazard Mitigation Grant Program (HGMP), the Pre-Disaster Mitigation program (PDM), and the Flood Mitigation Assistance (FMA) program.

See http://www.fema.gov/government/grant/government.shtm for more information.

Identification of Potential Mitigation Measures
MAPC solicited ideas for mitigation measures from city officials because these individuals have the most comprehensive knowledge of local conditions. MAPC developed a matrix of natural hazard issues, current mitigation measures, and measures suggested in reports or by individuals. The local team reviewed and refined the matrix at its December 14, 2006 meeting and discussed possible priorities. Considerations when determining priorities included how well developed an existing mitigation measure was (e.g., a number of high priority measures were already important priorities and fairly well-developed) and the extent of impact to emergency operations.

Some items have been the subject of extensive studies and already have cost estimates. Others are more conceptual or at an early stage. For those projects, costs would need to be determined prior to applying for funding.

Process for Setting Priorities

The decision on priorities was made at a meeting of the local committee. The method used was to reach consensus through discussion, rather than taking a vote. Priority setting was based on local knowledge of the hazard areas, cost information and an assessment of benefits.

MAPC staff attended the Benefit-Cost Analysis Training Course on October 31-November 1, 2005. Information from this training was shared with local officials when MAPC made a Power Point presentation on the Benefit/Cost Analysis at the February 23, 2006 meeting of the Metro Boston Hazard Mitigation Community Planning Team. This was done in order to help local officials understand the role of a benefit/cost analysis.

Based on information gained from the Benefit-Cost Analysis training and a review of the STAPLEE criteria (a checklist for evaluating social, technical, administrative, political, legal, economic and environmental issues) MAPC instructed City staff to take 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, anticipated costs, whether the City 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.

High Priority Mitigation Measures

Flooding – Muddy River
- Complete Muddy River project – requires Federal & State funding ($92M)
- Protect Fire Alarm Building – build 370' long floodwall/levee to protect up to 500-year event. Install 2 pumps at the existing catch basins to convey rainwater to Muddy River and close off existing drainage from basins to Muddy River ($118,000).

Flooding – Storrow Drive
- DCR work to further reduce problems.
- DCR continued maintenance of pumps, drains.
- Implement DCR's Storrow Drive reconstruction project.

Flooding – Charlestown Underpass
- Rebuild the tunnel (10 year timeframe).

Earthquake – City-wide
- There is a need for greater understanding of potential damages to buildings and impacts to utilities and infrastructure that could result from a large earthquake. A detailed study should be conducted, building on earlier draft studies.
- Purchase a new fire boat ($12.3 million). The current boat is too old to handle the city's fire-fighting needs in the event of a major earthquake.

High Winds and Hurricanes – Long Island Bridge
- The bridge needs a total rehabilitation. This bridge can not support fire apparatus and there is a sensitive population housed on the island. Impacts from coastal storms have affected the structural integrity of the bridge.

Winter Storms – Snow Storage
- Acquire snow melting technology. The city has begun contracting with vendors on a limited, emergency basis. The city will likely have a shortage of places to put snow in the next year or two and must find alternatives ways to handle snow.

Multiple Hazards – Emergency Communications
Ensure that emergency communication systems work during a natural hazard event, including interdepartmental communication. Some of this is being addressed under Homeland Security. Specific needs are:
- Need alternatives / redundancy for signals
- Need back-up communications building (see Fire Alarm building above).

Medium Priority Mitigation Measures

Flooding – Canterbury Brook, Mattapan
The waterway continues to clog and the effects of flooding will likely worsen as development occurs.
- DCAM could dredge the brook to possibly improve flow.

- Implement more efforts to capture trash in the upper watershed to further reduce catch basin clogging.

Coastal Erosion – East Eagle Street, East Boston

- A long term strategy, rather than temporary fixes, needs to be designed and implemented here. This is especially important since the city may need to use affected land for future facilities and continued erosion could undermine water and sewer infrastructure in this area.

Coastal Erosion – Columbia Point

- UMass and the state should stabilize the bank or establish a new bank.

Other Potential Mitigation Measures

A number of additional mitigation measures arose during the course of the project. These additional measures were either considered to be a low priority, a better alternative was deemed a medium or high priority, or they were not considered feasible. However, it is worth recording them in the plan, because they could be revisited in the future.

Multiple Hazard

- City officials suggested that the city establish a well-located redundant disaster center that has adequate space to house emergency workers/city workers over an extended period.

- Each fire station should have a generator (only half do currently) and they need to be able to run for multiple days. The cost is roughly $25,000 per generator.

- City departments/facilities need additional generators, including portable ones. Each city department headquarters should have one. New technology for more reliable back-up power should be considered, such as hydrogen cells or solar energy.

- Continue to maintain and update the CEMP, evacuation plans and other relevant plans and protocols. Coordinate with other entities, including the Colleges of Fenway.

- Move the Police Harbor Patrol site further into the more protected harbor. This should happen in the short term, since potential sites are also prime sites for development.

- The Fire Marine Unit needs to be better protected. One option is to cover the site, but that would not likely be compatible with the surrounding neighborhood.

- Resources to help retrofit man-hole covers with non-conductive covers would minimize potential dangers.

Flooding

- Muddy River – When restoration is completed, support the Colleges of Fenway in their proposed petition to FEMA to restudy and map the Muddy River watershed including a reanalysis of the Stony Brook culvert.

- Archdale area, Roslindale – During Article 80 review process, ensure new development or redevelopment does not increase Bussey Brook stream flow. Encourage LID techniques to minimize water flow off-site.

- Day Boulevard – DCR should conduct preventative beach nourishment.

- Morrissey Boulevard – DCR could block off tides, but this could cause problems elsewhere. Could also leave as is and allow flooding to occur since this is a low-lying area or make drainage improvements when the roadway undergoes full depth reconstruction.

-
- Neponset River, Dorchester – Continue to remove sediment as needed. Ensure that flood control occurs through safe and appropriate operations of the dams by DCR.

- Pine Neck Creek – Conduct regular maintenance and sediment removal.

- St. Botolph Area, Back Bay – Owners should implement/construct the system being designed by BWSC or the city could try to find funding such as through I/I contributions.

- Longwood Medical Area – Construct improvements recommended in BWSC study. Funding could come from CIP or from institutions or a combination. This can not occur until after the Muddy River restoration is completed. Also, Colleges of Fenway has proposed to establish an annual storm monitoring program, develop a routine maintenance plan and coordinate with various city departments in its efforts.

- Centre Terrace, Wedgemere, West Roxbury – BWSC monitoring of how well improvements handle a larger storm and then make additional improvements if needed.

- George Wright Golf Course – Continue active prevention by checking and unclogging drains as needed.

- Engine 20, Dorchester – Options may include trying larger pumps, sealing the basement, alleviating issues in Pine Neck Creek (see above) or providing more natural flood storage areas. It is not likely viable to direct water off-site because it would impact the neighborhood.

- Purchase or contract for more sandbags.

- Find resources for monitoring private storm water facilities post-construction to ensure proper operation. Or require annual reporting by landowners – this option would still require some staff resources for follow-up.

- Continue to encourage LID techniques for public and private development.

- Expand capacity to monitor water levels remotely. Install more permanent rain gauges and monitoring stations to allow monitoring of brooks and major trunks and to help in design of

improvements. Replicate the system BWSC has with hospitals and schools which allows them to have real-time information using the internet.

- Utilities and the city should continue to maintain underground facilities so as to reduce flood water impacts.

- Provide funding or loans to business owners to move their generator/electrical equipment to higher ground or to flood proof. (suggestion that such a program be administered by the Department of Neighborhood Development).

- Public education, including warning property owners of potential hazards of basement apartments in areas prone to flooding, such as in the South End.

- Examine if there are areas in the city where certain policies or regulations may be worsening flooding – examples may include I/I requirements, ground water recharge, etc.

<u>High Winds and Hurricanes</u>

- Police and Fire communications – upgrade to antenna that can withstand stronger winds if needed in certain vulnerable locations.

- Better secure the BWSC metering equipment, located on the roofs of some buildings and upgrade equipment, as necessary, to better withstand strong winds.

- Fire Alarm Building – Replace select windows, fix mortar joints and install roof drain covers ($224,000).

<u>Earthquake</u>

- Conduct a public education campaign for owners of low masonry buildings. Recommend that they hire someone to inspect the building and to provide advice on how to better secure the building to minimize impacts from an earthquake.

- Secure communications equipment in all police and fire stations.

<u>Winter Storms</u>

- Ensure that ISD, which enforces the sidewalk clearing regulations and must respond to post-snow issues, has an adequate number of vehicles for inspectors.

- Ensure that ISD has adequate personnel and resources for enforcement.

- Record catch basins with GPS.

- Continue to upgrade older water mains.

- Encourage preventative roof drain maintenance by building owners to minimize the formation of dangerous icicles.

Coastal Erosion

- Long Island – The remaining coastal banks need to be stabilized.
- Rainford Island – The coastal banks need to be stabilized.
- Moon Island – Implement recommendations from the Assessment. This includes rebuilding damaged portions, filling joints, strengthening 300-foot section, removing arches, and some further investigations ($1.07 million). May also wish to relocate range and training facility upland.
- BRA Properties in East Boston – Issues will be addressed through the private redevelopment process.
- Fort Point Channel – Issues will be addressed through the private redevelopment process.
- Reserved Channel – Multiple parties have jurisdiction here and need to work to stabilize the shoreline.
- Pier 5, Charlestown – Issues will be addressed through the private redevelopment process.
- Millennium Park, West Roxbury – Investigate whether a permanent buffer wall is needed to ensure that the landfill and methane burner are adequately protected from erosion.

Mitigation Summary Table

The following columns are included in the summary table below (Table 13):

Mitigation Measure – A brief description of each mitigation measure.

Priority – The designation of high or medium was based on input by the Local Multiple Hazard Community Planning Team and the key project staff. The designations could change as conditions in the community change. Non-prioritized measures are not included in the table.

Lead Implementation – This column lists the most logical implementer. 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 the city. In some cases, a non-local entity ideally would be the lead implementer.

Time Frame – The time frame was based on the level of priority for the measure, the complexity of implementing the measure, and whether or not the measure is conceptual, in design, or already designed and awaiting funding. Time frames could change as funding opportunities arise.

Estimated Cost – Where available, cost estimates are provided. The cost data would need to be adjusted for inflation and for any changes or refinements in the design of a particular mitigation measure as a project progresses.

Potential Funding Sources – This column attempts to identify possible sources of funding. This information is preliminary and varies depending on a number of factors such as whether a mitigation measure has been studied, evaluated or designed or is still in the conceptual stage. 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. The best way to determine eligibility for a particular funding source is to review the project with the funding agency.

Table 13. High and Medium Priority Mitigation Measures

Mitigation Measure	Priority	Lead Implementation	Time Frame	Estimated Cost	Potential Funding Sources
Muddy River Restoration	HIGH	Fed., state, city, Town of Brookline	0-5 years	$92 M	Federal, state funding
Protect Fire Alarm Building	HIGH	Fire Dept.	0-5 years	$118,000	HMGP, city share
Storrow Drive continued maintenance	HIGH	DCR	ongoing	n/a	DCR operating budget
Storrow Drive reconstruction	HIGH	DCR	By 2012	$45 – 135 M	State, Federal transportation funds
Rebuild Charlestown Underpass tunnel	HIGH	DPW	5-10 years	Greater than $1m	City, Federal transportation funds, HMGP
Conduct earthquake study	HIGH	DPW	0-5 years	Less than $250,000	PDM
Purchase fire boat	HIGH	Fire Dept.	0-5 years	$12.3 M	City, possibly Homeland Security programs
Rehabilitate Long Island Bridge	HIGH	DPW, MHD	0-5 years	Greater than $1 M	City, fed. transportation funds, HMGP
Acquire snow melting technology	HIGH	DPW	0-2 years	Uncertain	CIP, consider regional cost-sharing
Improve communications systems	HIGH	Multiple Depts.	0-5		Homeland Security programs
Long term solution to stabilize bank at East Eagle Street	MED.	DPW	0-5 years	Less than $1 M	HMGP, private assistance
Address Canterbury Brook flooding in Mattapan – dredging (DCAM) and/or more trash capturing efforts in upper watershed.	MED	DCAM, BWSC	0-5 years	Less than $1 M	State, city operating budget
Stabilize bank or establish new bank at Columbia Point	MED.	UMass, state	0-5 years	Less than $1 M	State and private funding

PDM – Pre-Disaster Mitigation program
HMGP – Hazard Mitigation Grant Program

REGIONAL AND INTER-COMMUNITY CONSIDERATIONS

Some hazard mitigation issues are strictly local. The problem originates primarily within the municipality and can be solved at the municipal level. Other issues are inter-community and require cooperation between two or more municipalities. A third level of mitigation is regional and may involve a state, regional or federal agency or three or more municipalities.

Regional Partners

Mitigating natural hazards in densely developed communities often requires the efforts of more than a single community. This is particularly true for flooding issues.

The drainage systems that serve Boston are complex systems of storm drains, tide gates, roadway drainage structures, pump stations and other facilities owned and operated by a wide array of agencies including the city, DCR, MWRA, Massachusetts Highway Department (MHD), the MTA, the Massachusetts Bay Transportation Authority (MBTA), and others. In addition, a number of federal facilities are located in Boston. The planning, construction, operations and maintenance of these structures are integral to the hazard mitigation efforts of communities, so these entities must be considered regional partners in hazard mitigation. They also operate under the same budgetary and staffing constraints as communities do and must make decisions about numerous competing priorities.

The Metro Boston Multi-Hazard Mitigation Plan provides details on region-wide natural hazard mitigation strategies. Following, is a brief overview of regional facilities found in Boston and inter-municipal issues.

Overview of Regional Facilities in Boston

Major facilities owned, operated and maintained by state or regional entities include:

- Massachusetts Turnpike and development parcels/air rights owned by the MTA
- A number of state routes, such as Route 9 (MHD)
- DCR parkways including Storrow Drive, Soldiers Field Road, the Jamaicaway, VFW Parkway, West Roxbury Parkway, and others
- Commuter rail, subway, ferries and associated stations and docks (MBTA)
- Water and sewer infrastructure (MWRA)
- As noted earlier, DCR dams
- Conservation areas and parks such as Belle Island Reservation, Stony Brook Reservation and Pope John Paul II Park (DCR)
- Recreation facilities, pools, beaches and bike paths (DCR)
- National Parks including the Charlestown Navy Yard (National Park Service)
- Logan International Airport and port facilities (MassPort)
- State and community colleges
- Various federal offices and facilities

Hazard mitigation measures undertaken by each of these entities clearly has impacts on the city.

Inter-Community Considerations

As discussed earlier, one of the largest flooding issues facing Boston is the Muddy River restoration. This issue and the mitigation strategies to address it involve the cooperation of Brookline, Boston and the state. These entities have worked together to formulate a mitigation strategy, and is currently being designed by the U.S. ACOE.

Flood control along the Neponset River also affects Milton and Quincy. Also, since Moon Island is located in Quincy, actions to address erosion would affect that city also.

PLAN ADOPTION AND MAINTENANCE

Plan Adoption

The Boston Annex of the Metro Boston Regional Multi-Hazard Mitigation Plan was adopted by the City Council on xx, 2007. See Appendix E for documentation.

Plan Maintenance

MAPC recommends the following approach to plan maintenance.

Regional Implementation Group

In order to ensure that the regional plan is monitored, evaluated and updated, the Metro Boston Hazard Mitigation Community Planning Team which was established for this planning process will continue to meet on an as-needed basis as the Regional Implementation Group for the regional plan.

This group will select a chair that is willing to provide regional leadership, oversee the implementation schedule detailed below and provide administrative support to the process. An alternative approach would be for each community to secure funding to hire a consultant such as MAPC to provide support for the process. Because the plan was prepared by MAPC, having MAPC continue to monitor and prepare an updated plan would ensure a level of continuity and consistency that would benefit the communities. Contingent on funding being available, MAPC could take on this role.

Local Implementation Group

MAPC worked with the local teams to prepare this annex. In Boston, this Team was an ad hoc group pulled together for this project. This group will continue to meet on an as-needed basis to function as the Local Implementation Group. Additional members should be added to the Local Implementation Group from businesses, non-profits and institutions.

Implementation Schedule

Yearly Survey and Annual Report
Once a year the chair of the Regional Implementation Group will prepare and distribute a survey to the local implementation groups from each of the nine communities. The survey will poll the local groups on changes, revisions and accomplishments from the local and regional perspective and whether any new hazards or problem areas have been identified in the communities.

This information will be used to prepare an annual report or addendum to the regional plan and the annexes. The Local Implementation Groups will have primary responsibility for updating the annexes.

The Regional Implementation Group will meet after all communities have responded to the survey to review any changes in regional goals or mitigation measures and to be briefed on any changes that may have occurred in the Federal Disaster Mitigation Act or hazard mitigation guidelines.

Yearly Review of Regional Mitigation Measures
The Regional Implementation Group will meet twice a year (at a minimum) to review the list of regional mitigation measures and begin to develop a priority list for implementation.

Develop Fourth Year Update Subcommittee
At the start of the fourth year after initial plan adoption, the chair of the Regional Implementation Group will convene a subcommittee to prepare an update of the plan. At this point, the Regional Implementation Group may decide to undertake the update themselves, contract with MAPC to update the plan or to hire another consultant.

As the Regional Implementation Group prepares for a full update of the regional plan and annexes, an evaluation of the plan's effectiveness will be undertaken. This will include the following:

- The membership of the Regional Implementation Group and local committees.
- Issues related to integration of the plans with local and regional plans and procedures.
- An analysis of the relevance of the hazard mitigation goals.
- The successfulness of the plan in accomplishing mitigations measures.

Prepare and Adopt New Community Annexes and Regional Plan
However the Regional Implementation Group decides to update the plan, the group will need to review the current disaster mitigation plan guidelines for any changes. The plan update subcommittee will present the full Regional Implementation Group with a new plan for each community to adopt and forward to FEMA for approval.

Integration of the Plans with Other Planning Initiatives
Upon approval of the regional plan and annexes by FEMA, each local committee 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:

- Public Works Department
- Mayor's Office of Emergency Preparedness
- Boston Redevelopment Authority
- Environment Department
- Boston Water and Sewer Commission
- Public Health Commission
- Parks and Recreation Department
- Fire Department
- Police Department
- Inspectional Services Department

The actions in the hazard mitigation plan will be incorporated into the City's Capital Improvement Plan and departmental budgets where relevant. The actions will also be incorporated into the Community Development Plan and Open Space Plan where relevant. Hazard mitigation concerns are already included in various local ordinances and programs as summarized on pages 65-68. For a list of local plans where integration may be relevant, see page 82.

Other groups that will be coordinated with include large institutions (hospitals, colleges), Chambers of Commerce, land conservation organizations and watershed groups. The plans or components of the plan will also be posted on a community's website with the caveat that each community 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.

In addition, the plan will be reviewed with state agencies MEMA and DCR and regional agencies such as the MWRA.

RESOURCES

Please see maps for mapping data sources.

2006-2008 Capital Improvement Program. BWSC. December 2005.

Boston Fire Alarm Risk Assessment and Protective Measures Plan – Final Draft. Prepared by URS Corporation. March 7, 2006.

A Civic Vision for Turnpike Air Rights in Boston. Boston Redevelopment Authority. 2000.

Infrastructure Systems, Services and Climate Change: Integrated Impacts and Response Strategies for the Boston Metropolitan Area. Also referred to as "CLIMB". Tufts University, University of Maryland, Center for Transportation Studies, and MAPC. EPA Grant Number R.827450-01. August 13, 2004.

MAPC Build-Out Analysis. 2000.

Open Space Plan, 2002 – 2006. Boston Parks and Recreation Department. September 2002.

Residential Land Use in Boston. Report #592. Boston Redevelopment Authority. February 2004.

State Hazard Mitigation Plan. Commonwealth of Massachusetts. October 2004.

State and Local Mitigation Planning How-To Guides. FEMA.

Supplemental Final Environmental Impact Report. Phase 1 Muddy River Flood Control, Water Quality and Habitat Enhancement and Historic Preservation Project. EOEA #11865. February 2005. Prepared by CDM for the City of Boston and Town of Brookline.

U. S. Census, 2000 and 2005.

William Lettis & Associates, Inc. and Tufts University.

Letter to Capital Construction Division, Public Facilities Department from Bourne Consulting Engineering, January 31, 2006, regarding Moon Island Seawall Investigation.

Appendix A – Maps

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Appendix B

Agendas for Metro Boston Regional Hazard Mitigation Community Planning Team

Cristine McCombs
Director

Katherine F. Abbott
Commissioner

Marc D. Draisen
Executive
Director

The Commonwealth of Massachusetts

MITT ROMNEY, GOVERNOR

Massachusetts Emergency Management Agency
400 WORCESTER ROAD, FRAMINGHAM, MA 01702-5399 508-820-2000 FAX 508-820-1404

Department of Conservation and Recreation
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Metropolitan Area Planning Council
60 TEMPLE PLACE, 6TH FLOOR, BOSTON, MA 02111 617-451-2770 FAX 617-482-7185

METRO BOSTON PRE-DISASTER MTITGATION PLAN

Boston
BROOKLINE
CAMBRIDGE
CHELSEA
EVERETT
MALDEN
MEDFORD
MELROSE
SOMERVILLE

Metro Boston

Hazard Mitigation Community Planning Team

First Meeting

THURSDAY, DECEMBER 16, 9:30 AM

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

AGENDA

9:30 WELCOME & INTRODUCTIONS *(Please sign contact sheet)*

9:45 OVERVIEW OF FEDERAL DISASTER MITIGATION ACT & PRE-DISASTER MITIGATION PLANNING

- *Presentation, Questions & Discussion*
  --Martin Pillsbury, MAPC

10:15 GETTING STARTED: THE METRO BOSTON REGIONAL PRE-DISASTER MITIGATION PLAN

- *Review of Scope of Work & Schedule –MAPC project team:*
  --Martin Pillsbury, Joan Blaustein, Heidi Samokar & Alan Bishop
- *Questions & Discussion – Local Issues & Priorities*

11:00 PREVIEW OF MAPPING AND DATABASES FOR THE PLAN

- *Examples from the North & South Shore PDM Plans*
  --Alan Bishop, GIS Manager, MAPC

11:20 NEXT STEPS / MEETING SCHEDULE

11:30 ADJOURN

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Cristine McCombs
Director

STEPHEN R. PRITCHARD
Acting Commissioner

Marc D. Draisen
Executive Director

The Commonwealth of Massachusetts

MITT ROMNEY, GOVERNOR

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Metro Boston

Hazard Mitigation Community Planning Team

Regional Meeting

THURSDAY, MAY 19, 2005, 9:30 AM

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

METRO BOSTON PRE-DISASTER MTITGATION PLAN

BOSTON
BROOKLINE
CAMBRIDGE
CHELSEA
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MEDFORD
MELROSE
SOMERVILLE

AGENDA

9:30 WELCOME, INTRODUCTIONS & OVERVIEW OF AGENDA
- *Martin Pillsbury, MAPC*

9:40 REVIEW OF MAPPING – CRITICAL INFRASTRUCTURE AND SAMPLE MAP SERIES
- *Allan Bishop, MAPC will review progress to date on mapping*

10:00 REVIEW OF SUGGESTED PUBLIC PARTICIPATION APPROACH
- *Joan Blaustein, MAPC will discuss a strategy for public participation in development of the local plans.*

10:10 OVERVIEW OF LOCAL ACTIVITIES AND EMERGING REGIONAL ISSUES
- *Joan Blaustein and Heidi Samokar, MAPC will discuss initial findings and regional issues that have emerged while working with the local teams.*

10:30 OTHER ANNOUNCEMENTS

10:40 NEXT STEPS / MEETING SCHEDULE
- *Martin Pillsbury.*

10:50 ADJOURN

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Cristine McCombs
Director

STEPHEN H.
BURRINGTON
Commissioner

Marc D. Draisen
Executive Director

METRO BOSTON PRE-DISASTER MTITGATION PLAN

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Metro Boston

Hazard Mitigation Community Planning Team

Regional Meeting

FRIDAY, OCTOBER 14, 2005, 9:30 AM

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

AGENDA

9:30 WELCOME, INTRODUCTIONS & OVERVIEW OF AGENDA

- *Martin Pillsbury, MAPC*

9:40 ISSUES AND CONCERNS RAISED BY KATRINA, RITA, ETC.

- *Recent natural disasters have heightened public awareness of the need for preparedness. Heidi Samokar will moderate a discussion and encourage the committee to brainstorm the ways these events will affect our Pre-Disaster Mitigation Plan for Metro Boston.*

10:00 REGIONAL ISSUES IN THE PDM PLAN

- *Joan Blaustein will moderate a discussion of multi-community and regional issues that should be addressed in the PDM Plan.*

11:00 DISTRIBUTION OF COMMUNITY MAP SERIES

- *Allan Bishop, GIS Manager, will distribute copies of the PDM local map series and lead a brief discussion on how the maps will be used in the development of the PDM Plan.*

11:15 NEXT STEPS / MEETING SCHEDULE

- *Martin Pillsbury.*

11:30 ADJOURN

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Cristine McCombs
Director

STEPHEN H. BURRINGTON
Commissioner

Marc D. Draisen
Executive Director

The Commonwealth of Massachusetts

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Metro Boston

Hazard Mitigation Community Planning Team

Regional Meeting

THURSDAY, FEBRUARY 23, 2006, 9:30 AM

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

METRO BOSTON PRE-DISASTER MTITGATION PLAN

BOSTON
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MEDFORD
MELROSE
SOMERVILLE

AGENDA

9:30 WELCOME, INTRODUCTIONS & OVERVIEW OF AGENDA
- *Martin Pillsbury, MAPC*

9:40 OVERVIEW OF BENEFIT/COST ANALYSIS
- *In order to apply for funding for mitigation projects under FEMA grant programs, a Benefit Cost Analysis must be submitted to FEMA. Joan Blaustein will present a summary of the process and requirements and moderate a discussion on Benefit/Cost Analysis.*

10:15 FOLLOW-UP ON REGIONAL ISSUES: DCR & MBTA
- *MAPC has met with DCR and MBTA to review regional issues raised at the last meeting in December. Heidi Samokar will moderate a discussion that will include voting by committee members to prioritize regional issues so they can be addressed in the plan.*

11:00 SUMMARY OF EXISTING MITIGATION MEASURES
- *The existing mitigation measures of each community have been summarized in a matrix; copies will be distributed for review.*

11:15 NEXT STEPS AND TIMELINE TO COMPLETE THE PDM PLAN
- *Martin Pillsbury will summarize the remaining tasks and the timeline to complete the PDM Plan for the Metro Boston region.*

11:30 ADJOURN

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Cristine McCombs
Director

STEPHEN H. BURRINGTON
Commissioner

Marc D. Draisen
Executive Director

The Commonwealth of Massachusetts

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Metro Boston

Hazard Mitigation Community Planning Team

Regional Meeting

THURSDAY, NOVEMBER 16, 2006, 9:30 AM

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

METRO BOSTON PRE-DISASTER MTITGATION PLAN

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9:30 WELCOME, INTRODUCTIONS & OVERVIEW OF AGENDA

- *Martin Pillsbury, MAPC*

9:40 OVERVIEW OF THE DRAFT REGIONAL PLAN

- *Joan Blaustein and Heidi Samokar, MAPC will walk through the regional plan to provide an overview of the draft.*

10:15 REVIEW AND ADOPT THE HAZARD MITIGATION GOALS

- *This will be an opportunity to review regional hazard mitigation goals that MAPC has developed based on discussions at the previous meetings. Participants will be given an opportunity to suggest revisions or new goals. The goals will then need to be approved by the group.*

10:35 DISCUSS THE REGIONAL IMPLEMENTATION CHAPTER OF THE PLAN

- *The final chapter of the plan discusses how to implement, review and update the plan. This will be an opportunity to discuss how best to accomplish this.*

11:15 NEXT STEPS AND TIMELINE TO COMPLETE THE PDM PLAN

- *Martin Pillsbury will summarize the remaining tasks and the timeline to complete the PDM Plan for the Metro Boston region.*

11:30 ADJOURN

**There is a parking lot behind City Hall. If the lot is full, park in a metered on-street space.*

Appendix C

Local Multiple Hazard Community Planning Team Meeting Agenda

(Note: There was no formal agenda for the first team meeting)

Boston Natural Hazard Mitigation Plan
Team Meeting
December 14, 2006

1. **Introductions.** (5 minutes)

2. **Brief Overview of the Boston Natural Hazard Mitigation Plan**. (10 minutes) MAPC staff will remind attendees about the purpose of the plan and general requirements.

3. **Develop Plan Goals and Objectives.** (10 minutes) MAPC will help attendees brainstorm a list of natural hazard mitigation goals and objectives.

4. **Review of Initial Findings** (45 minutes). MAPC will review its initial findings on vulnerabilities and existing mitigation measures.

5. **Discussion of Potential Future Mitigation Measures**. (45 minutes) MAPC will review a list of future mitigation measures suggested by various city officials to date. Attendees will give a sense of their priorities.

6. **Next Steps** (5 minutes). MAPC will review the next steps to complete the Plan.

Appendix D

Media Advisory and Meeting Agenda for Public Meeting

PUBLIC HEARING

In accordance with the Massachusetts Wetlands Protection Act, M.G.L. Chapter 131, Section 40, the BOSTON CONSERVATION COMMISSION will hold a public hearing in Boston City Hall, Room 801 on Wednesday, April 18, 2007 to review the following projects to determine what conditions, if any, the Commission will impose in order to protect the interests of the public and private water supply, ground water, prevention of pollution, flood control, prevention of storm damage, protection of fisheries and land containing shellfish, and protection of wildlife habitat:

6:00 PM Presentation from the Metropolitan Area Planning Council on the City of Boston Natural Hazard Mitigation Plan, as required under the Federal Disaster Mitigation Act.

6:30 PM Review of the Massachusetts Turnpike Authority - Central Artery/Tunnel Project's North Point Park Water Quality Monitoring Program, and request for deletion of requirements in Special Condition No. 37, of Order of Conditions **DEP File No. 006-0793**, regarding a water feature aeration system constructed as part of North Point Park, Charles River, Charlestown. *Continued from the April 4, 2007 Public Hearing*

6:45 PM Request for Extension Permit for Order of Conditions **DEP File No. 006-0988** from Roseland Property Company to replace an existing 24-inch timber sewer line and outfall with a 36-inch, concrete storm drain line and outfall for the Boston Water and Sewer Commission, including the removal of existing wharf and piles and bank stabilization at 29 Marginal Street, Pier 5, Boston Inner Harbor, East Boston (Coastal Bank, Coastal Beach, Land Under Ocean, Land Subject to Coastal Storm Flowage).

7:00 PM Request for Extension Permit **for Order of Conditions DEP File No. 006-0996** from the Peninsula Yacht Club to install mooring piles and additional floats to reconfigure and expand its existing floating dock system, 671 Summer Street, Reserved Channel, South Boston (Land Under Ocean).

7:15 PM Notice of Intent from the Camp Harbor View Foundation for the construction of a day camp, including site re-grading, landscaping, and construction of three pavilions, a bathhouse, tennis and basketball courts, and installation of utilities, on Long Island, Boston Harbor (Land Subject to Coastal Storm Flowage, 100-foot Buffer Zone to Coastal Bank).

7:30 PM Notice of Intent from Fan Pier Development, LLC for Phase 1 of the Fan Pier Project, involving the development of three commercial/residential buildings, and associated landscaping, utilities and stormwater management system; and construction of a public green, Harborwalk and a water transportation dock and public touch-and-go dock, requiring dredging and the installation of pilings, at 28-52 Northern Avenue, Boston Inner Harbor, South Boston (Land Under Ocean, Coastal Bank, 100-foot Buffer Zone).

8:00 PM Notice of Intent from the Boston Water and Sewer Commission for construction of the Morrissey Boulevard Drainage Conduit, including the removal and restoration of a riprap revetment, installation of a tide gate chamber, reinforced concrete conduit, and stormwater discharge outfall basin, involving the driving of piles, steel sheeting and dredging in Savin Hill Cove, Dorchester (Coastal Beach, Coastal Bank, Land Containing Shellfish, Land Subject to Coastal Storm Flowage).

Sign Language interpreters are available upon prior request. The Commission will hold a public meeting immediately following the last hearing or as appropriate following any hearing. For more information, call (617) 635-4417.

For the Commission,

Chris Busch, Executive Secretary

Appendix E

Documentation of Plan Adoption by Boston City Council

[To be provided after adoption of the plan by the city]